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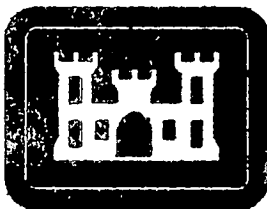
**FINAL**  
**USACE/OR/DACA62-1045**

**SAMPLING AND ANALYSIS PLAN  
FOR THE ST. LOUIS AIRPORT  
AND DOWNTOWN SITES**

**ST. LOUIS, MISSOURI**

**JUNE 1998**

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

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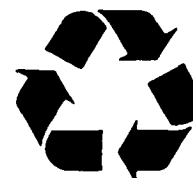
**JUNE 1998**

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

with technical assistance from  
Science Applications International Corporation ESC-FUSRAP  
under Contract No. DACW45-98-D-0029



# Sampling and Analysis Plan for the St. Louis Airport and Downtown Sites

## St. Louis, Missouri

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## ACRONYMS, ABBREVIATIONS, AND SYMBOLS

Ac	actinium
ACGIH	American Conference of Governmental Industrial Hygienists
AEC	Atomic Energy Commission
AMSL	above mean sea level
ANL	Argon National Laboratory
ASTM	American Society of Testing and Materials
bgs	below ground surface
BNI	Bechtel National, Inc.
BRA	baseline risk assessment
°C	degrees centigrade (Celsius)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	contract laboratory program
cm	centimeter(s)
COC	contaminant of concern
cpm	counts per minute
CPs	Contiguous Properties
Cr	chromium
Cu	copper
DCM	dichloroemethane
DMP	Data Management Plan
dpm	disintegration per minute
DOE	Department of Energy
DOT	Department of Transportation
DQO	data quality objectives
EE/CA	Engineering Evaluation/Cost Analysis
EM	Engineering Manuals
ER	Engineering Regulations
F	fluoride
FEMA	Federal Emergency Management Act
FID	flame ionization detector
FIDLER	field instrument for detecting low-energy radiation
FS/EIS	Feasibility Study/Environmental Impact Study
FUSRAP	Formerly Utilized Sites Remedial Action Program
ft	foot/feet
g	gram(s)
GPR	ground-penetrating radar
GPS	global positioning sensors
GWS	gamma walkover survey
h	hour(s)
ha	hectare(s)



## ACRONYMS, ABBREVIATIONS, AND SYMBOLS (cont'd)

He	helium
HISS	Hazelwood Interim Storage Site
HPGe	High Purity Germanium
IA	investigation area
IDW	investigation derived waste
IG	instructional guide
IRA	Interim Remedial Actions
kg	kilogram(s)
km	kilometer(s)
L	Liter(s)
LCS	laboratory control sample
LIBS	laser-induced breakdown spectroscopy
m	meter(s)
MDL	method detection limits
MDNR	Missouri Department of National Resources
MED	Manhattan Engineer District
Mg	magnesium
mg	milligram(s)
mrem	millirem(s)
MS/MSD	matrix spike/matrix spike duplicate
NIOSH	National Institute of Occupational Safety and Health
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
OVA	organic vapor analyzer
Pa	protactinium
PAM	* Preliminary Assessment Memorandum
PARCC	precision, accuracy, representiveness, comparability, and completeness
Pb	lead
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pCi	picocuries
PCOC	potential constituents of concern
PCP	pentachlorophenol
PID	photoionization detector
PM <sub>10</sub>	particulate material, less than 10 microns
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PQL	practical quantitation limit
PVC	* polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control

## ACRONYMS, ABBREVIATIONS, AND SYMBOLS (cont'd)

Ra	radium
RCRA	Resource Conservation Recovery Act
RD/RA	remedial design/remedial action
RI	Remedial Investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SOP	standard operating procedure
SOR	sum of the ratios
SOW	statement of work
Sr	strontium
SSHP	Site Safety and Health Plan
SSL	Soil Screening Level
SVOC	semi-volatile organic compound
TAL	Target Analyte List
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TD	total depth
Th	thorium
Tl	thallium
TOC	total organic carbon
TPP	Technical Project Planning
TSP	total suspended particulates
TSS	total suspended solids
U	uranium
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Society
VOC	volatile organic compound
XRF	X-ray fluorescence
yr	year(s)

## 1.0 INTRODUCTION

This document presents the United States Army Corps of Engineers (USACE) Sampling and Analysis Plan (SAP) for additional sampling tasks at the St. Louis Airport Site (SLAPS) and the St. Louis Downtown Site (SLDS) properties as part of the Formerly Utilized Site Remedial Action Program (FUSRAP). SLAPS and the SLAPS contiguous properties (CPs) form one of several St. Louis FUSRAP sites which also include SLDS, the Latty Avenue vicinity properties, and the Hazelwood Interim Storage Site (HISS). SLAPS is located in St. Louis, Missouri, approximately 17 miles northwest of downtown St. Louis. The location of SLAPS and SLDS is shown on Figure 1-1.

The primary focus of the planned SLAPS sampling work is to provide the necessary data to support ongoing remedial efforts, define the constituents of concern (COCs) at SLAPS and CPs, and confirm site conditions and assumptions needed to supplement the Feasibility Study (FS) and develop a Record of Decision (ROD) for this site. The extent of the SLAPS investigation including CPs is shown on Figure 1-2. A plan for background soil sampling at SLDS is also attached separately to this plan. The objectives for the two plans were developed as a result of an on-board Technical Project Planning (TPP) process which included USACE, regulatory agencies (United States Environmental Protection Agency [USEPA] Region VII and Missouri Department of Natural Resources [MDNR]), and other stakeholders. Summaries of these meetings are provided as the last appendix to this report. The following Chapters 1.0 through 9.0 address only the SLAPS sampling and analysis activities.

### 1.1 PURPOSE AND SCOPE

The purpose of this SAP is to provide the guidelines necessary to meet the additional project objectives for SLAPS and CPs. The primary guidelines needed in this SAP are:

1. The type, quantity and quality of additional data needed;
2. Decision rules that will be used to guide on-site decision making as data is acquired;
3. Field procedures that will employ technologies and methods of investigation that will provide the necessary data of the desired quality; and
4. An investigation schedule and sampling and analysis strategy that will facilitate collection of the required information, of sufficient quantity and quality, in an expedited manner.

### 1.2 ORGANIZATION

This SAP is organized into 10 chapters. The remaining part of Chapter 1.0 provides a summary of historic information for operations at SLAPS, a summary of the site's physical and climatic conditions, as well as the nature and extent of previously detected radionuclides, metals, and chemicals at SLAPS and CPs; describes the 13 separate investigative areas (IAs) that have been identified for SLAPS and CPs; and outlines the data quality objectives (DQOs). Chapter 2.0 details the types of field sampling activities and identifies specific tasks to provide appropriate data

to apply to the DQO decision process. Chapter 3.0 describes the sample handling, packaging, and shipping requirements. Chapter 4.0 describes decontamination requirements and procedures. Chapter 5.0 describes investigation-derived waste (IDW) management procedures and requirements. Chapters 6.0, 7.0, and 8.0 discuss the quality assurance, health and safety, and data management aspects of the project, respectively. Chapter 9.0 provides a project schedule for the SLAPS sampling and analysis activities. Chapter 10.0 describes the planned background soil sampling activities at SLDS. Chapter 11.0 is a bibliography and reference list.

### 1.3 SITE HISTORY

Between 1946 and 1966, SLAPS was used to store Manhattan Engineer District (MED)/Atomic Energy Commission (AEC) residue material generated by uranium separation processes at Mallinckrodt Chemical Works. This residue material included solids from the neutralization and filtration of ore raffinate, which was stored on the ground, and radium-bearing residues, which were stored in drums (Figure 1-3). Barium cake residue was also stored on the ground at the site. Other wastes brought to SLAPS included used dolomite liner and recycled magnesium fluoride liner; tailings from a process used to recover uranium from magnesium fluoride slag; 50,000 empty drums; 3,500 tons of radioactively contaminated metal scrap; 2,400 drums containing miscellaneous residues; uranium-containing sand; and radioactive scrap materials. Some of these materials were buried in pits dug on the site.

MED acquired SLAPS in 1946, and used the site to store uranium-bearing residues from SLDS from 1946 until 1966. In 1966, these residues were purchased by Continental Mining and Milling Company of Chicago. 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 (USEPA, 1989). Clean fill material was spread over the disposal area from 0.3 to 1.0 meters (1 to 3 feet) to achieve surface radioactivity levels acceptable at that time. 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.

As shown on Figure 1-2, the area of planned investigation includes several CPs beyond SLAPS. These areas include the ball fields located immediately north of SLAPS across McDonnell Boulevard; the Norfolk and Western Railroad which runs along the southern boundary of SLAPS; McDonnell Boulevard which runs along the northern boundary of SLAPS; Coldwater Creek and the flood plain located along the northern side of the creek; a portion of the Boeing parking lot located across Coldwater Creek to the west of SLAPS; and a portion of the airport property and Banshee Road located just south of the railroad and SLAPS. The CPs are being investigated due to known or suspected contaminant migration routes. These routes include wind deposition, surface drainage and overland flow, flooding, ground-water movement, and previous routes of waste transportation.

## 1.4 SITE DESCRIPTION

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. Planning and zoning for SLAPS are governed by the adjacent City of Berkeley. SLAPS is currently zoned "M-1" (Light Industrial). This category allows for the full range of light industrial uses, such as building material storage yards, utility substations, wholesale warehouses, and some manufacturing activities. Limited commercial uses include offices, financial institutions, and training academies (Zoning Code, City of Berkeley, Section 23.12.1). The south-central and eastern portions of the property are in the approach zones of runways 17 and 24, respectively, of the adjacent Lambert-St. Louis International Airport (Bechtel National, Inc. [BNI], 1994a). This proximity to the airport imposes additional restrictions on SLAPS related to noise from aircraft and height restrictions in the approach zones. The portion of the site adjacent to Coldwater Creek is zoned "M-1/FP," which indicates that it is also located within the flood plain district.

The airport area is dominated by industrial uses. Because of its proximity to the airport, however, more than two-thirds of the land within 0.8 km (0.5 mi) of SLAPS is used for transportation-related purposes. The remaining land is used for commercial and industrial purposes. Information presented in the Remedial Investigation Report for the St. Louis Site (BNI, 1994a) indicates that no sizeable residential population centers exist within 1.6 kilometers (km) (1 mile) of SLAPS; the nearest population center (75 to 100 people) is approximately 0.8 km (0.5 mile) west of the property in an industrially zoned area of Hazelwood. The next nearest is approximately 1.6 km (1 mile) northwest of SLAPS along Chapel Ridge Drive, with about 1,500 people. Most of the Hazelwood population is north of Interstate 270, more than 2.4 km (1.5 miles) north of SLAPS.

Land in the immediate vicinity of SLAPS is not used for agricultural purposes. As shown on Figure 1-2, SLAPS is bounded on the north and east by McDonnell Boulevard. South of SLAPS is the Norfolk and Western Railroad, then Banshee Road, and the Lambert-St. Louis International Airport. West of SLAPS is Coldwater Creek and then the Boeing property. Additional information on land use in the area is presented in the Remedial Investigation Report for the St. Louis Site (BNI, 1994a) and the Feasibility Study/Environmental Impact Statement for the St. Louis Site (SAIC, 1994).

SLAPS covers 8.8 hectares (ha) (22 acres) and is surrounded by security fencing. A water line runs along the northern boundary of SLAPS, and a gas line crosses the northwest corner and runs parallel to the property on the north. There are overhead utility lines on the western end of SLAPS.

The elevation at SLAPS varies from approximately 155 to 161 m (530 to 510 feet) from east to west, and the land surface ranges from 4.5 to 6 m (15 to 20 feet) above Coldwater Creek (BNI 1992b). Generally, the property surface is flat; however, because the fill placed over the property in the early 1970s was not spread evenly, compaction, revegetation, differential settling, and erosion have created an irregular surface (BNI, 1992b). The 100-year flood level at SLAPS is 159 m (522 feet) above mean sea level (MSL) [Federal Emergency Management Agency (FEMA 1983)]. The ball fields cover approximately 32 ha (80 acres) of an abandoned former

recreational area. This area was constructed on former lowlands which were filled with up to eight feet of various fill material.

Coldwater Creek flows for 153 m (500 feet) along the western border of SLAPS. The creek originates 5.8 km (3.6 miles) to the south of SLAPS and continues for 24 km (15 miles) in a northeasterly direction through Hazelwood, Florissant, and unincorporated areas of the county, and along the northern edge of the unincorporated community of Black Jack, until it discharges into the Missouri River. The creek, with the exception of the 1.2 miles it travels under the airport, is accessible to the public (Science Applications International Corporation [SAIC], 1992).

Coldwater Creek is classified by the 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 which support aquatic life. Flooding in Coldwater Creek occurs annually. Coldwater Creek is protected downstream of SLAPS from U.S. 67 to its mouth for livestock/wildlife watering (designation LWW) and aquatic life (designation AQL) usage.

The water quality in Coldwater Creek is generally poor. Pollutants enter the stream in storm water primarily from the Lambert-St. Louis International Airport. SLAPS runoff also flows into Coldwater Creek. Only one National Pollutant Discharge Elimination System (NPDES)-permitted discharge is known to enter the creek upstream of SLAPS. This discharge is from Lambert-St. Louis International Airport. The nearest known downstream NPDES-permitted discharge to the creek is from HISS.

## **1.5 PREVIOUS INVESTIGATIONS/CURRENT SITE CONDITIONS**

### **1.5.1 Site Setting**

In 1982, a radiological characterization of the ditches located to the north and south of SLAPS and of portions of Coldwater Creek (BNI, 1983) indicated radioactivity levels exceeding the DOE guidelines in effect at that time.

In 1986, an extensive radiological and limited chemical characterization of SLAPS determined that radioactive impacts extended as deep as 5.5 m (18 feet) below grade (BNI, 1987). A radiological characterization of airport area properties was subsequently conducted from 1986 through 1990 to further define the extent of radioactive contamination and to evaluate possible disposal alternatives.

The site stratigraphy at SLAPS and CPs (Figure 1-4) is divided into six units: a fill layer, three discontinuous units of non-lithified materials ranging in thickness from 15.2 to 24.4 m (50 to 80 feet), and two undifferentiated bedrock units underlying the nonlithified materials. The top fill layer consists of intermixed rebar, scrap metal, reinforced concrete, glass, and slag within loose to compacted silt, sand, and gravel. The fill layer ranges in thickness from 0 to 4.3 m (0 to 14 feet).

The three units underlying the fill represent nonlithified loess, lake, and glacial sediments. Each unit has an average thickness ranging from 2 to 9 m (7 to 30 feet). The uppermost unit beneath the fill is loess. The next subunit 3T directly overlies subunit 3M. Beneath the SLAPS area, the 3T subunit varies in thickness from 3 to 8 m (9 to 27 feet). The next unit is subunit 3M, which is approximately 9 m (30 feet) thick on the western edge of the ball fields, and thins to the east, finally pinching out near the eastern edge of SLAPS. Subunit 3B directly underlies subunit 3M. It is continuous beneath SLAPS and thickens towards the east. The lower nonlithified unit (Unit 4) is clayey gravel with an increasing amount of fine- to very fine-grained sand and occasional sandy gravel at the contact with limestone bedrock. This unit is interpreted to be approximately 2 to 5 m (5 to 15 feet) thick and thins eastward, and is absent beneath the eastern part of SLAPS. Bedrock at the site consists of Pennsylvanian sandstones, shales, and siltstones (Unit 5) or Mississippian limestone (Unit 6). The shale is the Cherokee Shale Formation with the limestone interpreted as the St. Genevieve Formation. Depth to bedrock ranges from 16.5 m (55 feet) on the eastern side of SLAPS to a maximum of 27 m (90 feet) near Coldwater Creek. An erosional buried valley system is interpreted near the site.

Ground water beneath SLAPS and the ball fields has been investigated since 1979. At least 48 monitoring wells have been installed to obtain ground-water quality and piezometric surface information. The depth to ground water ranges between 1 and 7 m (3 to 23 feet) beneath the site. The piezometric surface of the upper zone shows a gentle ground-water gradient to the west and northwest towards Coldwater Creek. Interpretation of September 1997 ground-water surface measurements illustrating the gradient and flow direction of shallow ground water is shown on Figure 1-5. Shallow ground water beneath properties located north of the creek also converges to the creek. The shallow-most ground water of the unconfined upper zone is interpreted to discharge into Coldwater Creek, which divides the shallow ground-water system south and east of the creek from areas north and west of Coldwater Creek.

Potentiometric surface elevation for the lower hydrostratigraphic zone is highest at well M10-25D located at the southeastern corner of the site. The potentiometric surface contours of the lower hydrostratigraphic zone indicate a northwest to west flow direction in two radial type of patterns. The potentiometric surface of the lower zone does not appear influenced by Coldwater Creek because the "confined" ground-water potentiometric surface of the lower zone is higher than the upper zone and the creek elevations (creek elevation is about 500 feet above mean sea level [AMSL]). This condition is also supported by the absence of a potentiometric trend paralleling the creek, the apparent extension of the potentiometric surface beneath the creek, and other hydrogeologic data (presence of 3M unit). The configuration of the lower zone potentiometric surface is probably influenced by the orientation and thickness of the lower zone material in the buried channel system which trends similar to the present course of Coldwater Creek.

Ground-water levels recorded in several well clusters along the southern perimeter of SLAPS indicate a downward gradient potential. The remaining shallow/deep well pairs at the western portion of the site, in the ball fields, and along the creek exhibited an upward vertical gradient potential. An analysis of piezometric measurements of the upper and lower zones indicate that a downward gradient potential or head differential occurred beneath most of SLAPS in September 1997.

Based on available information, three main hydrostratigraphic zones which possess different ground-water flow and chemistry characteristics are interpreted to occur in the nonlithified material beneath SLAPS. The upper hydrostratigraphic zone contains stratigraphic units 1, 2, and 3T. The middle hydrostratigraphic zone at SLAPS is defined by the aquitard identified as the 3M subunit. The 3M subunit is composed of massive clay (occasionally varied) ranging in thickness from 0 feet beneath the eastern end of SLAPS and up to 26 feet beneath the western part of the site. The 3M layer has the lowest hydraulic conductivity of Unit 3. The lower hydrostratigraphic zone beneath the 3M subunit is composed of stratigraphic units 3B, 4, and 5. Wells designated with an "S" suffix monitor the upper hydrostratigraphic zone. Wells with a "D" suffix monitor the lower hydrostratigraphic zone.

As of August 1997, 32 wells penetrated the upper zone to a maximum depth of 49 feet bgs. These wells penetrate the shallow rubble and fill, the loess (clayey silt) identified as the stratigraphic unit 2, and the 3T (silty clay) unit. Several of these wells may partially penetrate the 3M unit, but none penetrate the entire 3M unit. In most cases, wells constructed in the upper hydrostratigraphic zone have their screened interval at least 10 feet below the static ground-water surface. Only eight wells (A, B, C, E, F, B53W19S, B53W18S, and B53W03S) have a screened or sand packed interval across the phreatic ground-water surface, based on September 1997 ground-water level measurements. Monitoring wells A, B, C, M13.5-8.5S, and MW13.5-8.5D at the western end of the site were closed and abandoned as part of a soil remediation effort performed in the fall of 1997. Four new piezometers (TW-1 to TW-4) were installed to a maximum depth of 20 feet bgs at the western end in September 1997 for ground-water levels. Two additional wells (F and M11-21S) were closed and abandoned in April 1998.

Sixteen wells are completed in the lower zone beneath the 3M unit. Fourteen wells are completed in the silty clay and clayey gravels of the stratigraphic units 3B and 4. Monitoring wells B53W09D and B53W11D are completed in the shale bedrock (Unit 5) beneath the eastern end of the site. No wells have been completed in the bedrock limestone. Additional wells are planned to monitor the limestone bedrock and it is likely that, with additional characterization, the limestone bedrock will be identified as being a separate hydrostratigraphic zone.

Recent studies of aquatic life indicate that the stream ecology is severely impacted. The stream has been impacted by salt, oil, antifreeze, jet fuel, and other pollutants in storm water runoff. In addition, high ammonia levels and low levels of dissolved solids have been detected downstream from a former sewage treatment plant discharge, located downstream of the site (USACE, 1987).

Recharge to the ground water occurs from precipitation, off-site inflow of ground water, and creek bed infiltration during high creek stage. Discharge may occur by seepage into Coldwater Creek during low creek stage (BNI, 1994a). The vertical ground-water flow direction varies beneath the site and is influenced by stratigraphic heterogeneity and seasonal fluctuations in recharge and evapotranspiration. The position of shallow ground-water surface tends to be lower in the summer and higher in the winter ranging from 1 m to more than 5 m below existing grade. The maximum average linear velocity of shallow ground water is calculated to be 7.8 m/yr (26 feet/yr) (BNI, 1994a).



Vegetation at SLAPS as observed in 1992 appears to have changed little since the 1979 Weston survey and is dominated by a grass-forb community that reflects past disturbances. Perennial brome grass (*Bromus* sp.) and bluegrass (*Poa* sp.) appear to be the dominant grasses. Forbs include thistle (*Cirsium arvense*), vetch (*Vicia* sp.), sunflower (*Helianthus* sp.), goldenrod (*Solidago* sp.), and ragweed (*Ambrosia* sp.). Motts of woody shrubs, including sumac (*Rhus* sp.), are present on the southern border. Cottonwoods (*Populus deltoides*) are present on the western border of the creek. Cottonwoods, maples (*Acer* sp.), and other species of deciduous trees are abundant along the creek north of SLAPS.

Song sparrows (*Melospiza melodia*), swifts, and red-winged blackbirds (*Agelaius phoeniceus*) were the most common birds observed during the May 1992 reconnaissance. Three American goldfinch (*Carduelis tristis*) were seen along the creek woodlands north of SLAPS. In addition, a Mississippi kite (*Ictinia mississippiensis*) and a red-tailed hawk (*Buteo jamaicensis*) were seen just north of SLAPS. Gopher (*Geomys* sp.) holes were numerous, and more than 10 cottontail rabbits (*Sylvilagus* sp.) were observed on the site. Squirrels (*Scirurus* sp.) were observed in the woodlands lining Coldwater Creek. Raccoon (*Procyon lotor*) tracks were observed on mud flats by the creek just north of SLAPS. A pair of mallards (*Anas platyrhynchos*) was observed on the creek approximately 91 m (300 feet) downstream from SLAPS.

Because of the poor water quality resulting from the chemical and physical pollutants in the creek, biological resources in and along Coldwater Creek are less diverse than those of similar creeks in rural areas. No significant amounts of continuous vegetation are found in the watershed, and the quality of the remaining forests is rated "marginal" (Parker and Szlemp 1987). Coldwater Creek is lined with cottonwoods, maples, elms (*Ulmus* sp.), black locust (*Robinia* sp.), box elder (*Acer negundo*), beech (*Fagus* sp.), and mulberry (*Morus* sp.). Trees intermittently shade the creek, and herbaceous vegetation is composed of vines, forbs, and grasses. The largest vegetated areas occur downstream from the airport area, closer to the mouth of Coldwater Creek.

Previous surveys identified 19 benthic and 6 fish taxa (Nash, 1982; Parker and Szlemp, 1987). Benthic organisms were dominated by tubificids and chironomids, which are tolerant of organic pollution. Fathead minnows (*Pimephales promelas*) represented 97 percent of the 221 fish collected during a survey (Parker and Szlemp, 1987). This species tolerates waters with conditions of low oxygen, high temperatures, and turbidity, which characterize much of the creek.

The worst ambient air quality and conditions for air emission control occur on summer mornings in the St. Louis area because of the pattern of strong temperature inversions at night. Inversion conditions occur during cool, clear nights under low to calm wind speeds. The resulting dense air trapped near the ground resists vertical mixing and creates poor dispersion conditions.

## **1.5.2 Nature and Extent of Contamination**

Site characterization activities and a formal remedial investigation (RI) were conducted to determine the nature and extent of contamination in soil and ground water and to characterize the geological and hydrogeological features of the St. Louis sites. Analytical results for radiological and chemical characterization surveys are summarized in the preliminary characterization reports and RI reports (BNI, 1989; BNI, 1990; BNI, 1994a; and SAIC, 1995). In addition, SLAPS and the ball fields were studied to determine their suitability as possible locations for an engineered disposal facility for waste from the downtown St. Louis site (BNI, 1994b). Radiological characterization included near-surface gamma measurements, downhole gamma logging, and analysis of over 400 soil samples for uranium-238 (U-238), radium-226 (Ra-226), thorium-232 (Th-232), and/or thorium-230 (Th-230). Surface soil samples from the ditches north and south of McDonnell Boulevard were also collected and analyzed for the same radionuclides.

The formal environmental surveillance program which had been discontinued at the end of the second quarter of calendar year 1992 was reinstated at the beginning of the third quarter in 1994 and continues to the present. Routine environmental surveillance has consisted of periodic measurement of the following: perimeter radon concentrations in the air, potential external gamma radiation exposure at the fence line, upstream and downstream concentrations of radionuclides in surface water and sediment (through 1992), upgradient and downgradient concentrations of radionuclides in ground water, and measurement of radionuclide constituents in storm water discharge from the site (since 1994).

A comprehensive ground-water and surface water sampling program was implemented at SLAPS in the summer of 1997. The proposed work to be completed was described in an abbreviated sampling plan dated September 1997 (SAIC, 1997) and was recommended by the ground-water technical working group. From mid-July to early September 1997, site ground-water monitoring wells were redeveloped to remove accumulated silt and then sampled to collect ground water for radiological and chemical analyses. Static ground-water surface levels were also measured in the shallow and deep wells (except well B53W10D). Forty-eight wells were sampled during this event by BNI. Results of the sampling program are discussed in this plan and used to define further site tasks. The United States Geological Survey (USGS) acquired surface water samples from Coldwater Creek and three of its tributaries for radiological and chemical analyses in the fall of 1997. Results of that sampling effort are summarized in Section 1.5.3.3. In addition, BNI installed a storm flow discharge monitoring weir on an outfall from SLAPS to Coldwater Creek. Further evaluation of Coldwater Creek is also being planned as a separate task order under the FUSRAP program for the various St. Louis sites.

## **1.5.3 Characterization Results**

As identified above, a number of previous investigations have been conducted at SLAPS to identify environmental impacts from radionuclides and chemicals. A summary of the characterization results for soil, ground water, and Coldwater Creek, as well as the existing baseline risk assessment summary for SLAPS is provided below.

### 1.5.3.1 Soil

#### *Radiological Results*

Radiological results for soil at SLAPS revealed an extensive area of elevated radioactivity across the site, as presented in Table 1-1, for the primary radionuclides (Ra-226, Th-230, Th-232, and U-238) associated with this site. Historical radiological soil sampling data are illustrated with depth on Figures 1-7 through 1-10. At SLAPS, radioactivity in excess of DOE 5400.5 guidelines is generally located within 1.5 m (5 feet) of the surface, but has been found at depths up to 18 feet. The ditches to the north of McDonnell Boulevard are more heavily impacted than those to the south in terms of the maximum detected activity, although ditches both to the north and south have radioactive contamination. Average concentrations in the ditches are of similar magnitude for most of the radionuclides. However, concentrations of Th-230 in the north ditches is twice that in the south ditches. The CPs are marginally contaminated with primarily Th-230 at shallow depths.

Only limited soil sampling data are available with respect to the radionuclides Actinium-227 (Ac-227) and Protactinium-231 (Pa-231). These isotopes are considered to be decay products of the primary radionuclides associated with this site, which were only analyzed during a recent interim removal conducted at the west end of SLAPS. These data are also summarized in Table 1-1. Because only a limited amount of data from a limited portion of the site are available for these radionuclides, it is inappropriate to make inferences about their relationship to the primary radionuclides or about their presence and extent on SLAPS and CPs.

#### *Chemical Results*

Table 1-2 provides the chemical data in soil analyzed from SLAPS and CPs. The location of existing soil sampling for nonradiological constituents is shown on Figure 1-6. Less extensive chemical data exists compared to radiological data. No chemical or metals data exists for properties other than SLAPS and the ball fields. The chemical data are based on 90 samples taken in 30 borings (see Figure 1-6). A number of the samples contained elevated concentrations of chemicals and metals above "typical background" levels as depicted on the figure (BNI, 1992a). True background concentrations have not yet been established for the site, and these locations may or may not be of concern. Due to the paucity of the available chemical data, it is difficult to draw conclusions regarding the nature or extent of chemical contaminants at SLAPS; however, based on these limited data, there does not appear to be a widespread occurrence of chemical contaminants at SLAPS. Three organic compounds (toluene, trans-1,2-dichloroethene, and trichloroethene) were detected in a small percentage of the borings that were analyzed for chemicals. A total of six target chemicals were detected in Toxicity Characteristic Leaching Procedure (TCLP) tests, as shown in Table 1-3 along with the TCLP limits. Mercury exceeded TCLP limits in one sample out of the 34 TCLP analyzed. The sample in which mercury exceeded the maximum allowable concentration was also the only sample in which mercury exceeded the detection limit. Selenium was found to exceed its maximum allowable concentration (1 mg/L) in one sample, which had a concentration of 1.18 mg/L. The next highest concentration was 0.411 mg/L. Based on these results, it is not anticipated that this condition will generate mixed waste. The presence of mixed waste will continue to be evaluated as more data on the chemical

contamination at SLAPS become available. Limited data exist for PCBs, herbicides, and pesticides in SLAPS soil samples.

**1.5.3.2 Ground Water** - Current ground water conditions at SLAPS were assessed following the completion of a comprehensive ground-water sampling event conducted from July to September of 1997. Results of the ground-water chemistry data acquired from site monitoring wells in the summer of 1997 were compared to USEPA-designated MCLs (October 1996) in four major categories: radionuclides, VOCs and SVOCs, metals, and inorganic constituents. The MDNR MCLs for the ground-water constituents are the same as the USEPA standards.

### *Radiological Results*

The following radioisotopes were analyzed in the collected ground-water samples: total uranium (U), actinium-227 (Ac-227), thorium-228 (Th-228), Th-230, Th-232, protactinium-231 (Pa-231), radium-226 (Ra-226), Ra-228, and lead-210. Tritium concentrations were also measured in select wells. The radioisotopes Ac-227 and Pa-231 were only tested in ground water during the summer of 1997 in 48 wells across SLAPS and CPs. Elevated total uranium concentrations above MCLs were detected in some ground-water samples submitted for SLAPS and surrounding areas. The USEPA MCL for total uranium is 20 µg/L. Detected concentrations of uranium exceeded its MCL in 11 upper zone wells, 9 of which are within the boundaries of SLAPS (see Figure 1-11). The highest concentrations of total uranium were detected in samples from the shallow wells in the western portion of SLAPS. The highest concentration was 7,330 µg/L in well B. The only off-site location which contained ground water exceeding the MCL for total uranium was well B53W06S at a concentration of 75.4 µg/L. This well is located north of SLAPS on the southern side of Coldwater Creek.

No ground-water samples analyzed for radium-226 in 1997 from SLAPS wells had concentrations exceeding its MCL of 20 pCi/L. All radium-226 concentrations reported in 1997 were less than previous analyses. The reported concentration of 33.8 pCi/L of radium-226 in well B53W11D in 1992 decreased to 0.12 pCi/L in 1997. Ground-water samples collected in 1997 from SLAPS did not contain thorium-230 concentrations exceeding 1 pCi/L. No USEPA MCL has been established for this radionuclide. All wells had lower concentrations of thorium-230 in 1997 compared to historical results. Non-detectable concentrations of actinium, protactinium, and lead-210 were reported for the 1997 baseline ground-water samples from SLAPS and CPs. The detection limits for Ac-227 and Pa-231 were 20 pCi/L and 200 pCi/L, respectively.

Tritium was detected in ground-water samples from shallow and deep wells ranging between 0.02 pCi/L and 47.10 pCi/L. Tritium values of the upper zone were consistently and significantly higher than those of the lower zone.

### *Chemical Results*

Ground water at the site was analyzed for USEPA Method 8260 priority pollutant VOCs and USEPA Method 8270 SVOCs. Three compounds--trichloroethene (TCE), pentachlorophenol (PCP), and dichloromethane (DCM)--were detected above their respective MCLs. Trichloroethene has an MCL of 5 µg/L and was detected above this level in five wells. Two of the wells are located

in the southwestern corner of SLAPS, and the other three wells are located north of McDonnell Boulevard in the ball fields. Well B53W17S, located near the western end of Khoury Road, had the highest TCE concentration (600 µg/L). The recent TCE concentration in this well is roughly 50 percent lower compared to 1992 results. The distribution of dissolved TCE appears to be limited to the upper hydrostratigraphic zone (above 37 feet in depth). The compound, 1,2-dichloroethene (1,2-DCE), a transformation compound of TCE, was detected in site ground water at several wells slightly below its MCL of 70 µg/L.

Dissolved PCP was detected in one well above its MCL of 1 µg/L. This compound was detected at an estimated concentration of 6 µg/L in well B53W14S. This well is completed in the upper zone and is located north of SLAPS in the ball fields area.

Dissolved DCM was detected above its USEPA MCL of 5 µg/L in nine wells. In eight of the nine wells, the concentration of DCM was below 25 µg/L. DCM was also detected in well M10-25D at a concentration of 610 µg/L. M10-25D is located at the south-central boundary of SLAPS. Because DCM (also known as methylene chloride) is a common laboratory contaminant, the detections may not be representative of site ground-water conditions.

Ground-water samples collected in the summer of 1997 were also analyzed for various inorganic compounds and metals. Arsenic, chromium, manganese, nickel, nitrate, and selenium were detected in some samples above their respective USEPA MCLs. Dissolved arsenic was detected in nine wells above its MCL of 50 µg/L. Elevated concentrations of arsenic ranged from 71 µg/L to 138 µg/L. The elevated arsenic concentrations were only detected in the lower hydrostratigraphic zone (Unit 4) (i.e., deeper than 57 feet bgs) beneath the western part of SLAPS, the western portion of the ball fields area, and in the deep wells north of Coldwater Creek. These arsenic concentrations are likely naturally occurring background levels in the lower zone as observed in several lower zone background wells. No concentration of arsenic above its MCL was detected in the upper hydrostratigraphic zone.

Chromium was detected in only one off-site well at a concentration above its MCL of 100 µg/L. This well is a shallow well located north of McDonnell Boulevard on the western side of Coldwater Creek. Because no elevated chromium was detected in wells on SLAPS, this metal is likely not related to site activities.

Dissolved nickel has an MCL of 100 µg/L and was detected above this level in three off-site wells located north, west, and south of SLAPS. The occurrence of this metal in local ground water is not related to SLAPS because of its estimated background concentration in ground water from site wells.

Dissolved manganese was detected in both upper and lower zone ground waters at concentrations exceeding its SMCL of 50 µg/L and estimated background values. The highest concentrations (up to 6,420 µg/L) occur in the upper zone ground water beneath the western part of SLAPS. Elevated manganese concentrations in the lower zone may be from natural sources.

Dissolved nitrate as nitrogen above its MCL of 10 mg/L was detected in 15 wells located on and surrounding SLAPS. Concentrations ranged from 11 mg/L in well D to 569 mg/L in well

M11-9. The distribution of elevated nitrates appears to be limited to the upper hydrostratigraphic zone. Elevated nitrates in the upper hydrostratigraphic zone occur beneath the western part of SLAPS and along Coldwater Creek, although other on-site wells and ball fields wells also contain nitrates exceeding 10 mg/L.

Selenium in excess of its MCL of 50 µg/L was detected in 11 wells in 1997. Seven of the wells are located on SLAPS, three wells are located north of McDonnell Boulevard in the ball fields, and one well is located along Banshee Road. Elevated selenium concentrations ranged from 129 µg/L to 4,360 µg/L. Elevated selenium occurs only in the upper hydrostratigraphic zone. The presence of this element at elevated concentrations above its estimated background value is likely the result of past SLAPS activities.

In summary, based on the 1997 ground-water sampling data, the primary PCOCs in site and nearby ground water that are interpreted to be present on-site due to past SLAPS activities are total uranium, manganese, nitrate, selenium, TCE, and 1,2-DCE. The occurrence of these ground-water PCOCs (except manganese) at significant concentrations is limited to ground water in the upper hydrostratigraphic zone.

### **1.5.3.3 Coldwater Creek - USGS Study Results**

Previous surface water and sediment quality studies of Coldwater Creek are discussed in the BRA (ANL, 1993), RI (BNI, 1994a), and FS (SAIC, 1994). To help resolve some data gaps identified in those reports, the USGS performed a seepage run and water-quality study of Coldwater Creek in the vicinity of SLAPS in the fall of 1997. The objectives of that study were to determine whether the creek was a gaining or losing stream; determine the concentrations of chemical constituents in surface water from locations upstream and downstream of SLAPS; and determine the physical, mineralogical, and chemical composition of streambed sediments upstream and downgradient of SLAPS. Results of the study were presented to the USEPA in a letter report on February 5, 1998 (USGS, 1998) and are summarized below.

Results of the seepage run investigation determined that there is no measurable diffuse inflow of ground water along Coldwater Creek from Banshee Road to the FOMOCO railroad crossing. The estimated base flow of the creek, excluding industrial inflows from the airport and two tributaries, is about 0.2 ft<sup>3</sup>/s (90 gpm). Within the study area from Banshee Road to the FOMOCO railroad crossing, three tributaries and two ground seepage areas were identified. The flow from the tributary immediately west of SLAPS was negligible (less than 0.1 gpm). The flow from each of the other two tributaries, located approximately one-quarter and one-half mile downstream of Banshee Road, ranged from 0.3 ft<sup>3</sup> and 0.6 ft<sup>3</sup>/s, respectively. One seepage area was found at the base of the SLAPS gabion wall; the other seepage area was found adjacent to the ball fields about one-half mile downstream of McDonnell Boulevard. Flow could not be measured from these two seeps.

Surface water samples were collected from eight locations on Coldwater Creek. One location was approximately one mile upstream of SLAPS prior to where Coldwater Creek goes underground to traverse the airport. The farthest downstream location was at the I-270 overpass. Water samples were also collected from two of the tributaries and from a pool at the base of the

gabion wall. Floating fuel, probably kerosene from the airport, was observed at the locations adjacent to and immediately downstream of SLAPS. Oil recovery booms were observed across the creek between McDonnell Boulevard and the airport.

Analytical results indicate that surface water in the creek has a relatively high concentration of sodium and chloride, possibly due to the use of road salts. Sulfate was detected in samples from the creek at higher concentrations than those found in ground-water samples from SLAPS. Chromium concentrations increased from 1 µg/L upstream of the airport to 54 µg/L immediately downstream of the airport. Uranium concentrations also increased from the upstream location to those collected below McDonnell Boulevard. The range of uranium concentrations detected during various sampling events was 0.7 µg/L upstream of SLAPS to 5.9 µg/L, immediately downstream of McDonnell Boulevard.

The concentration of  $\text{NO}_2+\text{NO}_3$  (total nitrite plus nitrate) downstream from the ball fields (6 mg/L) was higher than concentrations in upstream samples. Concentrations of VOCs such as PCE, TCE, and substituted benzenes and SVOCs increased substantially from below or near their detection limits in the sample upstream of the airport to several tens of micrograms per liter at sites adjacent to and downstream of SLAPS. The concentrations of VOCs further downstream, however, appeared to decrease, possibly due to the variable flow conditions at the time of sampling. Concentrations of acetone increased dramatically from less than 20 µg/L (estimated concentrations) in samples from sites above I-270 to 179 µg/L in the sample collected downstream of I-270. No organo-chlorine pesticides or polychlorinated biphenols (PCBs) were detected in the water samples.

A probable cause for the increase in U and total U concentrations in Coldwater Creek near SLAPS is the presence of a seep at the base of the gabion wall. The specific conductance values (2,500 µS/cm [microseimens per centimeter at 25 degrees Celsius]) and concentrations of alkalinity (486 mg/L as  $\text{CaCO}_3$ ),  $\text{NO}_2+\text{NO}_3$  (62 mg/L), strontium (Sr; 650 µg/L), and U (2,002 µg/L) in a sample from a pool at the base of the gabion wall were higher than those in the main stem of Coldwater Creek. Discharge from the pool into the main stem of the creek was estimated at less than 0.005 ft<sup>3</sup>/s. A field gas chromatograph (GC) scan of a sample from the pool detected 8 µg/L of TCE and 4.6 µg/L of cis-DCE (1,2-dichloroethene); these concentrations are also higher than those detected in the creek.

Seven composite streambed surface (upper 5 cm) sediment samples were collected from Coldwater Creek in the vicinity of SLAPS. The sediment samples were comprised mainly of sand-sized material (about 84 to 99 percent by weight) with smaller quantities of silt and clay. Samples collected downstream of McDonnell Boulevard generally contained a larger percentage of silt-size material than those collected upstream of McDonnell Boulevard. The sediment samples were composed mainly of calcite, dolomite, and potassium feldspar, with samples collected downstream from the airport containing larger quantities of potassium feldspar.

Concentrations of most metals, especially Cr and copper (Cu), were highest in the sample collected immediately downstream of the airport, but they did not increase downstream from SLAPS. Concentrations of U increased only slightly from 3 mg/kg in the upstream samples to between 4 and 5 mg/kg in samples collected downstream from SLAPS. All of the sediment

samples contained high concentrations of SVOCs. The highest concentrations of semi-volatile chemicals were detected in samples collected immediately downstream of the airport, but the upstream sample also had large concentrations of SVOCs. The elevated concentrations of SVOCs detected were expected because the stream sediments had an oily appearance and smelled strongly of petroleum products. Few VOCs were detected, none of which were chlorinated solvents. No organo-chlorine pesticides were detected in the streambed-sediment samples.

Each bed-sediment sample was also analyzed for an extensive suite of radionuclides in both the fine (silt and clay-size) fraction and the whole sample. This analysis was done to help determine the size-fraction where most of the radionuclides reside. Generally, the fine fraction contained higher concentrations of radionuclides than did the whole sediment. Similar to the USGS analytical data, concentrations of U increased slightly downstream from SLAPS, as did concentrations of Ra-226. Concentrations of Th-230 increased substantially downstream from SLAPS and were highest in the sample collected adjacent to the ball fields. Elevated Th-230 concentrations (more than 3 times those in the upstream sample) were detected in all samples collected downstream from SLAPS, including the sample collected downstream from I-270. No obvious trends were detected in the concentrations of other radionuclides, such as the actinides; however, detection limits were rather high for some isotopes.

#### **1.5.3.4 Risk Assessment**

Results of the baseline risk assessment (BRA) that was prepared for the St. Louis sites, including SLAPS and Coldwater Creek (ANL, 1993), are presented in Table 1-4. Receptors evaluated in the BRA were trespassers and maintenance workers at SLAPS, construction workers exposed to substances in media in impacted ditches, and recreational users of Coldwater Creek. Radiological and chemical carcinogenic risk and the potential for noncarcinogenic (systemic) effects were evaluated for these receptors. Radiological carcinogenic risks ranged from  $1.1 \times 10^{-3}$  (1 in 1,000) for the SLAPS maintenance worker to  $3 \times 10^{-6}$  (3 in 1,000,000) for recreational users of Coldwater Creek. Chemical carcinogenic risks ranged from  $4.6 \times 10^{-6}$  for recreational uses of Coldwater Creek to  $1.0 \times 10^{-6}$  for trespassers. The calculated hazard index, which represents the potential for noncarcinogenic effects, was below 1.0 for each receptor. Typically, chemical carcinogenic risks greater than  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  and a hazard index greater than 1.0 identify unacceptable levels of risk, based on regulatory guidance.

#### **1.5.3.5 Ecological Receptor Evaluation**

An ecological receptor evaluation was performed in the *Feasibility Study/Environmental Impact Statement (FS/EIS) for the St. Louis Site* (SAIC, 1994) and a qualitative assessment of ecological risks was performed in the *Baseline Risk Assessment (BRA) for Exposure to Contaminants at the St. Louis Site* (ANL, 1993). The FS/EIS reported the results of a site reconnaissance conducted in 1992 and collected information from various state and federal environmental agencies. The BRA qualitatively evaluated the potential impacts of radiological and nonradiological chemicals of concern on ecological receptors by evaluating published information. In addition, as part of the Remedial Investigation (RI) Report for the St. Louis Site



(BNI, 1994a), selected plant species were collected from SLAPS and analyzed for radiological constituents.

These reports sufficiently identify potential ecological receptors at SLAPS. These reports list flora and fauna species present on the property, evaluate the presence of sensitive habitats (e.g., wetlands), identify the locations of floodplains, and evaluate potential historical cultural and archaeological (e.g., Indian relics) resources. In accordance with USEPA's *Environmental Review Manual for CERCLA/SARA* (USEPA, 1988), however, further information on possible coastal zones (because of the proximity of the site to the Missouri and Mississippi Rivers), wilderness areas, and agricultural lands is required to be obtained from responsible state and federal agencies.

The BRA concluded that potential ecological impacts are minimal because habitats and biota at SLAPS are not: 1) unique or unusual; 2) necessary for continued propagation of key species; or 3) valued economically, recreationally, or aesthetically. These conclusions were drawn primarily because SLAPS, including the ball fields area, is situated in an industrial region. Based on these conclusions and the planned evaluation of Coldwater Creek, no ecological sampling is proposed for SLAPS in this SAP.

#### **1.5.4 Recent and Ongoing Remedial Actions**

Approximately 5,000 cubic yards of soil were removed from a narrow area adjacent to Coldwater Creek along the western boundary (West End) of SLAPS in fall of 1997. Low permeability soil material was used to backfill the excavation. Some radionuclide-impacted soil was left below 13 feet in depth in the extreme southern end of this excavation. Design and installation of two sedimentation basins has begun to control erosion across SLAPS and the ditches north and south of McDonnell Boulevard; construction of a railroad spur and loading facility on SLAPS is also underway to assist with the planned interim removal of designated soil on SLAPS.

#### **1.6 POTENTIAL CONSTITUENTS OF CONCERN**

A list of site-specific potential constituents of concern (PCOCs) and investigative action levels (IALs) for this investigation is provided in Table 1-5. The PCOCs were determined based on an evaluation of existing characterization data, knowledge of past disposal operations, and evaluation of waste characteristics of materials previously stored at SLAPS. PCOCs are considered to be those constituents which may be present at this site and which may require further remedial investigation or action at this site. If a PCOC is confirmed to require remedial action, cleanup criteria are typically established and identified in a ROD. The primary radiological PCOCs at SLAPS are uranium-238 (U-238), uranium-234 (U-234), uranium (U-235), thorium-230 (Th-230), Th-232, radium-226 (Ra-226), protactinium-231 (Pa-231), and actinium-227 (Ac-227). Other PCOCs include organic and inorganic constituents as presented in Table 1-5. IALs were identified to provide preliminary levels of environmental concern based on existing environmental or risk-related benchmarks for various media. These IALs are shown in Table 1-5 for soil and ground water.

Table 1-6 provides a site-specific list of possible "indicator" or tracer constituents. These constituents are not considered to require further investigation or remedial action but may assist in other ways with the project objectives. For example, tritium was analyzed in ground water at the site but is not considered to be a PCOC because its origin is from natural radioactive fallout in rainfall and no regulatory or risk guidelines exist for this radionuclide. Tritium, however, may allow evaluation of different ground-water hydrostratigraphic units and potential migration pathways. Inorganics such as boron, fluoride, and magnesium are not considered PCOCs, but may be used as "indicator parameters" to assist with the identification or removal of MED/AEC material.

## **1.7 SAMPLING OBJECTIVES**

The scope of this plan includes collecting various additional data from different media. The following sections define the objectives of additional site data which are needed. These objectives were developed as part of a TPP (TPP) meeting held with USACE, USEPA, and MDNR in Kansas City, Missouri, from February 25 through 27, 1998. A summary of this meeting is provided in the last appendix of this plan.

### **1.7.1 Data to Support Interim Remedial Actions (IRAs)**

Although final cleanup criteria have not been established for this site, removal of radioactively contaminated soil and off-site disposal activities have begun in accordance with an interim action Engineering Evaluation/Cost Analysis (EE/CA). Data are required to support the remedial design, define pre-excavation contaminant boundaries, determine concentrations of PCOCs at the site, and support contaminant disposal options. Data collected to support the remedial design and pre-excavation boundary delineation will focus on soil PCOCs. The approach to determining extent of impact is to divide the site into IAs, based on known former use and depositional mechanisms, and to methodically determine the constituents present and the impact boundaries. Spatial variability of the soil PCOCs will be evaluated in order to further define excavation limits prior to removal activities. Data collected will also provide information to evaluate placement of impacted soil, either as backfill at the site or for off-site disposal at a Subtitle C landfill or other appropriate site(s). Analytical results will be used to minimize the volume of soil requiring off-site disposal and will also be used for processing of wastes for off-site disposal and determining the presence or absence of characteristically hazardous constituents.

### **1.7.2 Data to Support the FS and ROD**

Additional analytical data from SLAPS will provide information on contaminant transport pathways and limits of contaminant migration. These data are essential to the completion of the ROD and the FS. Radiological PCOCs have been the primary focus of historical investigation. PCOCs which are either nonradiological inorganics or organics are not well documented. Protactinium and actinium concentrations have not been determined extensively, but will need to be defined for completion of the ROD. Additional sampling to obtain representative soil background chemical concentrations will establish baseline soil chemistry prior to contaminant impact and will assist in developing site cleanup criteria.

### **1.7.3 Data to Support a Preliminary Assessment Memorandum (PAM)**

The PAM is a supplementary data evaluation process developed during the TPP meeting to support previous risk assessment evaluations for this site. Data collected during this sampling will be used for this evaluation process in the form of a memorandum. Definition of the nature, extent, fate, and transport of PCOCs and performance of a pathways analysis form the basis for risk calculations. Data requirements to support risk calculations are dictated by two considerations: the risk exposure scenarios and the need for a statistically valid data set (capable of providing the appropriate confidence level) for each exposure pathway. Risk considerations also tend to be the primary criteria to define detection limits for the site-specific PCOCs. Radiological risks are well documented at SLAPS; however, risks to metal and chemical PCOCs are not well defined. Sampling to support the PAM will focus on collecting data specifically on organics and nonradioactive metals which may be present at the site and which have soil screening levels established. These data will be integrated with existing risk assessment data to confirm or modify existing information. This data will then be used to modify the contaminants of concern (COC) list and remedial guidelines at the site.

### **1.7.4 Health and Safety Data**

OSHA and USACE requirements necessitate the collection of appropriate data to ensure worker safety. Data provided by the original site investigation is sufficient to indicate the need to minimize dermal contact with impacted soils and water at the site. Airborne particulates could also present a threat by inhalation. Site-wide ambient air quality monitoring will be performed as an early action. Breathing zone air monitoring is also planned during field sampling investigations. Revisions to personal protective equipment (PPE) requirements will be made based on the data as it is collected. Details of the decision criteria and methodology for changing working requirements are provided in the Site Safety and Health Plan (SSHP). Screening tools (e.g., gamma surveys) will be used to roughly locate areas impacted by the PCOCs. On-site analysis using analytical quality instruments (alpha and gamma spectrometry for radionuclides) will be emphasized to demonstrate the location of the boundaries of impacted areas.

## 1.8 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. 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 USEPA's DQO process which focuses on a need/decision/action evaluation for the site. Each of these planning methodologies is used to define the minimum acceptable and necessary data set for each investigative area or media type. Once the minimum data set is defined, refinements and additions are 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 are deleted from the sampling plan. The systematic evaluation of exposure route source/receptor relationships and the decision/action evaluations result in collecting only needed data in a cost-effective and expedited manner.

### 1.8.1 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 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.

Based on current knowledge regarding past practices at SLAPS, the assumed primary sources of the PCOCs are:

1. Surface storage of empty drums and other metal-containing radioactive residues;
2. Surface storage of ores, spoils, and other process residues (such as barium cake, raffinate residues, dolomite slag, and uranium tailings);
3. Former loading and building storage areas; and
4. Other potential source areas, including a former oil dump and gas tanks.

The primary release mechanisms for the PCOCs are:

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;
7. Biological uptake; and
8. Ground-water movement/discharge.

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

Secondary release mechanisms include:

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

Potential COC 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;
4. Dermal contact with soil, surface water, sediments, or ground water; and
5. Inhalation of VOCs (from soil 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 USEPA’s guidance is presented in Section 1.8.3. The development of a comprehensive set of decision rules is presented in Section 1.8.3.5.

## 1.8.2 Adaptive Sampling and Analysis

Adaptive Sampling and Analysis is an approach that has been successfully used at a number of DOD facilities (Robbart and Johnson, 1996; and USEPA, 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 quick turnaround results, adequate data quality, and detection limits which 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 technical decision team.

## 1.8.3 Data Quality Objectives

As previously stated, the USEPA DQO process (USEPA, 1987 and 1994) was used in conjunction with the Observational Approach and Adaptive Sampling and Analysis to develop this SAP. 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.

**1.8.3.1 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 (USEPA, 1994). Information addressing these issues is summarized below.

There are three primary objectives of this site characterization, all of which concern the collection of sufficient data. One primary objective is to collect data to support interim removals planned for portions of SLAPS and the ball fields. The second primary objective is to collect data of sufficient quantity and quality to support a preliminary assessment of potential risks, if any, posed by the identified PCOCs for this site. The third objective is to collect data to support the existing assumptions which are provided in the FS and which are required for the ROD.

The problem is to identify the types, quality, and quantity of data that are needed to support these objectives (refer to Section 1.7) within the planned project schedule. A number of data acquisition techniques are planned to meet the stated objectives. Chapter 2.0 describes the various methods of data gathering and data usage to meet the investigation objectives. In addition to the data requirements, the design of the study and the sampling strategy will require that all of the necessary data be acquired through a cost-effective and efficient field program. In order to meet the anticipated schedule and complete the ROD, this sampling effort must be accomplished by mid to late 1998. A detailed schedule is provided in Chapter 9.0.

The primary organizations involved in this study and the decision process include USACE and its contractors, MDNR, and USEPA. A project organization structure, including key SAIC and USACE team members, is provided in the QAPP (SAIC, 1998a).

**1.8.3.2 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 joined 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 PCOCs directly resulting from MED/AEC activities, along with any other constituents that may be mixed with the PCOCs. (Note that it is not the purpose of this SAP to determine the COCs to be addressed; however, it is a goal to evaluate the set of PCOCs from which the COCs will be determined.)
2. For this sampling, applicable environmental guidelines, such as those developed by DOE, Nuclear Regulatory Commission (NRC), or USEPA, will be used to identify IALs in soil, air, and water. In this SAP, DOR/NRC guidance were used to derive the IALs for radionuclides in soils and sediments based on basic public dose standards (see Table 1-5). Other federal/state environmental or risk-related benchmarks for non-radionuclides will be considered to be residential and industrial criteria in soils, and MCLs or drinking water criteria in water. These IALs are also presented in Table 1-5.
3. Screening technologies will be used whenever possible to define the areal extent of the PCOCs, identify intervals for biased sampling, and define the presence and depth of fill areas. Radiological walkover surveys using high and low energy gamma detectors will initially define areas of radiological impact.
4. Sampling to ensure the safety of on-site remedial investigation workers will be addressed in the SSHP (SAIC, 1998a).

#### Principal Study Questions

The goal of this SAP is to gather the data needed to meet the stated objectives. The following is a list of principal study questions which identify key unknown conditions or unresolved issues that will be investigated during the sampling:

1. Is worker safety and public access adequately controlled?
2. What is the distribution and volume of impacted soil at the site with radiological activity levels exceeding the current remedial guidelines?

3. Are nonradiological PCOCs present in soil exceeding investigation action levels? If so, do they require remedial action?
4. Do nonradiological PCOCs present in ground water exceeding investigation action levels? If so, do they require remedial action?
5. Is adequate background data available for establishing site impacts?

### Decision Statements

This section combines the principal study questions into a decision statement that expresses a choice among actions. 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" (USEPA, 1994).

### Decision Statements for Resolving Principal Study Questions

1. Determine where the PCOCs in the various media at SLAPS exceed investigative action levels and whether they may require remedial action.
2. Identify and develop a set of criteria which ensures that all the necessary data are acquired to support risk-type assessments that will identify a cost-effective combination of remedial actions which minimizes or eliminates public exposure to the site PCOCs.
3. Identify and develop a set of criteria to determine when adequate data have been collected to assess the volume and limits for specific removals based on adaptive sampling strategies.

These decisions will be made using the data collected under this plan. 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 develop a comprehensive plan for acquiring these data.

**1.8.3.3 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 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.

### Inputs Required for Resolving the Principal Study Questions

To define the distribution and volume of impacted soil, it will be necessary to perform the following sampling activities:

1. The approximate lateral surface boundaries of radiological PCOCs will be initially delineated by performing a radiological gamma walkover survey across SLAPS using a



combination of a sodium iodide detector for detecting high energy gamma radiation and a field instrument for detecting low-energy radiation (FIDLER).

2. In-situ gamma spectroscopy will be used to determine edge effects from the gamma survey along impacted areas defined by the radiological walkover survey.
3. A passive soil gas survey will be used to determine locations of potential VOC impacts.
4. An electromagnetic geophysical survey will be performed to identify buried features and metallic features that may not have a surface expression detectable by the radiological scanning equipment.
5. In areas identified as data gaps, soil samples will be collected to confirm the surface lateral boundaries at impacted areas, and subsurface borings will be drilled for deep soil sampling to define the subsurface vertical extent of the PCOC impacts.
6. Selected samples from each IA will have total TCLP analyses performed to confirm the presence or absence of RCRA waste on-site.

To define the nature, extent, and persistence of PCOCs in ground water, it will be necessary to perform the following sampling activities:

1. Ground-water samples will be collected from existing and new monitoring wells located near and downgradient of areas where PCOCs may be concentrated in site soils. Specialized drilling methods and procedures will be followed for the installation of new wells to prevent cross-contamination of penetrated zones. To assist in determining the migration rates of PCOCs in ground water, hydraulic conductivity tests will be performed in several test pits, as well as with minimally disturbed samples, from the different stratigraphic units. These tests are described in Section 2.3.11. They allow a better understanding of site conditions and the conceptual site model. They will also assess the potential for vertical and horizontal hydraulic conditions in the uppermost hydrostratigraphic unit, especially of the loess and 3M units.

**1.8.3.4 Step 4: Define the Study Boundaries** - For purposes of site characterization, spatial boundaries of the study area have been defined as the original SLAPS former use/disposal areas and the adjacent CPs. The study area spatial boundaries include all of the potential PCOC migration pathways leaving the site (e.g., adjacent properties, air, surface water, ground water, and drainage systems).

For the purposes of this study and based on the past disposal practices at SLAPS, the site study area has been divided into 13 IAs as follows:

1. SLAPS west end remediation area.
2. Northwest corner/miscellaneous former drum storage, buildings, and metal scrap area.
3. Former SLAPS raffinate (AM-10) disposal areas and oil dump.
4. Former SLAPS barium cake (AJ-4) disposal areas.

5. Former SLAPS pitchblende raffinate (AM-7) disposal areas.
6. Former SLAPS dolomite slag dump.
7. Eastern SLAPS/non-use/storage area.
8. McDonnell Boulevard/ditch area.
9. Ball fields area.
10. Coldwater Creek and northern flood plain.
11. Boeing parking lot area.
12. Railroad right-of-way.
13. Airport authority property (south of SLAPS).

These 13 IAs are shown on Figure 1-6.

With the exception of ground water, sufficient data (defined in Chapter 2.0) from the various media (surface and subsurface soils) will be collected in each IA. Additional samples to define horizontal and vertical boundaries will be collected for each identified impacted area within each IA.

**1.8.3.5 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 five 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 1-5) across the site in air, soil, ground water, and surface water, for which IALs have been derived to identify preliminary levels of environmental concern. Other parameters of interest include the tracer/indicator parameters (see Table 1-6) which may be useful to assist in delineating or predicting areas of radioactively contaminated soil or ground water.
2. **Scale of Decision Making** - The scale used for decision making varies by decision. As stated above, the site has been subdivided into 13 IAs. The site was subdivided in this manner because it was postulated that sample populations would be relatively consistent within each IA, but might be significantly different between IAs. Each area will be addressed as a separate decision-making unit, thereby, requiring separate sample sets for each IA. IAs are listed in the preceding section.
3. **Investigative Action Levels** - The primary set of investigative action levels for the PCOCs at SLAPS to be used in this characterization are summarized in Table 1-5. Defining the horizontal and vertical boundaries of impacted soils and other media impacted at these concentrations is the primary objective of the investigation. Site-specific constituents and their IALs for soil and groundwater are provided in Table 1-5. Constituents for which USEPA soil screening levels (SSLs) could be developed also are identified in Table 1-5. Because the SSLs are derived based on site-specific conditions for specific risk pathways, they are referenced only qualitatively but may be calculated later to further evaluate potential site risks, if necessary.

4. **Developing Decision Rules** - The decision rules for each of the decisions identified. DQO Step 2 (see Section 1.8.3), are summarized below. These “if...then...” statements describe what action will be taken based on the results of the data collection.

#### Decision Rules

1. If the results from ambient air samples collected from any of the sampling locations show activity levels exceeding applicable guidelines, then USACE will recommend that worker and public access to these areas be controlled and mitigation measures be implemented; otherwise, no change in work practices will be required.
2. If the results from any of the cursory radiological surveys show any radioactivity levels exceeding applicable guidelines, then more extensive radiological surveys will be conducted to define the limits of the impacted areas causing the elevated readings, and USACE will recommend that worker and public access to these areas be controlled; otherwise, no additional surveying or change in work practices will be required.
3. If results from the walkover survey exceed threshold levels of radionuclides or chemical PCOCs (i.e., above IALs), then boundary delineation soil samples will be collected.
4. If the results of the radiological analyses from the proposed BASIC soil sampling do not adequately confirm the extent of impacted soil for removal purposes, then additional (OPTIMUM) soil samples will be collected in accordance with the Adaptive Sampling and Analysis Approach.
5. If the results of the nonradiological soil analyses confirm the presence of these constituents above the IALs, then a higher frequency or additional soil samples will be collected in accordance with the Adaptive Sampling and Analysis Approach.
6. If the results of nonradiological analyses of ground water exceed the IALs, then consideration will be given for additional ground-water monitoring/sampling and possible source identification.
7. If the results of the proposed background sampling do not allow an adequate assessment of background conditions for soil and ground water, then additional or alternate locations will be considered.

**1.8.3.6 Step 6: Specify Limits on Decision** - The investigative action levels established in Table 1-5 for the primary PCOCs will 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, boundary delineation). Typical screening limits for many of the PCOCs are provided in Table 1-7. Required site detection limits are further addressed in Section 2.3.

## Analytical Data Category

USEPA has identified two categories of analytical data that are used to meet specific data quality objectives (DQOs) for investigating and remediating potentially hazardous constituents in the environment. The two categories are "screening data" and "definitive data," which are defined as follows (USEPA, 1995):

1. **Screening data** are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with a solvent, rather than elaborate extraction/digestion and cleanup. Typically, at least 10 percent of the screening data are confirmed using the analytical methods and quality assurance/quality control (QA/QC) procedures and criteria associated with definitive data. Screening data without associated confirmation data are not considered to be data of known quality. To be acceptable, screening data must include the following: chain of custody, initial and continuing calibration, analyte identification, and analyte quantification. Streamlined QC requirements are the defining characteristic of screening data.
2. **Definitive data** are generated using rigorous analytical methods (e.g., approved USEPA reference methods). These data are analyte-specific, with confirmation of analyte identity and concentration. Methods produce tangible raw data (e.g., chromatograms, spectra, digital values) in the form of paper printouts or computer-generated electronic files. Data may be generated at the site or at an off-site location, as long as the QA/QC requirements are satisfied. For the data to be definitive, either analytical or total measurement error must be determined. QC measures for definitive data contain all of the elements associated with screening data, but also may include trip, method, and rinsate blanks; matrix spikes; performance evaluation samples; and replicate analyses for error determination.

With respect to each of the four SAP objectives, screening data will be used primarily to supply health and safety activities and during some interim removal activities. Definitive data will be used primarily for support of the FS, ROD, and PAM objectives.

## **Goals For Analytical Data Quality**

The analytical data used as inputs to the data quality objective process must be of known and sufficient quality to support the end use of the data. Analytical data of known and acceptable quality for the intended use are generated by the implementation of carefully chosen quality assurance/quality control protocols, both in the field and in the laboratory. The CLP data collection methods will not be used at SLAPS. The CLP methods are more rigorous than those needed to meet the study objectives for SLAPS, especially with respect to data reporting and validation. When necessary, other USEPA methods (e.g., SW-846) will be used to obtain the required level of data quality.

SW-846 methods have long been accepted by USEPA and other government agencies. The SW-846 methods are a compilation of guidance methods using the same type of analytical equipment that is used with the CLP methods but without many of the rigorous QA/QC documentation requirements and without a specified data validation package. Raw data quality

using both methods is similar, since the methods are very similar and instrumentation is identical. While the CLP has a more rigorous validation procedure, the QC checks and calibration for the two methods are very similar. The method detection limits (MDLs) for the SW-846 are similar to lower than the comparable CLP methods. Preservation, holding times, and extractions are the same for both methods.

Quality assurance/quality control goals are set for:

1. Each single measurement, and
2. The entire data set of which the single measurement is a part.

Each individual measurement should be precise, accurate, representative, comparable and a part of a data set that should be complete. Precision, accuracy, representativeness, comparability and completeness are often referred to by the acronym PARCC and are known as the PARCC parameters. The PARCC parameters of precision and accuracy can be quantified for a single measurement and for a complete data set. Goals for precision and accuracy can be set for a single measurement and for a complete data set comprising all the data collected during a site characterization or remedial investigation. Representativeness and comparability are not as quantifiable as precision and accuracy, although there is necessarily some overlap between the parameters of representativeness, precision and accuracy. Analytical completeness is assessed by comparing the total number of analytical results expected for a data set with the total number of usable (i.e., not "R" qualified, rejected) analytical results.

#### **Data Quality Goals for Precision and Accuracy for the Individual Measurement**

The goal for analytical precision and accuracy is that each measurement should be associated with laboratory quality control that is within limits. Quality control limits for both chemical and radiological parameters are those required by the requested analytical method. The QAPP sets forth the quality control limits required for the SLAPS investigation for radiological and chemical analyses. Matrix samples–matrix spike (MS) and matrix spike duplicate (MSD) samples–will be used to assess the effect of matrix on the measurement process.

#### **Data Quality Goals for Precision and Accuracy for the SLAPS Site Characterization Data Set**

Requirements for precision and accuracy to meet data quality goals are identified in the QAPP (SAIC, 1998) and include the following:

1. Completeness of field measurements data;
2. Completeness of laboratory data;
3. Overall data completeness (comparison of planned versus obtained data);
4. Precision of field data;
5. Precision of laboratory data;
6. Accuracy of analytical data;

7. Sensitivity; and
8. Representativeness/comparability.

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

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

Biased sampling is used to:

1. Define the maximum depth of soil PCOCs for waste volume calculations;
2. Determine whether PCOCs have migrated to ground water;
3. Determine whether radiological mixed waste is present;
4. Define the boundaries of impacted areas;
5. Define the boundaries of non-impacted areas; and
6. Provide data for preliminary risk-type evaluations.

## **2.0 FIELD INVESTIGATION APPROACH**

### **2.1 INTRODUCTION**

This section identifies the approach to field work, data quality objectives (DQOs), and specific field tasks. DQOs and field tasks were developed using the USACE TPP Guidance (July 1995). Using the TPP approach, USACE, regulators, and other stakeholders were provided an opportunity to establish data quality needs and establish priorities for field tasks. This work was initiated at a meeting held in Kansas City, Missouri, in late February 1998. At this meeting, DQOs for the site were discussed. Data collected at the site will support the feasibility study (FS), the Record of Decision (ROD), and Interim Remedial Actions (IRAs).

#### **2.1.1 Level of Quality Assurance**

Data collection at SLAPS will follow protocols established in this Sampling and Analysis Plan (SAP) and by USACE guidance (USACE, 1994). Data will be collected to support the determination of residential risk standards. The Quality Assurance Project Plan (QAPP) and the Data Management Plan (DMP), prepared as a separate document (SAIC, 1998a), will also provide quality assurance guidance.

The TPP process segregates data objectives into three main categories: Basic, Optimum, and Comprehensive. The placement of data into these categories is determined by reconciling the data needs of stakeholders, regulators, and engineering with budgets and program objectives. Field tasks identified in this SAP are limited to Basic and Optimum categories, as determined by the stakeholders.

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

#### **2.1.2 Basic Quality Data**

This data set represents the minimum acceptable environmental documentation for the site. This type of data collection is often driven by regulatory guidance regarding site characterization, risk assessment, and contaminant delineation. Data quality to meet Basic data objectives also includes data needs identified by specific stakeholders or stakeholder groups.

#### **2.1.3 Optimum Quality Data**

This data set includes additional environmental documentation which is anticipated to be required. Data of this type could be collected during an existing mobilization, thereby reducing

costs. Under the expedited site investigation approach, these data sets would be discretionary samples, which could be authorized by the Technical Team to further delineate contamination at the site.

#### **2.1.4 Comprehensive Quality Data**

Data assigned to the Comprehensive quality set lacks a clear and identified need. Although the data will support the needs of the site investigation, it is not perceived by the stakeholders to be critical to evaluation or completion of the stated goals.

## **2.2 STAGES OF INVESTIGATION**

Four major stages of investigation are defined by this SAP. These stages are:

1. Premobilization activities;
2. Site reconnaissance;
3. Data compilation and sample location selection; and
4. Intrusive sampling field activities.

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 which will follow in subsequent stages of work. For example, if a previously unknown potential disposal area is defined on air photos in Stage 1, then changes to both the site reconnaissance surveys (Stage 2), and the intrusive field sampling (Stage 4) will be made to the plan to evaluate the impact of the identified area. The four major stages are comprised of 15 work elements (tasks) described in Section 2.3. These work elements will be executed to meet the goals set forth in this plan.

In accordance with Observational and Adaptive Sampling and Analysis approaches, decision making authority remains with the on-site technical lead but can be delegated to qualified field personnel. Data is evaluated as it is collected and a decision to add or delete samples and sample locations is made, as necessary, to achieve the goal of this investigation as stated in Chapter 1.0 to obtain data of sufficient quality and quantity to meet the needs of future studies and analyses in a single field program. Contingency for additional sampling is included in the optimum or discretionary sample estimates provided in this SAP.

### **2.2.1 Stage 1: Premobilization Activities**

Stage 1 activities are performed prior to mobilization of technical personnel to the site and will focus on reviewing photographic and historical records including types of chemicals used, detailed process information, volumes of process waste and remaining residual waste, former waste disposal and removal operations, location and distribution of site utilities, current information such as land use zoning, and ecological receptors in the vicinity of the site. Data from public sources will be assembled on site geology, soil classification for the local area, regional ground-water information, background chemistry of the soils in the local area, and climatic conditions (wind directions and intensity, rainfall and temperature range). Stage 1 tasks will also include establishing a surveyed site grid and benchmarks. The grid point spacing will be staked at 50 m by



50 m using existing monuments at SLAPS. In addition, surface geophysical surveys will be performed to identify the location of underground utilities, debris, and fill areas on SLAPS.

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 will 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 included based on Stage 1 data. Selected background sampling locations may also be changed based on information collected during Stage 1 pre-mobilization activities.

### **2.2.2 Stage 2: Site Reconnaissance**

Stage 2 site reconnaissance survey activities will 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 include the following:

1. A surface electromagnetic and magnetic geophysical survey will be performed at SLAPS. Use of additional methods will be based on the results of the electromagnetic surveys. The geophysical survey will be used primarily to define the perimeter of the fill areas and to locate buried drums, scrap metal, foundations, and other objects.
2. A gamma walkover survey will be performed across SLAPS and the ditches, for the purpose of confirming areas of elevated radioactivity identified during earlier investigations and to assist in defining the areal extent of the radiological PCOCs. If these cursory surveys identify the presence of radioactivity above the values presented in Table 1-7, then high density surveys will be performed either as a continuation of Stage 2 field work or as part of the Stage 4 field program. Based on the results of the site-wide gamma walkover survey, areas of elevated gamma activity will be defined. Within these defined areas, in-situ gamma radiation measurements will be taken to help identify the lower limit of the radiological IALs. These measurements will be taken using a collimated High Purity Germanium (gamma) Spectroscopy tool. This equipment will provide quantitative, isotope-specific measurements of radionuclides present in a limited area of surface soils.
3. Locations for the on-site meteorological monitoring station and both fixed background and mobile perimeter ambient air monitoring stations will be chosen and finalized. One fixed station will be sited to establish background concentrations. The second station will be sited to monitor ambient air at the site.
4. A passive soil gas survey will be conducted over portions of the site to determine whether any VOC-source areas exist. Because elevated concentrations of TCE are present in the shallow ground water, this survey will focus on evaluating soils adjacent to ground-water detections and debris disposal areas.

5. A selective metal indicator/radiological correlation will be initiated. Soil samples will be collected at the surface (the 0- to 6-inch depth) and from the subsurface in areas having elevated thorium, radium, or uranium within each IA. These samples will be used to correlate between isotopic and one or more associated metals. Isotopic measurements will be determined at the on-site laboratory, and metal concentrations will be assessed at an off-site laboratory. If a significant correlation is found, the samples will be analyzed with a LIBS or XRF instrument, following calibration of the instruments with the indicator compound. The results will be used to determine detection capabilities of the screening tools and the applicability of each to future removal or segregation activities.
6. Background concentrations of radionuclides and non-radionuclides of concern in soil and background gamma should be determined during Stage 2. When appropriate, instrumentation and methods to be used during the field activities will also be used to measure the background conditions. Background wells, however, will be drilled, constructed, and sampled during Stage 4 for efficiency reasons.

### **2.2.3 Stage 3: Data Compilation**

Data collected from Stage 1 activities and Stage 2 field reconnaissance will be integrated and interpreted in Stage 3. Compilation and integration of the historical reviews and site-wide radiological survey, soil gas survey, and geophysical survey will be evaluated to establish the best estimate of the lateral boundaries of impacted areas. Soil or ground-water well installation and sampling locations will be adjusted based on the data from the reconnaissance surveys to provide confirmatory data on these boundaries and to define the nature and extent of the impacts to soil and ground water for this investigation.

### **2.2.4 Stage 4: Intrusive Sampling Field Activities**

For each IA, a set of shallow depth and subsurface soil samples will be taken. For IAs where known or probable impacted soils are present, a systematic approach will be used to define both the lateral and vertical boundaries of impacted soils. The purpose of this sampling is to define the vertical extent of subsurface soil PCOCs. Samples will be collected on a biased basis to define the vertical and lateral extent of PCOCs with an emphasis on defining the boundary between non-impacted and impacted soils. Fewer samples will be collected in areas where significantly elevated concentrations of PCOCs are present and in unaffected areas. These samples also will be used to identify correlations with the field screening data that were collected during Stage 2.

Selected samples will be analyzed for both radiological PCOCs and non-radionuclide constituents. At least 10 percent of the samples collected in each IA will be analyzed for nonradiological parameters to support the PAM. All samples taken for the PAM document will be analyzed by an off-site laboratory. As described elsewhere, both QA and QC samples will be collected at a frequency of five percent of the soil and ground-water samples collected.

Drilling and sampling of deep boreholes to the top of the 3M subunit will be performed as part of Stage 4 and will be conducted concurrently with soil sampling as described above. The purpose of this sampling is to define the lateral and vertical extent of PCOCs. The purpose of these

boreholes is to determine the presence and vertical distribution of soils exceeding the investigative action levels. Precautions will be taken to prevent cross-contamination of penetrated zones. All boreholes will be described for stratigraphic definition and gamma log.

Ground-water sampling will be performed during Stage 4. Existing and newly installed ground-water monitoring wells will be used to collect the ground-water samples adjacent to impacted soils, at downgradient locations, and at background locations. Details of the planned placement of new monitoring wells are presented in Section 2.3.12. The planned well locations may change if new data causes a revision to the conceptual model of site ground water. Final locations will also be reviewed by the technical working group.

Samples of waste material which could potentially be shipped to a commercial facility for disposal will be collected for full suite (VOCs, SVOCs, metals, and radiological PCOCs) analysis. Previous analyses for TCLP parameters have adequately demonstrated that characteristically hazardous wastes are not present at this site.

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

Two ambient air monitoring stations will be established and sampling conducted to establish a data correlation between the area of background and site environments. Sampling conducted will be high volume air samples for TSP and PM<sub>10</sub>, collected periodically throughout Stage 4. Units will operate one week prior to intrusive activities and one week after conclusion of Stage 4 activities. Collected samples are to be analyzed for TSP; PM<sub>10</sub>; gross alpha/beta; and metal PCOCs.

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

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

## **2.3 WORK ELEMENTS**

The following discussion provides detail on the work elements that will be used to complete the objectives of this SAP. Table 2-1 provides a summary of the Basic work elements and sampling activities which are anticipated at SLAPS. Table 2-2 provides an estimate of additional optimum sampling which may be completed during the investigations to achieve the DQOs, in accordance with the Observational and Adaptive Sampling and Analysis approaches.

### **2.3.1 Soil Gas Survey**

Halogenated organic compounds were detected in a few soil samples and in one ground-water sample from well B53W17S in the ball fields area. A passive soil gas survey is proposed

for portions of IAs 4, 5, and 9. These locations are in upgradient regions from well B53W17S (see Figure 2-1). The soil gas survey will be used as a screening tool to identify any source areas of TCE or other VOCs that were evidenced in the earlier ground-water sampling activities. Where appropriate, this passive soil gas survey will be completed prior to any additional on-site soil and ground-water sampling events in order to target soil sampling locations for VOC analyses. The results of the passive soil gas survey will be used to support the FS and the preliminary risk assessment for the PAM.

The proposed basic sampling scheme includes up to 50 passive soil gas sampling locations taken across the survey area (Figure 2-1) on a 100-foot (30 m) grid pattern. These locations will be flagged and located by geopositioning techniques for mapping and sample retrieval purposes. At each passive soil gas sampling location, an adsorbent media will be placed a few inches beneath the soil and allowed to adsorb VOCs from the soil gas for a few days. Following that period of time, the adsorbent medium will be retrieved and placed into glass vials supplied by the laboratory. The sample media will 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. 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 to better delineate the edge of a source area. Up to 50 additional (optimum) soil gas sampling locations may be needed to address these concerns.

The planned field QC samples for the 50 basic samples is 5 percent, which includes 2 duplicates and 1 blank. All soil gas samples will be given a unique sample designation as described in the QAPP (SAIC, 1998a). In addition, the location of each soil gas sample will be mapped, and any distinct observations about the sampling locations will be noted in the field logbook.

### **2.3.2 Surface 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 or IRAs. As such, geophysical techniques can provide indirect characterization of the subsurface where little information currently exists. Electromagnetic, magnetic, and potential ground-penetrating radar (GPR) surveys covering a maximum area of 10 ha (20 acres) will be performed as a Stage 2 activity to delineate the depth and perimeter of suspected fill areas or suspected waste disposal areas within the SLAPS fence and north ditches. Areas of concern will be based on the historical aerial photograph review conducted in Stage 1 and upon specific areas targeted for removal. These surveys may also provide information that may be useful to assist in identifying the types of materials contained within the fill, buried foundations, and utility corridors and conduits.

#### *Methods*

The lateral extent of the buried waste in this setting will be defined using an EM-31 and an EM-61. The EM-31 is an electromagnetic (EM) terrain conductivity tool that measures the subsurface conductivity as an operator carries the equipment across the site. The EM-31 is used to delineate lateral variations of subsurface material containing ferrous metals. The EM-31 survey

will be conducted using vertical dipole orientation, with in-phase and quadrature-phase data collected. The EM-61 is a high sensitivity metal detector with stacked antennas that are pulled or carried across the site by an operator. With the EM-61, the presence and depth of metallic construction debris can be determined.

### *Study Area Definition and Measurement Spacing*

The area enclosed by the property fence and the north ditches (see Figure 2-1) represents the area of greatest interest at the site. This area will be subjected to an initial and detailed geophysical investigation. Areas of heavy vegetation and/or potential fall hazards will not be surveyed. After brush clearing, a survey grid will be established. Potentially unsafe areas (heavy trees, debris piles, unstable slopes, mounds, and standing water) will be worked around.

The investigation will use the EM-31, EM-61, and magnetometer on north/south traverses. Traverses will be conducted at 2-meter (6.5-foot) intervals. Along each traverse, EM-31 vertical dipole and EM-61 measurements will occur approximately every 1 m (3.281 feet). Magnetometer measurements will occur continuously, with fiducial marks placed in the record every 25 m. In the event that interferences are present which cause elevated readings on all instruments, the interference will be noted and the survey will be terminated along that traverse line.

### *Procedures*

The EM-31 and EM-61 to be used at the site is manufactured by Geonics Ltd. Of Mississauga, Canada. The data for both of these units will be collected and stored digitally on a polycorder manufactured by Omnidata. Interface firmware modules are provided by Geonics for the interaction between their equipment and the polycorder.

A Geometrics cesium gradiometer will be utilized to collect the magnetic data. The data will be collected and stored in the gradiometers internal storage system.

The GPR unit to be used for this site is Subsurface Interface Radar (SIR) System-2, manufactured by Geophysical Survey Systems, Inc. (GSSI) of North Salem, New Hampshire. The choice of antenna will be dependent on site-specific conditions. A 200-megahertz (Mhz) antenna is anticipated for use at depths up to nine meters. A 500-Mhz antenna may also be used to provide greater resolution; however, the 500-Mhz antenna depth of penetration is limited to 2.5 meters (12.5 feet). A determination will be made during the preliminary method testing described below.

The presence of subsurface utilities or a metal cyclone fence at the edge of the property and other similar cultural features may cause the EM-31, EM-61, and Gradiometer to measure elevated readings. In the event the geophysical techniques identify significant interferences in areas where the fence or similar cultural interferences are present, the survey will be terminated along that traverse line. The survey will be restarted at the next planned traverse line away from the interference source.

GPR antenna and settings will be evaluated by repeatedly collecting data across a short traverse where buried features are known to exist using different settings and antenna. The setting

and antenna providing optimum penetration and resolution will be used for the site survey. GPR survey activities will not be undertaken until preliminary testing provides to SAIC and the USACE evidence that the GPR technique is effective in the SLAPS soils.

Geophysical equipment will be calibrated according to manufacturers' specifications. Calibration will occur or be verified on a daily basis. Calibration will be verified and a log will be signed by the operator certifying the equipment calibration. At this site, the EM-31, EM-61, magnetometer, and GPR will repeat, on a daily basis, a short segment of line to verify the consistency of measurements from day to day. This repeat segment may be a portion of a selected traverse.

Digitally recorded EM-31, EM-61, and magnetometer data will be downloaded to a field computer daily. The downloaded information will be examined by the equipment operator for the presence of data and a preliminary evaluation of data quality. Downloaded data will be backed up on a floppy disc or similar device before the memory in the geophysical data is erased. GPR data for each traverse will be examined in the field before beginning the next traverse. GPR data will be downloaded to a field computer on a daily basis.

Geophysical equipment operators will retain field logs identifying the data collected and the file identifiers of the data. Field maps will be maintained showing the data collection progress. In the event more than one week is required to collect the data, a weekly progress report will be prepared. The progress report will identify the type of data collected, the amount of data collected, and any significant problems identified.

The north/south geophysical survey traverses will occur along the same traverse locations. The northern and southern ends of each initial traverse location will be marked in the field with a wooden stake that contains the stake coordinate. Stakes will be placed by a Missouri-licensed surveyor on a 50-meter by 50-meter grid. In the area of the liner, the surveyor will place spray paint on the ground surface. A utility survey will also be conducted to locate buried utilities in the vicinity of geophysical survey areas.

EM-61 and GPR data collected along each traverse will have the position monitored by a hip-chain. This device is accurate within 0.2 percent of the survey distance. A differential global positioning system will be utilized for horizontal location of EM-31 data. The global positioning system is accurate to within 30 centimeters. EM-31 equipment will be recorded in point mode at the frequency of locations noted above. The GPR data fiducial markers will be placed by the operator at the frequency noted above. The EM-61, when pulled, automatically records in-line distance and data values.

The EM-31 data will be processed and presented using a recent version of the commercial software DAT-31. Data will be presented in profile form, showing in-phase and quadrature-phase data. The EM-31 data will be exported to line, distance, and value (X,Y,Z) files for mapping.

The EM-61 data will be processed and presented using a recent version of the commercial software DAT-61. Data will be presented in profile form showing upper and lower antenna response. The EM-61 data will be exported to line, distance, and value (X,Y,Z) files for mapping.

The gradiometer data will be exported to line, distance, and value (X.Y.Z) files for mapping.

X,Y,Z file data will be contoured and presented using the commercial software SURFER. The data will be inverse-distance or kreig gridded for interpretation and evaluation. Color scales will be adjusted to enhance data interpretation and presentation.

The GPR data will be plotted on thermal paper using a gray-scale plot. If significant interference is present on the data, the GPR information will be processed using commercial software RADIAN. This software will allow rubber-sheeting to the fiducial markers, data migration, transformation, frequency filtering, and color scale manipulation. Actual data processing steps will be determined after evaluation of the effectiveness of each method and the value of the processing technique.

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

### **2.3.3 Gamma Walkover Surveys**

Gamma walkover surveys will be performed within the fenced area at SLAPS (see Figure 2-1). Gamma walkover surveys will be used to identify the boundaries of radiological PCOCs. One survey will be performed using two different sodium iodide scintillation probes. These probes include a high gamma sensitivity detector with a 2-inch by 2-inch sodium iodide crystal for the detection of high energy gamma emitters and a low-energy FIDLER detector with a 5-inch diameter thin crystal for the detection of low energy gamma emitters. This sampling effort will use a global positioning radiological survey procedure. This procedure allows location and measurement data to be captured electronically. After post-processing, the system is capable of batch downloading to graphic visualization tools.

Acquisition of data will 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 the standard error of the positioning instrumentation. This demonstration should be made well before the commencement of data acquisition. Daily calibrations will also be performed at a designated location.

If the results from gamma walkover surveys show areas with activity levels exceeding two times background (see Table 1-7), then shallow soil samples will be collected to determine if the underlying soil exceeds the investigative action levels. Soil sampling is described in Section 2.3.8. This approach is needed because the gamma walkover survey will not detect radionuclide PCOCs at depth.

Following the site-wide gamma walkover surveys, in-situ gamma spectroscopy will be performed in areas of elevated gamma activity as defined by the walkover surveys. In-situ gamma spectroscopy will 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<sup>2</sup>. These measurements will be used in conjunction with the soil samples from impacted areas to define the nature and extent of isotope-specific radiological impacts at the site. Specifically, the HPGe will allow a better definition of poorly defined walkover boundaries, thereby reducing sampling and allowing better correlations between walkover data and analytical results.

#### **2.3.4 Meteorological Monitoring**

On-site meteorological monitoring is proposed with the installation and setup of an on-site meteorological station during Stage 2. Meteorological parameters to be monitored include wind speed and direction, ambient temperature, barometric pressure, precipitation, and evapotranspiration. The site-specific meteorological data will be used to correlate site conditions to local National Weather Service Stations with long-term historical data. Both site data and historical data will be used in detailed modeling of proposed remedial alternatives. The site-specific meteorological data will also be used to support environmental monitoring during future 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 during the duration of the field activities.

Monitoring protocols will be based on USEPA guidance for meteorological monitoring. A tentative location proposed for the meteorological monitoring station is shown on Figure 2-2. The final location will be field verified and finalized during Stages 1 and 2 of this investigation. The monitoring points will be surveyed or located using geopositioning techniques.

#### **2.3.5 Ambient Air Monitoring**

The RI report concluded that the potential for contaminants to become airborne could increase if the contaminated surface areas of SLAPS are disturbed during further site work or remediation. Ambient air particulate monitoring is required to verify that off-site locations are not impacted during site activities. Particulate monitoring results collected at site perimeters will be compared to areal background concentrations and applicable standards to determine compliance. Particulate monitoring includes sampling for both total suspended particulate (TSP) and particulate matter with aerodynamic diameters less than or equal to 10 micrometers (PM<sub>10</sub>). Collected samples will be analyzed for TSP, PM<sub>10</sub>, gross alpha/beta screening, and metal PCOCs. Field screening for total gross alpha/beta counts will be performed using either a Ludlum 4310 zinc scintillator detector with a 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 proposed. One fixed station will be sited to establish background concentrations. This station should be generally located upwind from the site and away from point sources of particulate and PCOCs. The second station will 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 SLAPS, proximity to other potential sources, and availability of utilities. A tentative location proposed for the fixed and on-site ambient air monitoring stations is shown on Figure 2-2. 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 will be 24-hr. high volume air samples for TSP and PM<sub>10</sub>, collected every other day throughout Stage 4. Samples collected will be analyzed for TSP, PM<sub>10</sub>, gross radiological activity, and metal PCOCs. Total gross alpha/beta will be sampled in accordance with Appendix B to the Code of Federal Register (CFR) Title 10, Part 20. Particulate sampling protocols will be based on Reference Methods presented in Appendix B and J to the CFR Title 40, Part 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. If field screening indicates IALs are exceeded, then samples will be analyzed by the on-site laboratory to further quality potential public and worker exposure risks.

### **2.3.6 Background Surveys**

By congressional directive, USACE must distinguish between MED/AEC constituents and all others. It is quite possible that other chemicals/metals may be present in non-impacted MED/AEC areas in this highly industrial area. Additional background samples will be collected for most media including surface and subsurface soils and ground water. Background air sampling is described in Section 2.3.5. In addition, background surveys will be completed for all gamma screening survey techniques including gamma walkover surveys and gamma spectroscopy. The locations of potential background soil and ground-water samples are shown on Figures 2-3 and 2-4. Adequate numbers of background samples are necessary to quantify environmental conditions unaffected by site contaminants, upgradient ground-water quality, and surrounding conditions in support of the PAM, the FS, and the ROD.

Background soil and ground-water samples will be analyzed for the complete suite of radiological and nonradiological parameters, as shown in Table 2-1. Ground-water samples will also be collected for determination of total and dissolved metals concentrations. Additionally, soil and ground-water samples will be analyzed for the indicator compounds shown in Table 2-5.

One set of QA and QC samples will be submitted for every 20 soil or ground-water samples collected. QA and QC samples will be analyzed for the same constituents as their respective media. A set of QC samples will include one duplicate, one trip blank (VOCs only), one field blank, and one rinsate blank.

It is assumed that only one surface soil type exists at the site. For each surface soil type, 12 soil samples (0 to 0.5 foot) will be collected from potential background areas based on a review of local soil types and a field inspection. The proposed background locations for soil sampling are the former Elm Grove School, Aubuchon Park, and the airport property (see Figure 2-3). Background surface soil sampling techniques will be identical to the surface soil

sampling techniques described in Section 2.3.7. Fill, if present at these locations, will be noted in the appropriate logbook(s).

Three subsurface soil samples also will be obtained from each of four borings at the background locations. Background locations for these borings will be evaluated based on known soil types. Each of the 4 soil borings will be sampled continuously with discrete samples taken from intervals with midpoints at 1, 5, 10, and 15 feet using a 3-inch-diameter split-spoon or CME sampler. Background borings will be logged by a geologist to determine the lithology of the sampled zones. All borings and surface soil sampling locations will be surveyed or located using geopositioning techniques. Background subsurface soil sampling techniques and logging procedures will be identical to the subsurface soil sampling procedures described in Section 2.3.7.

All soil samples will be field screened for organics using a PID or similar device, and for external radiation using a gamma/beta detector. Results of all field screening will be recorded in the field logbooks.

One upper zone, one lower zone, and two bedrock background wells are proposed for construction at off-site locations south of SLAPS (Figure 2-4). These background well locations are approximate and will be field-verified prior to placement. These four new wells will monitor the upper and lower zone (above and below the 3M unit), as well as the shale and limestone bedrock at hydraulically upgradient locations where soil radiological contamination has not been detected. Ground-water sampling of each new background well will be performed following well construction and development. Installation and construction details for the new background wells intersecting the upper and lower zones and bedrock are described in Section 2.3.12. This section also describes the techniques for well development prior to sampling and surveying. Proper purging and collection techniques for ground-water samples are described in Section 2.3.14.

Gamma walkover surveys should be conducted at selected background locations. Three background locations for soil areas (one from each of the background soil sampling areas identified on Figure 2-3) and one each for asphalt and concrete are proposed to be surveyed for gamma radiation using walkover techniques. Details concerning gamma walkover techniques are described in Section 2.3.3. To the extent possible, background walkover surveys will encompass an area of at least 15 meters by 15 meters (50 feet by 50 feet). Surveying or geopositioning techniques will be used to identify all background surface gamma walkover survey locations. In addition, gamma spectroscopy screening will be conducted on surface soil and subsurface soil samples where needed.

The background data acquired will be used during the site investigation in the following manner. For each media, the mean background data value for each analyte will be compared to all other data points at SLAPS. The initial designation of two times mean background will identify surface radionuclide concentrations potentially elevated above the sum of the ratios criterion as defined in DOE Order 5400.5 (DOE, 1990). For soils, the average of all samples within a soil type will be used to calculate background, provided that all depth intervals could be

statistically demonstrated to be from the same population. Otherwise, separate background values may be calculated for surface and subsurface soils.

### 2.3.7 Soil Sampling

Existing soils data from previous surface and subsurface sampling locations were evaluated for radiological and nonradiological constituents. A summary of the existing data are shown with depth on Figures 1-6 through 1-10. The evaluation of the raw data indicated that additional soil sampling is required for several reasons. The delineation of the extent of contamination (primarily radiological) is necessary in several areas for the planned Interim Remedial Actions (IRAs). Additional soil sampling data are also required in many IAs to support the PAM in the evaluation of the PCOC list (Table 1-5). This may require some soil sampling for nonradiological constituents in some IAs.

Several criteria were used to evaluate the need for additional proposed soil sampling locations. The existing data were first evaluated against the DOE 5400.5 radiological standard for samples with a Sum of Ratios (SOR) greater than one. The primary intent of this evaluation was to determine if sample locations with radiological results above the SOR criteria were bounded horizontally and vertically by samples with radiological results below the SOR criteria. For evaluation purposes, the horizontal boundary distance was established at 50 feet, while the vertical boundary depth was established at 5 feet. If soil samples above the SOR criteria were unbounded beyond these distances by soil samples below the SOR criteria, then additional soil samples were proposed. Additionally, if an existing sample location was below the SOR criteria but was not analyzed for Thorium-230, and was unbounded as described above, that location was proposed for reanalysis.

The evaluation methods described above were evaluated for every sample depth across SLAPS and CPs. The results of this evaluation was a proposed surface sampling plan and boring plan for subsurface soil samples. These proposed sampling locations are shown on Figures 2-5 and 2-6, respectively. The proposed surface soil sampling plan includes sample depths from 0 to 0.5 feet and 1 to 2 feet. The proposed boring plan includes three types of soil borings - shallow, medium, and deep. The shallow borings are advanced to 5 feet with 1 soil sample collected from the 3- to 5-foot depth. The medium borings are advanced to 10 feet with 1 soil sample collected (from the 8- to 10-foot depth). The deep borings are drilled to 20 feet deep with 2 soil samples collected (from the 13- to 15-foot and the 18- to 20-foot depth). Where multiple borings are shown at one location on Figure 2-6, 3 to 5 soil samples may be collected.

Following the evaluation of soil samples for radiological constituents, the existing data were evaluated for nonradiological constituents. Figure 1-6 shows the existing locations where subsurface soil samples were analyzed for nonradiological constituents. In addition, this figure shows where nonradiological data exceeded typical statewide "background" criteria. The proposed soil sample points for radiological constituents were evaluated and are determined to be located in areas where nonradiological constituents should be analyzed. The proposed analytical scheme for nonradiological constituents is at 10 percent of the soil sampling locations proposed for radiological constituents. Nonradiological analytical data will be reevaluated following sampling in IA-1 through IA-7 to consider its applicability in the remaining IAs. Only nonradiological constituents

are planned to be analyzed at the proposed sampling locations in IA-10 and IA-11. Nonradiological parameters include VOCs, SVOCs, pesticides, herbicides, PCBs, and metals as presented in Table 2-1 and in the QAPP (SAIC, 1998a). These locations will be targeted around previous sampling locations where nonradiological constituents were evaluated previously and from other IAs where radiological data had not been previously collected.

The protocols that will be implemented for the collection of the five types of soil samples (surface soil, shallow soil, shallow borings, medium borings, and deep borings) are described in detail in the USACE Environmental Sampling Instructions (Appendix C, EM 200-1-3). This document is presented in Appendix D. Surface soil samples will be collected using the spade-and-scoop method. The shallow soil samples will be collected using either three-inch-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 (Appendix D). The shallow, medium, and deep boring samples will be collected using a carbon or stainless-steel split-spoon sampler 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 three-inch-diameter thick wall split spoon that is split lengthwise will be used. When a boring is advanced to the point that the samples 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 five-foot increments. The split barrel sampler is used in conjunction with the hollow-stem auger rig. The four-inch-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 two-foot or four-foot long stainless-steel sample tube. The stainless-steel sample tube is fitted with a disposable, internal acetate liner and the tube is then equipped with a cutting shoe which 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.

The protocols for sample handling, preservation, tracking, and shipping are presented in both the USACE Environmental Sampling Instructions manual and the project QAPP (SAIC, 1998a). During the removal of soil from the sampling device, the order of collection for analytical parameters will be for VOCs, SVOCs, metals, and radionuclides. In general, to maintain integrity of the collected samples, there will be no headspace in the sample containers for VOCs, preservation techniques will include refrigeration and protection from light, and the sample jars will be closed as soon as possible after filling. A clean pair of new disposable gloves will be worn each time a different location is sampled and gloves will be donned immediately prior to sampling. For further minimization of cross-contamination, samples containing low and high concentrations of contaminants will 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. Decontamination procedures for sampling equipment are presented in the SSHP (SAIC, 1998h).

During the collection of soil samples and the installation of the soil borings, a logging of the soil will be completed in accordance with the USACE Logging Manual. A copy of the manual is presented in Appendix F. 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 HTRW drilling log.

Each soil sample collected will be screened in the field for the relative concentration of total VOCs and beta-gamma activity. An OVA equipped with either a PID or FID will be used to screen the soil using the one-half-hour equalization headspace technique. Calibration procedures for the OVA are presented in the QAPP (SAIC, 1998a). Each soil sample will be screened with a beta-gamma detector prior to sample handling. Calibration procedures for a simulation detector are also presented in the QAPP (SAIC, 1998a).

The radiological and nonradiological constituents analyzed for in soil samples are described in Table 2-1 and Table 2-4. These samples will be submitted for laboratory analysis. In addition to the proposed samples, one set each of QA and field QC samples will be submitted for every 20 soil samples collected. The field QC samples will include one duplicate sample, one field blank, one rinsate blank, and one trip blank (for VOCs only). The QA and field QC samples will be analyzed for the same parameters as the soil samples. Most QA and field QC sets will be analyzed for the radiological parameters without a trip blank. Approximately eight sets of QA and field QC samples will also be analyzed for nonradiological parameters along with a trip blank.

The proposed number of borings and soil samples for each IA under the Basic plan are shown in Table 2-1. Based on the results of these proposed soil samples, additional soil sampling may be required to define the limits of contamination. If the proposed sample locations indicate that radiological or nonradiological contaminants above the evaluation criteria are still present, additional samples beyond those limits would be warranted. These additional soil samples are described as Optimum activities and are summarized in Table 2-2. The estimated number of additional soil samples that may be needed under the Optimum activities are 20 percent of the proposed borings and soil sampling locations. These 166 additional soil samples could be collected from data gap locations within any of the 13 IAs. Analytical requirements for Optimum soil samples are identical to the Basic proposed soil sampling plan.

A secondary goal of the proposed soil sampling activities is to identify the extent of fill across SLAPS and the ball fields. The soil borings that penetrate through the fill material will be clearly logged to indicated the depth where native material begins. Soil sampling intervals collected from any boring that penetrates the fill material may be modified to accommodate the depth of the fill. One sample should be collected from beneath the fill into the native material. In addition, the proposed depth of any boring that penetrates the fill material may be modified accordingly. If the boring encounters the bottom of fill near the proposed limit of the boring, the boring should be continued to obtain a sample beneath the fill.

The location of all proposed borings and soil sampling points, as identified by Missouri State plane coordinates from Figures 2-4 and 2-5, will be flagged and field located using GPR prior to sampling. All borings will be logged and described by a geologist or soil scientist in accordance to the USACE Logging Manual (Appendix F).

### **2.3.8 Soil Sampling for Remedial Indicator Parameter Correlation**

The soil data generated during the soil sampling program, as presented in Section 2.3.8, will be used to determine if a nonradiological metal indicator in the soil is correlated with the presence of one or more of the radiological PCOCs. The purpose of this evaluation is to identify a metal indicator that can be tracked during remedial excavation activities to minimize and control the volume of soil excavated and to ensure that only radiological-impacted soil is excavated. The use of a metal indicator could allow for collection of more samples on a tighter pattern. This could reduce the amount of soil needing remediation. In addition, turnaround times for metal screening are much faster than radiological testing. Samples will be selected for this evaluation to cover the anticipated concentration range of IALs expected for the radiological PCOCs. If metal indicator parameters are found to be effective, some confirmatory radiological samples will also be collected.

The first phase of the indicator parameter correlation evaluation involves the statistical analysis of the metals and radiological data collected during the soil sampling program. The second phase of the evaluation involves the analysis of collected soil samples using the portable XRF unit to determine its applicability and detection capabilities.

During the first step in the evaluation, the concentrations of individual common metals (including the TAL metals) from 25 soil samples will be compared to the concentration of each radiological compound through linear and non-linear regression analyses. The soil samples will be collected during the soil sampling program and will be collected from throughout the IAs. The regression analyses will establish if a positive correlation is present between any of the radiological compounds and any of the soil metals. If a positive correlation does exist, then the correlation evaluation will proceed to the second step. If a significant correlation cannot be established between the radiological compounds and the soil metals, the correlation evaluation will be completed at this point.

The second step in the correlation evaluation involves the calibration and analysis of soil samples for the indicator parameter(s) using a portable XRF unit. The 25 soil samples that were analyzed for the common metals will be retained after the laboratory analyses are completed. These 25 samples will be analyzed with the portable XRF unit for the metal(s) that most closely correlates with one or more of the radiological compounds. The results of the XRF analyses for the soil metal will be statistically compared to the laboratory analysis of the soil metals to determine the accuracy of the analyses. Prior to using the XRF unit, the unit will be calibrated using site-specific soil samples with known "spiked" metal concentrations.

### **2.3.9 Storm Water Sampling**

Storm water runoff from SLAPS to Coldwater Creek will be evaluated. BNI has installed a weir on the drainage ditch near the northwestern corner of SLAPS. To evaluate the quality of

storm water being discharged from the site to the creek, surface water, when present, will be collected from the weir or outfall of the planned sedimentation basin. Samples will be analyzed for radiological and nonradiological PCOCs (including total and dissolved metals), total suspended solids (TSS), total dissolved solids (TDS), alkalinity, hardness, sulfate, nitrate, nitrite, ammonia, and chloride. The samples will be collected during or immediately following a significant rainfall, defined as 0.1 inches of precipitation (in 24 hours or less). At least 72 hours will be required between storm events, and sampling will occur within one hour after 0.1 inches of rain has been recorded by the on-site gauge or local weather station. Four such events are planned (providing that those events occur while field personnel are on-site and flow is sufficient for measurement and sampling).

The samples will be collected directly into appropriate sample bottles that have been pre-preserved or will be preserved immediately following collection. Automatic samplers will be considered for installation. Sample collection methods will be performed in accordance with the instructions for surface water provided in Appendix D. Filtering of the sample, if required, will be performed in the field in accordance with the instructions provided in Appendix E. During one of the sampling events, a duplicate sample will be collected. A trip blank will accompany each shipment containing samples to be analyzed for VOCs. The sample bottles will be kept cool and shipped in a cooler with ice to a laboratory via overnight carrier. All sampling procedures and paperwork will be performed in accordance with the site-specific QAPP (SAIC, 1998a) and the SSHP (SAIC, 1998b).

Also collected at the time of sampling for screening purposes will be field measurements of the height of water over the weir, pH, conductivity, temperature, turbidity, and dissolved oxygen. If a rain event does not produce enough precipitation to cause flow over the weir, then a sample will not be collected.

### **2.3.10 Sampling of Waste Materials for Commercial Disposal**

It has been proposed that excavation and off-site disposal of soils found in "hot spots" of SLAPS may occur in the near future. These soils may also contain nonradiological constituents or debris and be classified as mixed wastes. Once the remedial areas are identified, several representative samples of these wastes will need to be collected to characterize them for off-site disposal. Samples of IDW such as soil/rock cuttings and decontamination fluids will also require sampling and analysis for waste characterization. These wastes will be shipped to a designated off-site disposal facility, as necessary.

A total of four representative samples of the waste material, comprised of impacted soil, and up to ten samples of IDWs, comprised of drill cuttings and decontamination water, will be collected for characterization testing. The exact number of samples is dependent on the number of proposed areas of excavation and method of IDW handling. A portion of these samples will 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

#### 4. Soil pH / paint filter liquids test

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

1. Particle size (12", 4", 1", 1/4", 1/40", 1/200")
2. Density
3. Moisture content (ASTM D-698)
4. Ignitability
5. Reactivity

The proposed waste sampling procedures involve collecting grab samples for volatile organic constituents and composite samples for the other constituents. Several soil borings will be completed within each proposed remedial area. Radiological screening will be conducted to confirm the depths from which samples are taken. Grab samples for organics analyses will be collected directly from the sampling tool, while the remaining material will be placed into a stainless steel bowl for compositing with soil from other borings. Soil from up to 4 borings will be composited for each disposal characterization sample. Sample collection will be in accordance with the sampling methods presented in Section 2.3.8 and sample handling will be conducted in accordance with the project QAPP (SAIC, 1998a).

If additional discrete areas of soil for off-site disposal are identified at the site, additional characterization samples will be necessary. Two additional characterization samples are proposed at discretionary locations. If debris materials are encountered within the areas targeted for off-site disposal, swipe testing of the debris will also be required in accordance with RCRA guidelines. Tables 2-1 and 2-2 present a summary of the sampling and analyses work scope for waste characterization and IDW.

#### 2.3.11 Sampling for Determination of Geotechnical Properties

To adequately determine the mechanisms that control contaminant transport and attenuation at SLAPS, it is necessary to identify the physical and chemical properties of the unconsolidated deposits in Units 1 through 4. At three new lower zone ground-water well locations (10, 11, and 12) (Figure 2-7), core-like recovery will extract a continuous record of substrate to the top of bedrock. The substrate at each 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 the USACE Logging Manual presented in Appendix F. A separate representative sample of soil/sediment core material from each identifiable stratigraphic unit (1, 2, 3T, 3M, 3B, and 4), if present at each well location, will be collected for laboratory analysis. Geotechnical determinations will include: porosity, permeability, hydraulic conductivity (hysteresis curves), percent moisture, bulk density, total organic carbon, and particle size. Chemical determinations will include the full suite of radionuclides, metals, anions, pH, Eh, and specific conductance. A summary of the geotechnical and analytical parameters and methods is provided in Table 2-1. The results of physical testing will identify the transmissive character of each identifiable unit or member, and the chemical



results will make it possible to determine the composition of in-situ materials. This data will be used to assist in contaminant migration modeling and to determine hydraulic characteristics of each unit.

This phase of the investigation will confirm the local stratigraphy at each new well location and provide a screen for hydraulic and chemical indicators that influence ground-water flow and contaminant transport or attenuation. It is assumed that six stratigraphic members will be present at all three well locations. A total of 18 samples for both physical and chemical analyses will be necessary to adequately characterize in-situ conditions. QA and field QC procedures for this phase also provides a five percent sampling overlap. ASTM, USEPA, and field SOPs will be followed. In addition, for the geotechnical parameters, the applicable sections of the USACE Engineering and Design Soil Sampling Manual (USACE, 1996) will be used as guidance.

Additional testing will be conducted on the top of Unit 2. This dense loess deposit beneath the fill (Unit 1) is interpreted to limit the rate of downward migration and infiltration of precipitation. The rate of recharge to the ground water is believed to be partially controlled by the significant change in vertical conductivity that occurs between the surficial fill and the underlying natural loess. To evaluate infiltration that is transmitted through the loess to the zone of saturation, a series of falling head saturated hydraulic conductivity tests will be conducted. Procedures are shown in detail in Appendix B. At one off-site location in non-impacted soil, a test pit will be excavated into the top of the loess deposit. Three-inch-diameter PVC casing will be set and backfilled in the pit. The PVC casing will then be repeatedly filled with water until a constant rate of falling head is determined. A hydraulic conductivity specific to the loess deposit will be calculated from the test results and used to determine areal recharge to the shallow ground water at SLAPS.

### **2.3.12 New Monitoring Well Installation, Development, and Surveying**

Anticipated locations for 17 new ground-water monitoring locations are shown on Figures 2-7 and 2-8. These planned locations will help define background chemistry parameters, further define the impacts of radionuclide, organic, and inorganic constituents to the ground water, and provide for additional points for compliance monitoring. This type of information is necessary to address ground-water issues of the upcoming FS. The planned locations are for planning purposes only, and the locations may be modified depending on ongoing soil and ground-water analysis and results of other planned activities described in this plan. Input from the ground-water technical working group will also be solicited prior to finalization of new well locations. Background wells may also be installed downgradient of SLAPS at proper locations.

Of the 17 planned wells, 10 wells will be installed to monitor the shallow ground water that occurs within the upper hydrostratigraphic unit (Units 2 and 3T). These wells will have a total depth of approximately 20 to 25 feet with a 10-foot screened interval. Two of the shallow wells will be placed near existing well B53W06S along the southern side of Coldwater Creek. The depth of these wells is estimated at 15 feet in order to monitor the top of ground water. Three additional wells will be installed to monitor the lower hydrostratigraphic zone (unit 4) that occurs below the key aquitard layer (3M unit). These deep wells will have an anticipated depth of between 75 and

90 feet bgs, and will be drilled to the top of bedrock. Further information about the extent and thickness of the 3M unit will be acquired during the installation of these lower zone wells. The final two wells will be installed in the limestone and shale bedrock to help identify background ground-water chemistry. The rationale for the placement of each well is discussed below:

1. **Wells 1 and 2** - These shallow monitoring wells located in the IA-2 and IA-3 will assist to define the current western extent of dissolved VOCs and uranium in the ground water.
2. **Well 3** - This shallow well will be located along the northern boundary of SLAPS and will identify dissolved constituents in the upper zone ground water of this area. It may also serve as a property boundary compliance well in the future.
3. **Well 4** - This shallow well located north of McDonnell Road will provide better definition of the northern extent of dissolved VOCs and uranium. Existing nearby wells are completed in the deeper portion of the upper hydrostratigraphic unit.
4. **Well 5** - This shallow monitoring well will monitor any migration of radionuclides or VOCs to the western side of Coldwater Creek or the presence of off-site impacts.
5. **Well 6** - This shallow monitoring well located south of Banshee Road on airport authority property will be used as an upgradient background well for the upper hydrostratigraphic zone.
6. **Wells 7 and 8** - These shallow monitoring wells located north of McDonnell Boulevard will help to define the extent and possible source area of dissolved TCE previously identified in well B53W17S. Construction of the new wells will monitor the same hydrostratigraphic interval as in B53W17S.
7. **Well 9** - This shallow monitoring well is located between existing well E and closed well F in IA-5. The placement of this well will better define the extent of uranium in the upper zone ground water beneath the east end of SLAPS.
8. **Well 10** - This deep well constructed near new well 5 on the western side of Coldwater Creek will provide an additional piezometric measurement point and provide additional data on the distribution of chemical contaminants in Unit 4.
9. **Well 11** - This deep well will be sited south of Banshee Road (on airport authority property) to represent a background monitoring point in the lower hydrostratigraphic zone (Unit 4). It will be part of a well cluster.
10. **Well 12** - This deep well is planned for IA-2 along the northern property boundary near new well 3. It will be the only well to monitor the piezometric surface and distribution of PCOCs in the lower zone (Unit 4) beneath this part of SLAPS.
11. **Well 13** - This bedrock well will be sited south of Banshee Road on airport authority property near new wells 6 and 11. It will be constructed to identify the stratigraphy and background ground-water chemistry of the limestone bedrock (Unit 6).

12. **Well 14** - This deep well will be located south of SLAPS (on airport authority property) to monitor background ground-water chemistry in the shale bedrock (Unit 5).
13. **Well 15** - This shallow well will be installed approximately 100 feet upgradient of existing well B53W06S to monitor the extent of dissolved uranium in the upper zone (Unit 2) of this area. The decision to install this well will also be based on the results of the resampling of existing well 6S.
14. **Wells 16 and 17** - These two wells will be located adjacent to Coldwater Creek to monitor ground-water quality that may be discharged into the creek. The occurrence of dissolved uranium in the uppermost shallow ground water is of particular interest and will be confirmed in existing well 6S prior to the installation of these two wells.

The drilling and sampling of subsurface materials and the installation of ground-water monitoring wells at SLAPS and CPs will be completed in accordance to protocol and specifications of USACE Logging Manual and Manual 1110-1-4000 (August 1994). A copy of these manuals are in Appendices F and G, respectively. The "Monitor Well Design, Installation, and Documentation" manual (August 1994) provides the basic elements for consideration for monitoring well work such as drilling operations, borehole logging, well installation, and other elements. Requirements of the MDNR regarding well drilling, installation, and construction (RSM.256.600-640 and 10CRS23) will also be followed as applicable for the installation of monitoring wells at SLAPS. The soil/rock cutting and fluids produced by the drilling and installation of new wells will be managed as IDW.

In the upper zone boreholes, sampling work will include the acquisition of continuous split-spoon samples of the nonlithified sediments to total depth. Soil samples will be lithologically described and archived for potential analysis or geotechnical evaluation. In the new lower zone boreholes, soil samples will be acquired using a split-spoon sampler in the upper 20 feet as done for the upper zone boreholes. From a depth of 20 feet or the top of bedrock, the subsurface material will be continuously cored to obtain a 2- to 3-inch-diameter core of the material (see Section 2.3.11). Each split-spoon sample and core will be described by a geologist or soil scientist in accordance to protocols of the USACE Logging Manual (Appendix F) and will be screened with a PID/FID.

The wells completed in the nonlithified deposits (wells 1 to 12, 15, 16, and 17) will be constructed using two-inch-diameter PVC screen and riser pipe (Figure 2-9). The use of PVC will be suitable for the expected concentrations of VOCs, inorganics, metals, and radionuclides. The screen will be 10 feet in length (except in new shallow wells such as 16 and 17, which will be 5 feet), and the screen slot size will be 0.010 inch. The screen of a new shallow well will be placed to intercept the seasonal variation of the ground-water table. These wells will be installed in a minimum six-inch-diameter borehole made by using cable-tool or hollow-stem augering methods. The screened intervals will be packed with an appropriate-sized sand (Morie No. 0 sand or equivalent) by use of a tremie pipe. A minimum three-foot bentonite seal will be placed on the sand pack. Bentonite pellets will be used to form the seal below the water table and granular bentonite will be used for seals above the water table. A cement/bentonite grout will be placed from the bentonite seal to surface. A side-discharging tremie pipe will be used for grout placement. A protective steel casing with a locking cap will be installed on each well. The drilling and

installation procedures and materials for these wells will comply with the requirements of Manual EM-1110-1-4000 (Chapters 3, 4, 5, and 7).

The well installation program will also include the placement of two monitoring wells into the bedrock. The wells are being installed to acquire information about the bedrock stratigraphy and collect data on background ground-water chemistry in the two types of bedrock (limestone and shale) near SLAPS. One bedrock well will be drilled into the limestone bedrock, southwest of SLAPS. This well, designated as new well 13, is anticipated to be sited on the airport authority property, south of Banshee Road. Total depth of the well is anticipated to be approximately 150 feet bgs. The depth to bedrock at this proposed location is estimated at about 85 feet. The nonlithified deposits above bedrock will be drilled using a hollow-stem auger or cable-tool methods. Drilling in the bedrock will be accomplished by rock coring and/or air percussion methods. Steel casing (4- or 6-inch-diameter) will be placed and grouted in the borehole through the unconsolidated deposits and at least 10 feet of competent limestone bedrock. The grout will consist of a Portland Type II cement slurry with 5 to 10 percent bentonite powder. After setting of the grout, further drilling of a four- or six-inch-diameter borehole will be done into the limestone. Drilling will proceed to a depth of 150 feet, or deeper, if additional ground-water yield is necessary for ground-water monitoring purposes. A water yield of at least three gpm is desired from the open-hole bedrock interval. A construction schematic of the planned open-hole bedrock well is provided on Figure 2-10.

The second bedrock well (new well 14) will be located south of existing well B53W15S on airport authority property, and will be constructed to monitor the shale bedrock near the eastern part of SLAPS. The depth to bedrock is estimated at 45 feet bgs and the shale unit is approximately 40 feet thick. Anticipated depth of the new well is 80 to 85 feet. The well will be constructed by the same drilling, casing, and construction methods described for new well 13. The steel casing will be set and grouted at a depth of about 55 feet, 10 feet into the shale bedrock. If the bedrock of this well or of new well 13 is incompetent, the wells may be constructed using PVC screen and casing.

Well development will be completed on the new wells in accordance to USACE Manual EM 1110-1-4000 protocol (Chapter 6), which is included in Appendix G. Well development will be done after the grout around a 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 yield, and restore hydraulic conductivity after its installation. The well development process will 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; air cannot be used as part of the development process. The volume of added water (if any) will be recorded and will be removed from the well. The development process will be completed when the turbidity of the well is as low as possible (below 50 NTUs) and minimal sediment (less than 0.1 foot) 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 will be temporarily containerized for later disposal on SLAPS.

At the completion of monitoring well construction activities, each new well will be surveyed for horizontal and vertical control in accordance to EM 1110-1-4000 protocol (Chapter 9) (Appendix G). 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. Some control checks will be made to several existing wells. The well location will also be established in the x,y plane relative to the existing state plane coordinate system. Vertical measurements will be made to the nearest 0.01 foot, and horizontal measurements will be taken to the nearest 1 foot. 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.

### **2.3.13 Downhole Logging**

Borehole geophysics will be performed in all the new boreholes prior to well development. Borehole logs to be obtained will be induction (electrical conductivity) and natural gamma logs. The purpose of the logs will be to provide the following:

1. The induction log will provide electrical conductivity data for the site stratigraphy. If there is a sufficient contrast in the electrical conductivity of the subsurface units, a determination as to the effectiveness of electrical imaging as a tool to map the 3M unit can be made after the first several boreholes have been logged. Induction can only be used in open or plastic-cased wells.
2. 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 or plastic- and metal-cased wells.

Boreholes will be logged according to ASTM standard D 5753-5 and USACE EM 1110-1-1802 for planning and conducting borehole geophysical logging.

### **2.3.14 Ground-Water Sampling and Analyses**

Several ground-water sampling events have been performed previously at SLAPS. Many of these previous sampling events have focused on the presence of radionuclides. Although a comprehensive sampling event was performed in the summer of 1997, baseline chemical sampling establishing the concentration trends for inorganic and organic chemicals is also needed to determine potential risks and remedial issues to be addressed in the upcoming FS. Two additional sampling events are planned in order to establish baseline chemistry concentrations and better identify the extent of PCOCs in ground water beneath SLAPS and CPs. These PCOCs include radionuclides, organics, and metals which are or may be related to site activities. Some other parameters such as tritium, carbon-14, and anions/cations are being analyzed as ground-water chemistry indicators to distinguish different ground-water zones.

The first ground-water sampling event will be performed prior to the installation of any new monitoring wells. For this initial event, ground-water samples will be collected from 24 existing

monitoring wells at SLAPS and the surrounding area. Results of this sampling effort will be used to verify the findings of the 1997 ground-water sampling event and for the siting of the planned new monitoring wells. Wells anticipated to be sampled for this first event are as follows: D. E. M10-8S, M10-8D, M10-25S, M10-25D, M15-15S, M15-15D, B53W01S, B53W01D, B53W03S, B53W06S, B53W06D, B53W07S, B53W07D, B53W09S, B53W10S, B53W10D, B53W12S, B53W13S, B53W17S, B53W18S, B53W19S, and B53W20S. The second sampling event will be conducted after the installation and development of the new monitoring wells. Ground-water samples are planned to be acquired from the 17 new wells and the same 24 existing wells during the second sampling event. The final selection of wells to be sampled will be reviewed and approved by the ground-water technical working group.

Ground-water samples acquired from all locations will be analyzed for the analytes listed in Table 2-5 using the methods and detection limits specified in the QAPP (SAIC, 1998a). Results will be reported for both filtered (0.45  $\mu\text{m}$ ) and unfiltered samples from each sampled location. A full suite of analyses will be performed on all unfiltered samples. All filtered samples will be analyzed for metals and radionuclides. The filtration of ground-water samples will be completed in the field prior to preservation in accordance to USACE protocol (Appendix E). Off-site laboratory analytical analysis of the acquired ground-water samples will be provided at the confirmatory level of documentation. The analytical protocol used for both planned sampling events will follow the Abbreviated Sampling Plan (dated September 1997), Appendix C of EM 200-1-3 (Appendix D), and the project QAPP.

Ground-water sampling and sample analyses tasks will follow EM 200-1-3, Appendix C, and Appendix E (USACE, 1994). These guidelines are presented in Appendices D and E of this plan. Collection of ground-water samples from monitoring wells will be accomplished in three general steps: 1) well purging; 2) measurement of field parameters; and 3) ground-water sample collection. Monitoring wells will be purged and sampled from areas suspected to be least contaminated to areas suspected to be the most contaminated. Ground-water levels in each of the wells will be measured with an electronic water level indicator on a single day prior to ground-water purging and sampling. The measurement will be made to the nearest 0.01 foot 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 to  $\pm 0.01$  foot. The well will then be sounded to determine the depth to the bottom of the well. The measured depth will be compared to its constructed depth to determine the necessary water purge volume.

Purging and sampling of monitoring wells will be accomplished using a two-inch-diameter submersible pump or similar equipment. The inlet of the pump or surface pump tubing will be placed at the midpoint of the water column. This level will be adjusted for wells where the static water level is within the well screen.

Micro-purging techniques will be employed in all wells to minimize the volume of purge water, disturbance of the aquifer, and samples. The field parameters, pH, conductivity, temperature, dissolved oxygen, and turbidity will be monitored during micro-purging. The purge rate will 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 0.5 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 units; temperature - within 0.5 degrees; and other parameters - within 5 percent. The methods of the field parameters are given in Table 2-5. The anticipated purge volume for stabilization is at least two wells 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 will be collected at least 24 hours later. The ground-water sample volume obtained initially will be used for laboratory chemical testing. All ground-water samples will be transferred directly into laboratory sample containers from the pump tubing. The portion of the sample designated for volatile organic analysis will be transferred into laboratory sample containers first, followed by other types of chemical analyses. Sample containers designated for volatile organic analysis will be filled so that no headspace is present in the containers. Immediately after 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.

Purging and sampling equipment will be decontaminated before use and between sampling locations/intervals to prevent the potential for cross-contamination of samples. The decontamination procedure for this equipment that is in contact with the sample is presented in the SSHP (SAIC, 1998b).

Generated water from purging of all wells will be discharged onto the ground at a designated location on the SLAPS property. Decontamination water from ground-water sampling activities will be containerized for later analysis and disposal as IDW.

### 3.0 SAMPLE HANDLING, PACKAGING, AND SHIPPING

Sample handling, packaging, and shipping practices will be conducted in accordance with established SAIC procedures, which are consistent with USACE EM 200-1-3 Guidance (see Appendix C). Samples shall be handled and documented using the sample custody and labeling methodology described in the QAPP (SAIC, 1998a). The SAIC sample packaging and shipping requirements are described in the Field Technical Procedure (FTP) 650 titled "Packaging and Shipping of Environmental Field Samples" (SAIC, 1996). This FTP is provided in Appendix C. Various samples for on-site and off-site analyses will be shipped to and analyzed by the laboratories identified in the QAPP (SAIC, 1998a).

All samples collected from SLAPS and the CPs under this SAP will have a unique sample station location identification. The numbering system is based on USACE guidelines and does not duplicate previous sample identifiers used at the site. The proposed numbering system is provided in the QAPP (SAIC, 1998a).



#### 4.0 DECONTAMINATION

Decontamination procedures vary depending upon the method of collection and the parameters for which samples will be analyzed. Decontamination will be conducted in accordance with the FTP-400 "Equipment Decontamination" (SAIC, 1996) and FT-405 "Cleaning and Decontaminating Sample Containers and Sampling Equipment" (SAIC, 1996) presented in Appendix C. Other decontamination procedures, especially those for personnel decontamination, are identified in the SSHP (SAIC, 1998a).

## 5.0 HANDLING OF INVESTIGATION-DERIVED WASTE

-All waste generated during field activities will be handled in bulk or drummed at the site for future disposal by USACE. Efforts throughout the field program will be made to minimize not only the volume of waste derived from sampling and decontamination procedures. Prior to disposal, personal protective equipment (PPE) will be scanned on-site using a hand-held alpha and beta/gamma screening instruments to segregate radiological waste from clean waste.

Disposal of IDWs will be shipped to a commercial disposal facility, as necessary. Efforts to dispose of IDW in bulk, along with other wastes which may be generated during interim removal actions, will be encouraged.

## 6.0 QUALITY ASSURANCE (QA) PROJECT PLAN

-SAIC has prepared a "Quality Assurance Project Plan" (QAPP) for the St. Louis Airport Site and Contiguous Properties (SAIC, 1998a). The QAPP presents the organization, objectives, functional activities, and specific QA/QC activities associated with this SAP for the SLAPS and CP investigations. It describes the specific protocols that will be followed for sampling, sample handling and storage, chain of custody, and laboratory analysis. The QAPP also presents details regarding DQOs for the project, sampling and preservation procedures for samples collected in the field, field and sample documentation, sample packaging and shipping, and laboratory analytical procedures for all media sampled. Analytical activities and methodologies associated with chemical testing of QA split samples to be performed by the government laboratory assigned to this project by the USACE are not addressed within the QAPP. Components of the QAPP include the following:

1. Project organization and responsibilities;
2. DQOs;
3. Sampling locations and procedures;
4. Sample custody and holding times;
5. Analytical procedures;
6. Calibration procedures and frequency;
7. Internal QC checks;
8. Calculation of data quality indicators;
9. Corrective actions;
10. Data reduction, validation, and reporting;
11. Preventative maintenance procedures;
12. Performance and system audits; and
13. QA reports to management.

## 7.0 HEALTH AND SAFETY

All field operations will be performed under the guidance and direction of an on-site Health and Safety Representative who will ensure that at a minimum the health and safety requirements outlined in the SSHP for activities at SLAPS and CPs prepared by SAIC (1998b) are implemented. The SSHP was developed in accordance with Appendix B of ER 385-1-92 (USACE, 1994) to meet the regulatory requirements of 29 CFR 1910.120 hazardous waste operations. Hazards of particular concern at SLAPS that are described in the SSHP are in the following categories:

1. Radiological hazards;
2. Chemical hazards;
3. Electrical hazards;
4. Biological hazards; and
5. Physical hazards.

The SSHP also identifies responsible personnel, required training for working on-site, personal protective equipment, medical surveillance requirements, monitoring requirements, site control measures, decontamination procedures, contingency plans, and other information necessary to protect worker safety depending on the activities planned for the site.

## **8.0 DATA ACQUISITION, MANAGEMENT, AND ANALYSIS REQUIREMENTS**

A Data Management Plan (DMP) for activities and procedures at SLAPS is included in Appendix B of the QAPP (SAIC, 1998a). The DMP presents the process used for the planning, collection, tracking, verification, validation, analysis, presentation, and storage of site characterization data. The plan identifies required data documentation materials and procedures, as well as project file requirements. The plan also provides the reporting requirements for presenting the raw data and conclusions of the investigation.

## **10.0 BACKGROUND SOIL SAMPLING AND ANALYSIS AT THE ST. LOUIS DOWNTOWN SITE**

The scope of this project includes collecting background soil samples near SLDS. The detailed scope of work and associated health and safety procedures for these activities are provided in Appendix H. The objectives for this sampling were developed as part of a TPP meeting held with USACE, USEPA, and MDNR in St. Louis, Missouri, on March 25, 1998.

## 11.0 REFERENCES AND BIBLIOGRAPHY

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# FIGURES

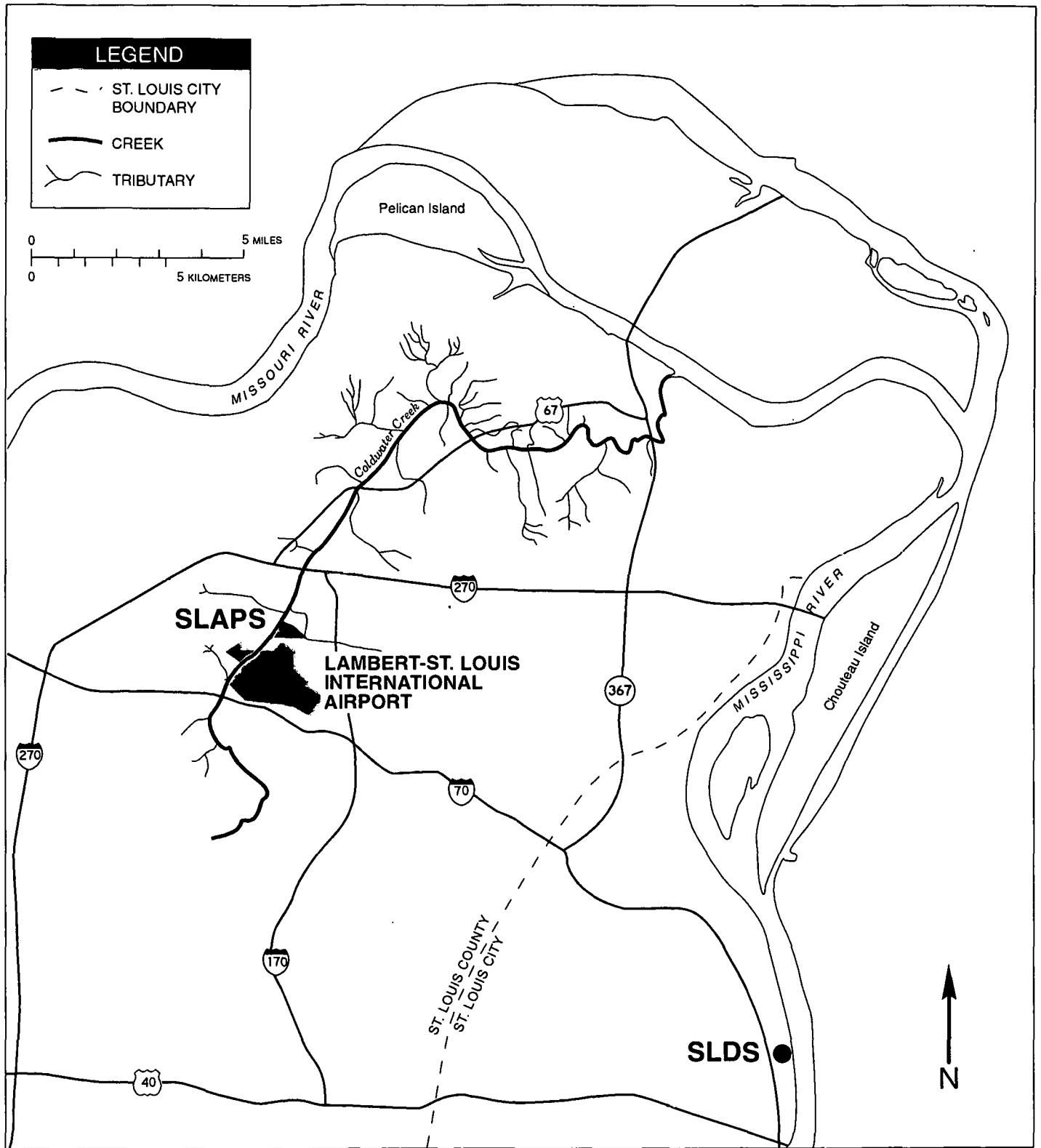


Figure 1-1. SLAPS Location Map

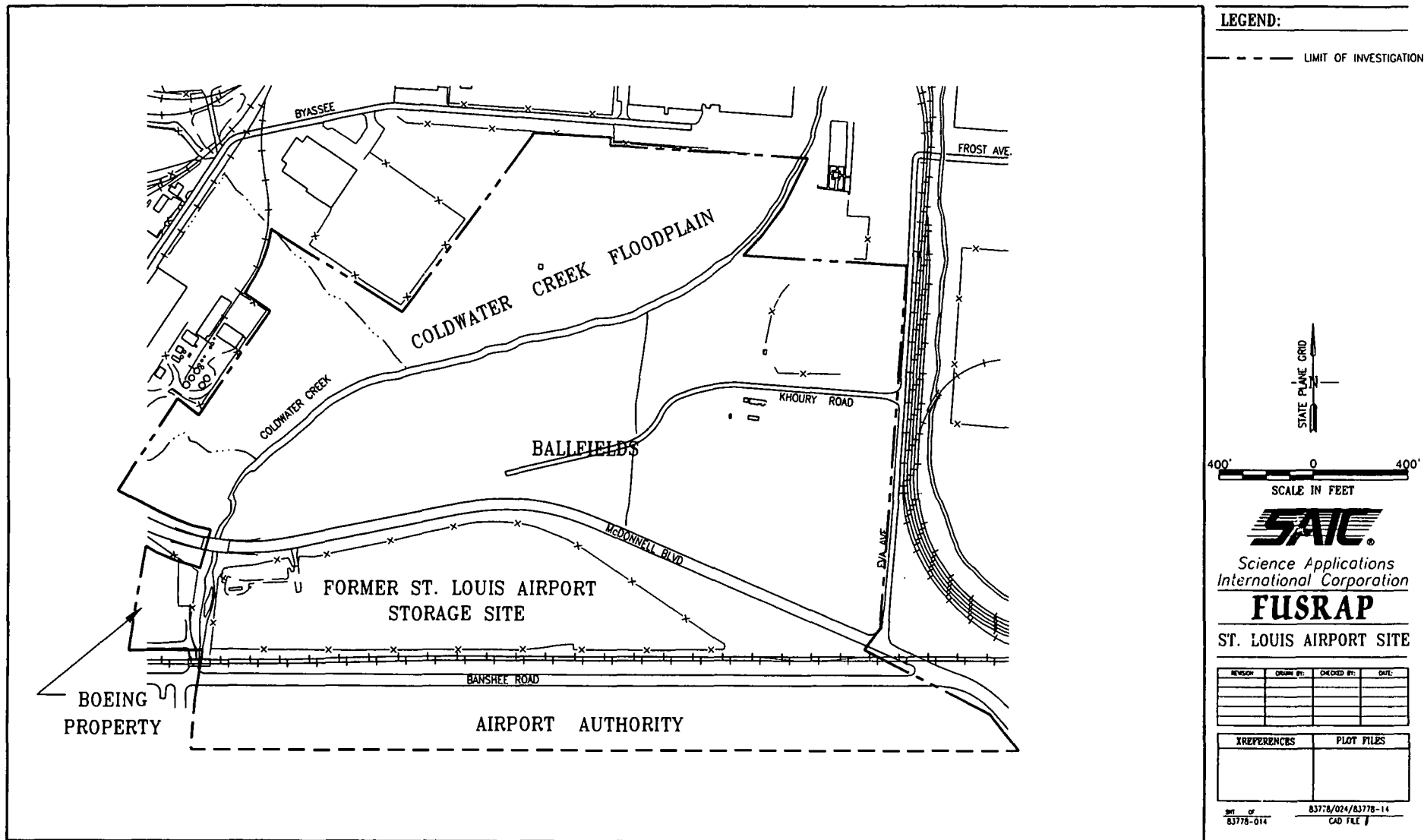
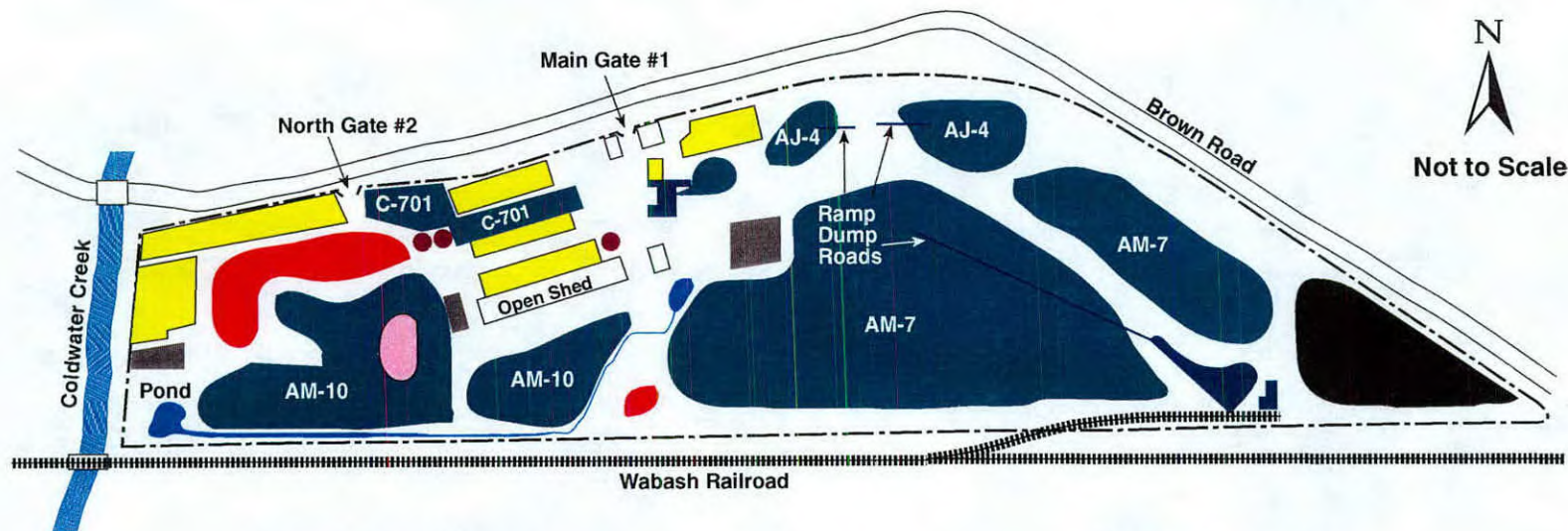


Figure 1-2  
Extent of Investigation



N  
 Not to Scale

- |                      |                         |            |
|----------------------|-------------------------|------------|
| Barrel Storage       | Buildings               | Dump Sites |
| Empty Barrel Storage | Loading Ramps and Docks | Wet Areas  |
| Metal Scrap          | Dolomite Slag Dump      | Gas Tanks  |
| Oil Dump             | Fence                   |            |

AM-7: Pitchblende Raffinate	C-701: Tailings of Uranium Scalping Operations from Magnesium Fluoride Slag
AM-10: Raffinate	
AJ-4: Barium Cake	

Depiction of areas and names of entities CA. 1955

Figure 1-3. SLAPS Areas of Former Use

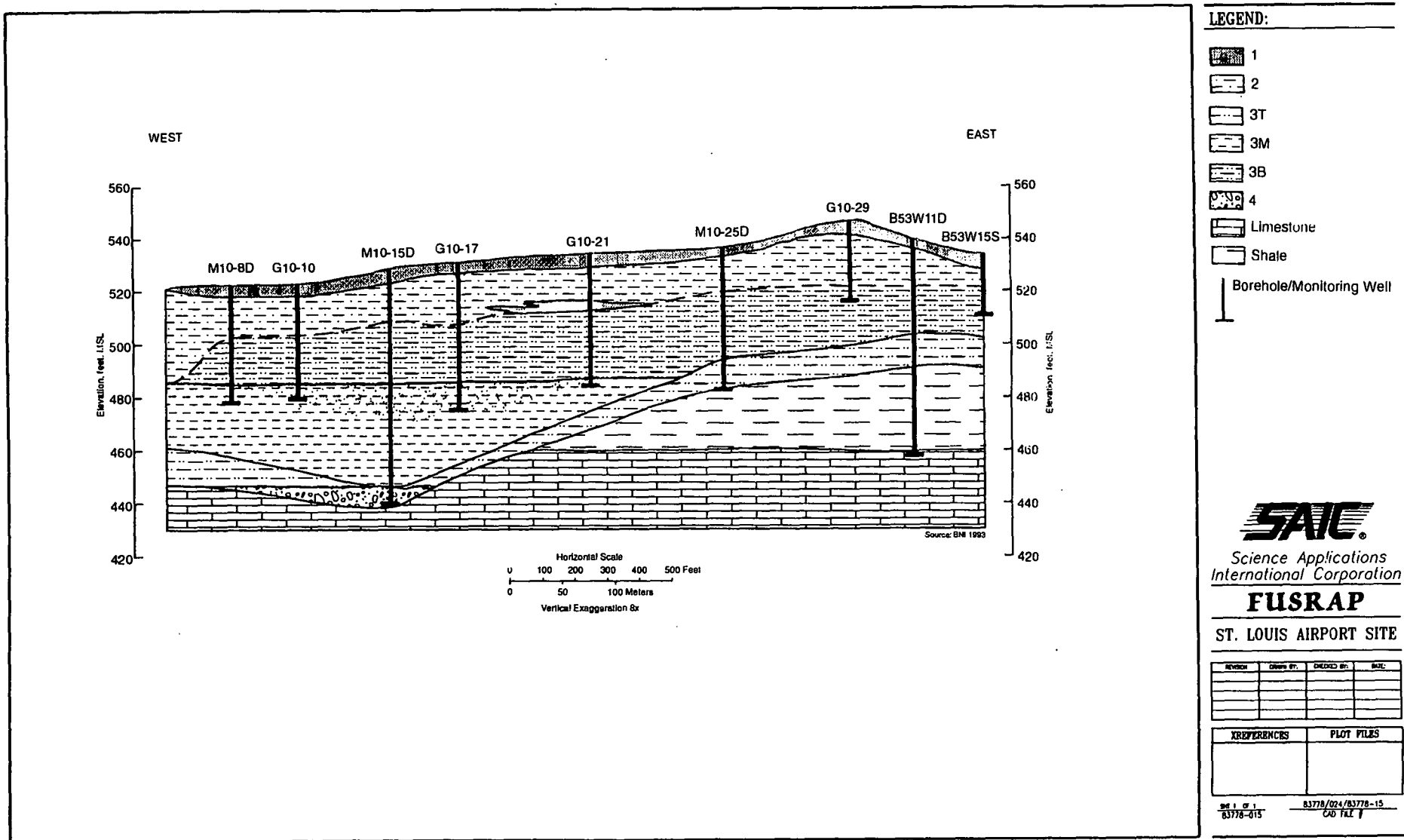


Figure 1-4  
Site Cross Section

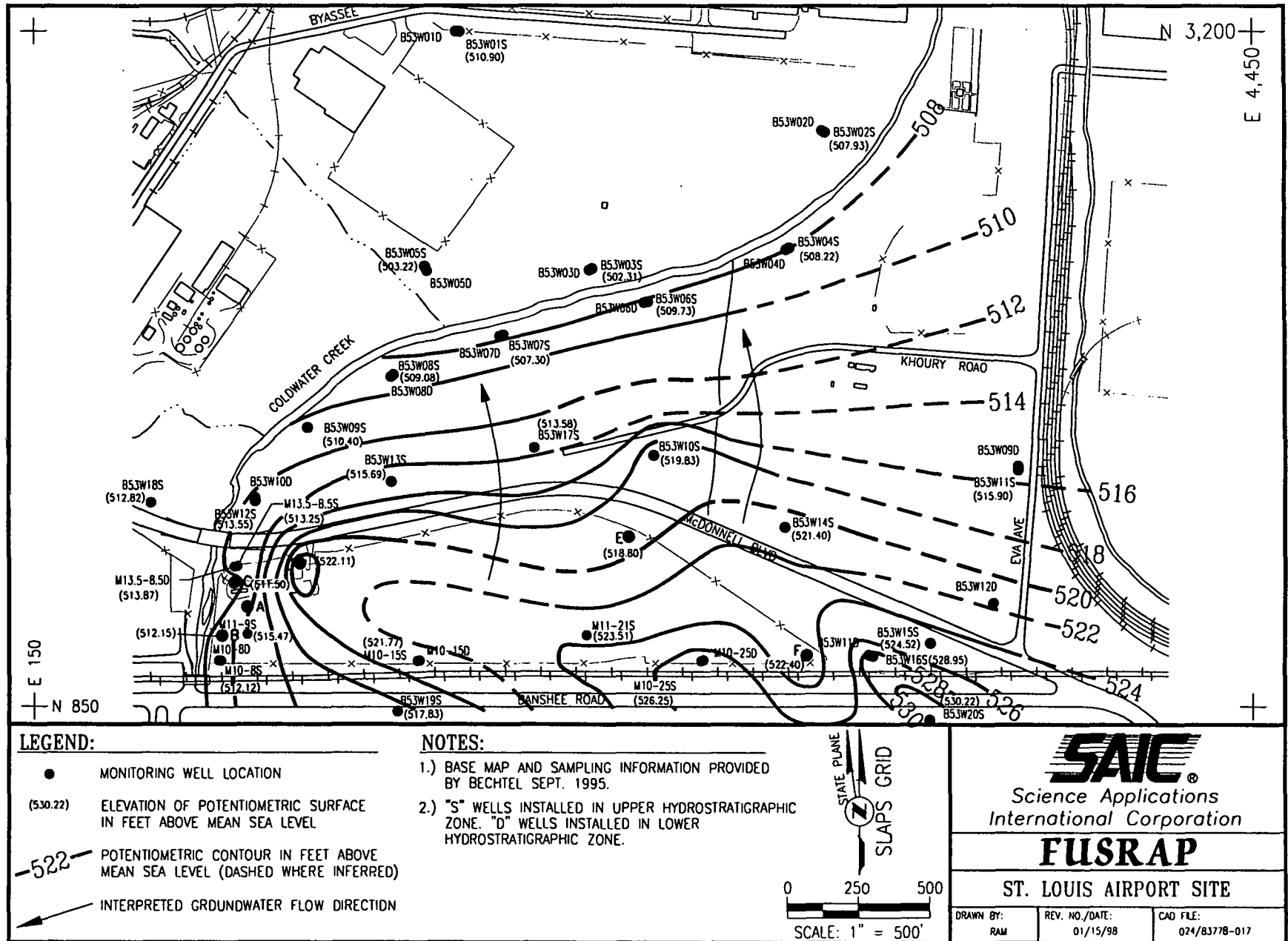
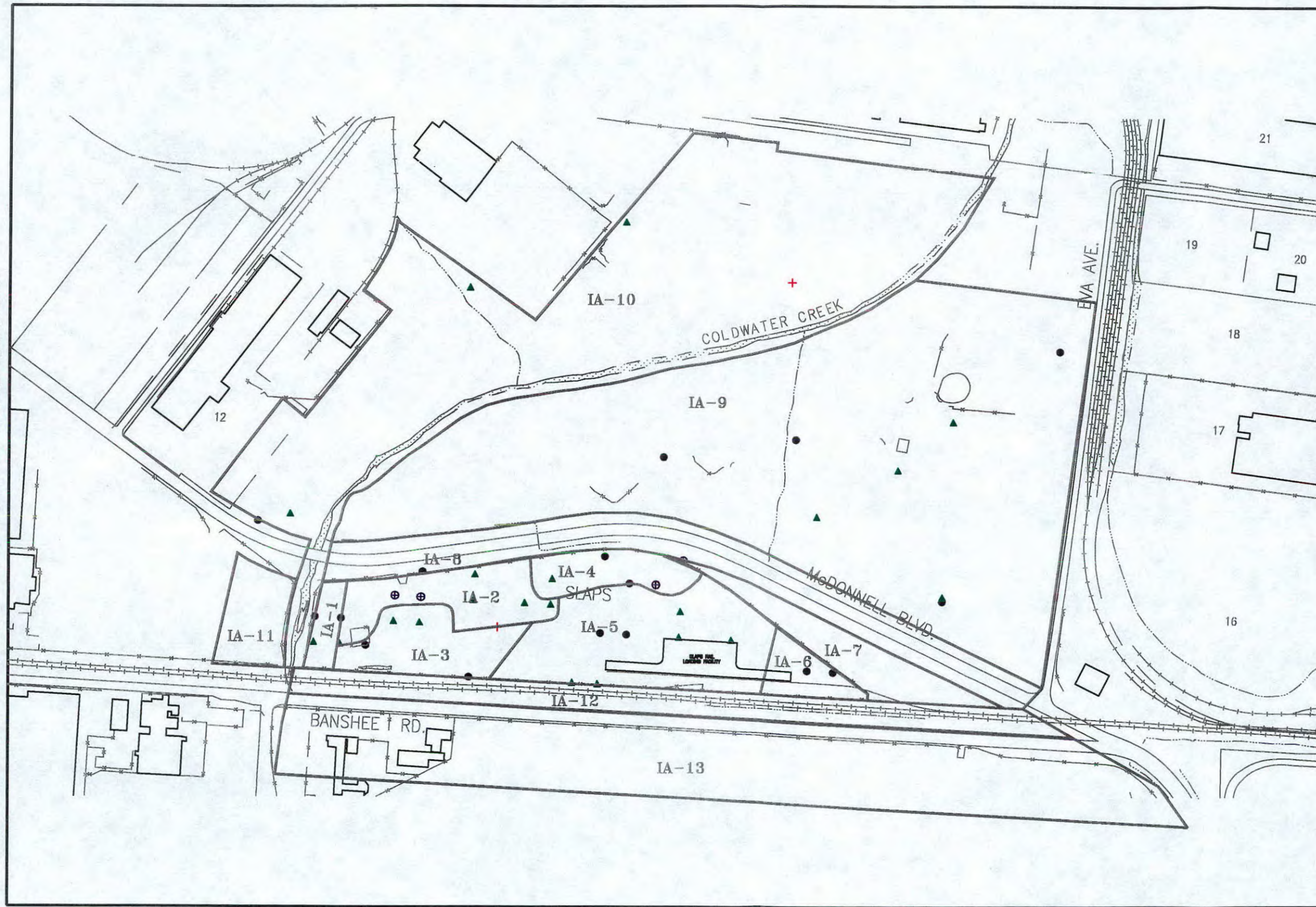


Figure 1-5  
Potentiometric Surface Map of Upper  
Hydrostratigraphic Zone (9/97)

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- LEGEND:**
- ▲ LOCATIONS WITH ELEVATED VOC CONCENTRATION(S)
  - ⊕ LOCATIONS WITH METAL CONCENTRATION(S) ELEVATED ABOVE BACKGROUND
  - ⊕ LOCATIONS WITH ELEVATED METAL AND VOC CONCENTRATION(S)
  - ALL OTHER SAMPLE LOCATIONS



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**Figure 1-6**  
**EXISTING NON-RADIONUCLIDE SAMPLING LOCATIONS**  
**at SLAPS and Contiguous Properties**



NAME: U:\3D\SLAPS\SAP\EX02.DWG DATE: APR 21, 1998 TIME: 4:44 PM PCP: U:\3D\SLAPS\SAP\FUSRAP.PCP

$$\text{DOE 5400.5 SOR} = \frac{\text{MAX}[(\text{Th230-BKGRND.}), (\text{Ra226-BKGRND.})]}{5 \text{ (ABOVE 6") OR } 15 \text{ (BELOW 6")}} + \frac{(\text{Th232-BKGRND.})}{5 \text{ (ABOVE 6") OR } 15 \text{ (BELOW 6")}} + \frac{(\text{U238-BKGRND.})}{50}$$



**LEGEND:**

- DOE 5400.5 SOR (UNITLESS; SEE EQUATION AT LEFT)
- LESS THAN 1 ; Th230 NOT ANALYZED
  - LESS THAN 1 ; Th230 ANALYZED
  - ▲ BETWEEN 1 AND 3
  - \* BETWEEN 3 AND 10
  - BETWEEN 10 AND 30
  - ⊕ BETWEEN 30 AND 100
  - + BETWEEN 100 AND 300
  - △ GREATER THAN 300

NOTE: THIS FIGURE PRESENTS THE MAXIMUM SOR VALUE AT EACH SAMPLING LOCATION WITHIN THE SPECIFIED DEPTH INTERVAL.



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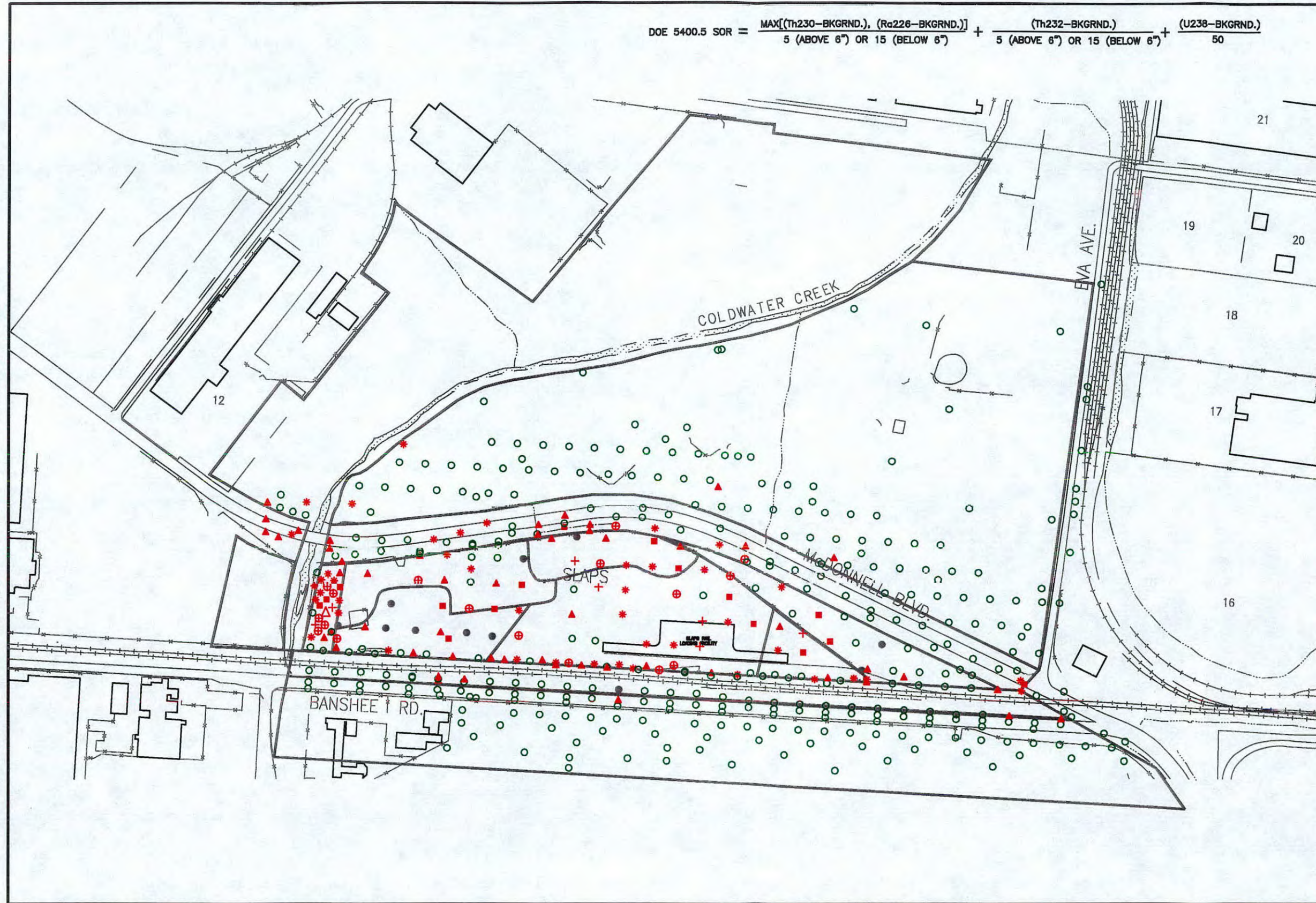
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Figure 1-7  
 EXISTING SURFACE (0-2 FEET) RADIONUCLIDE SOIL SAMPLING SUMMARY  
 at SLAPS and Contiguous Properties

NAME: U:\3D\SLAPS\SAP\EXGT2T05.DWG DATE: APR 21, 1998 TIME: 4:45 PM PCP: U:\3D\SLAPS\SAP\FUSRAP.PCP

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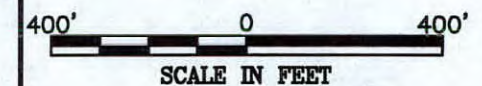


**LEGEND:**

DOE 5400.5 SOR (UNITLESS; SEE EQUATION AT LEFT)

- LESS THAN 1 ; Th230 NOT ANALYZED
- LESS THAN 1 ; Th230 ANALYZED
- ▲ BETWEEN 1 AND 3
- \* BETWEEN 3 AND 10
- BETWEEN 10 AND 30
- ⊕ BETWEEN 30 AND 100
- ⊕ BETWEEN 100 AND 300
- △ GREATER THAN 300

NOTE: THIS FIGURE PRESENTS THE MAXIMUM SOR VALUE AT EACH SAMPLING LOCATION WITHIN THE SPECIFIED DEPTH INTERVAL.



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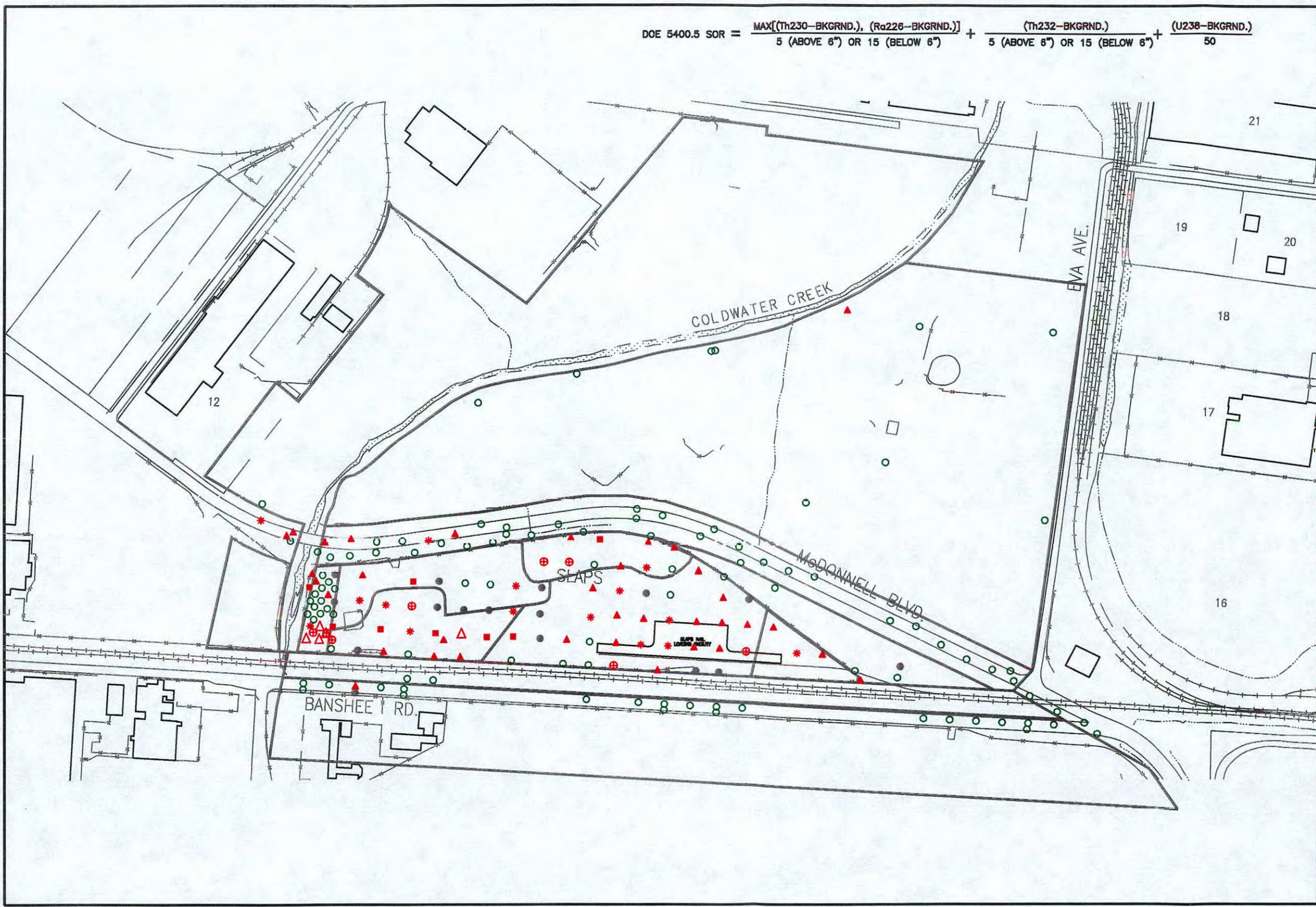
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Figure 1-8  
EXISTING SHALLOW (2-5 FEET) RADIONUCLIDE SOIL SAMPLING SUMMARY  
at SLAPS and Contiguous Properties

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**LEGEND:**

DOE 5400.5 SOR (UNITLESS; SEE EQUATION AT LEFT)

- LESS THAN 1 ; Th230 NOT ANALYZED
- LESS THAN 1 ; Th230 ANALYZED
- ▲ BETWEEN 1 AND 3
- \* BETWEEN 3 AND 10
- BETWEEN 10 AND 30
- ⊕ BETWEEN 30 AND 100
- + BETWEEN 100 AND 300
- △ GREATER THAN 300

NOTE: THIS FIGURE PRESENTS THE MAXIMUM SOR VALUE AT EACH SAMPLING LOCATION WITHIN THE SPECIFIED DEPTH INTERVAL.



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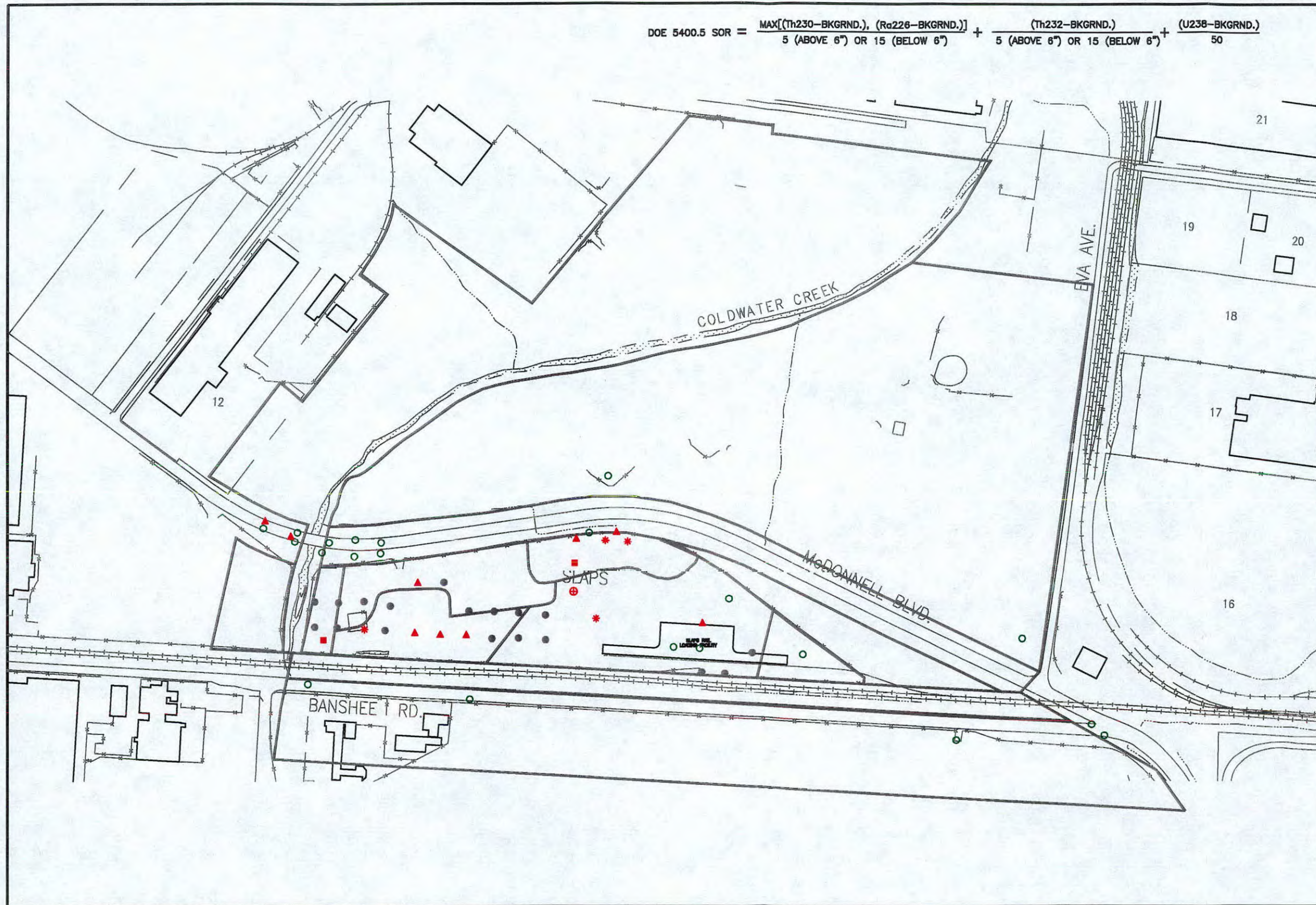
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Figure 1-9  
 EXISTING INTERMEDIATE (5-10 FEET) RADIONUCLIDE SOIL SAMPLING SUMMARY  
 at SLAPS and Contiguous Properties

NAME: U:\SD\SLAPS\EXGT10.DWG DATE: APR 21, 1998 TIME: 4:47 PM PCP: U:\SD\SLAPS\SAP\FUSRAP.PCP

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**LEGEND:**

DOE 5400.5 SOR (UNITLESS; SEE EQUATION AT LEFT)

- LESS THAN 1 ; Th230 NOT ANALYZED
- LESS THAN 1 ; Th230 ANALYZED
- ▲ BETWEEN 1 AND 3
- \* BETWEEN 3 AND 10
- BETWEEN 10 AND 30
- ⊕ BETWEEN 30 AND 100
- + BETWEEN 100 AND 300
- △ GREATER THAN 300

NOTE: THIS FIGURE PRESENTS THE MAXIMUM SOR VALUE AT EACH SAMPLING LOCATION WITHIN THE SPECIFIED DEPTH INTERVAL.



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**Figure 1-10**  
**EXISTING DEEP (10-20 FEET) RADIONUCLIDE SOIL SAMPLING SUMMARY**  
**at SLAPS and Contiguous Properties**

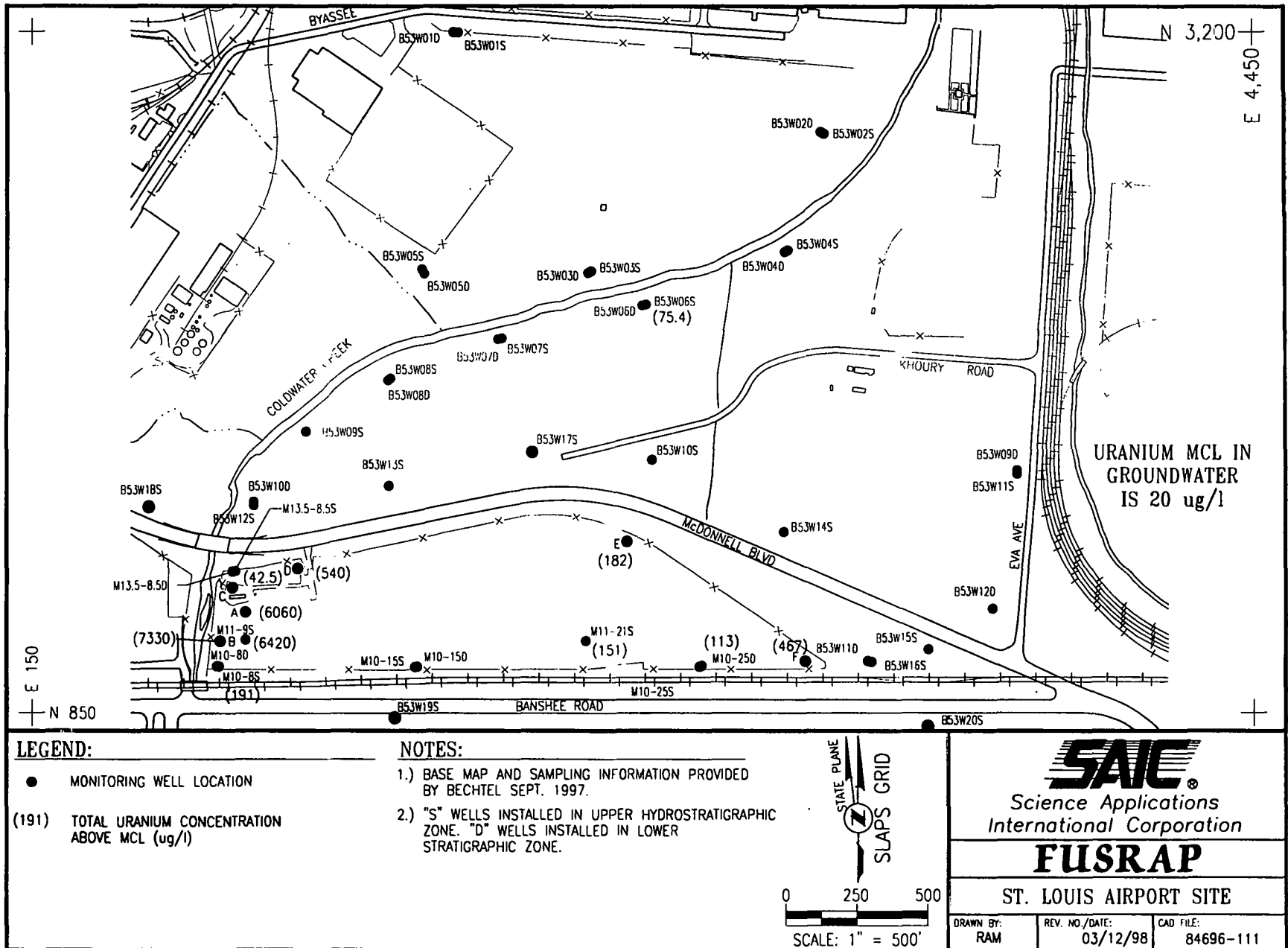
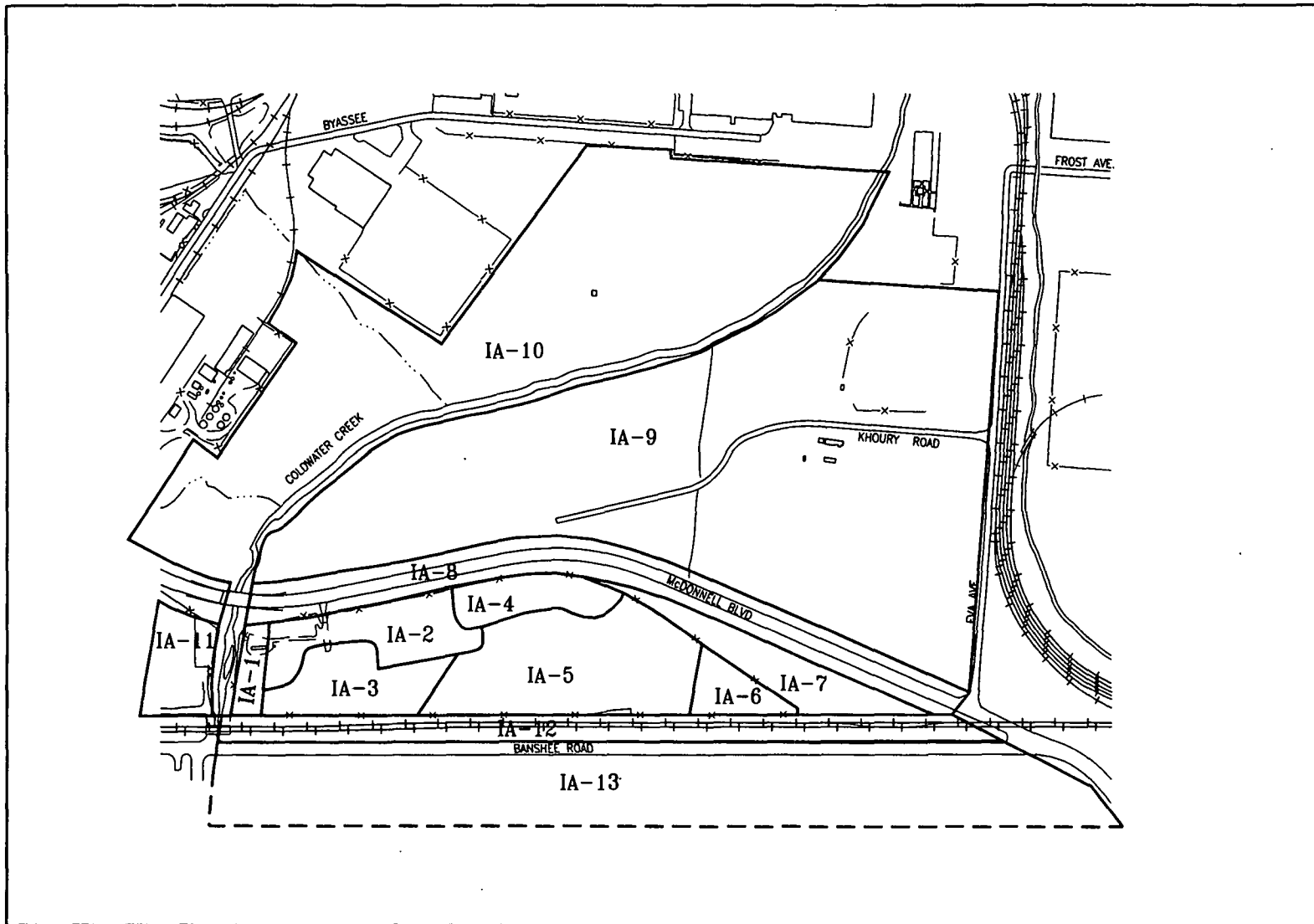
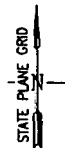


Figure 1-11  
1997 Total Uranium MCL Exceedances  
in Groundwater



**LEGEND:**

**IA** INVESTIGATION AREA BASED ON FORMER LAND USE



400' 0 400'  
SCALE IN FEET



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Figure 1-12  
Location of Proposed  
Investigation Areas (IA'S)

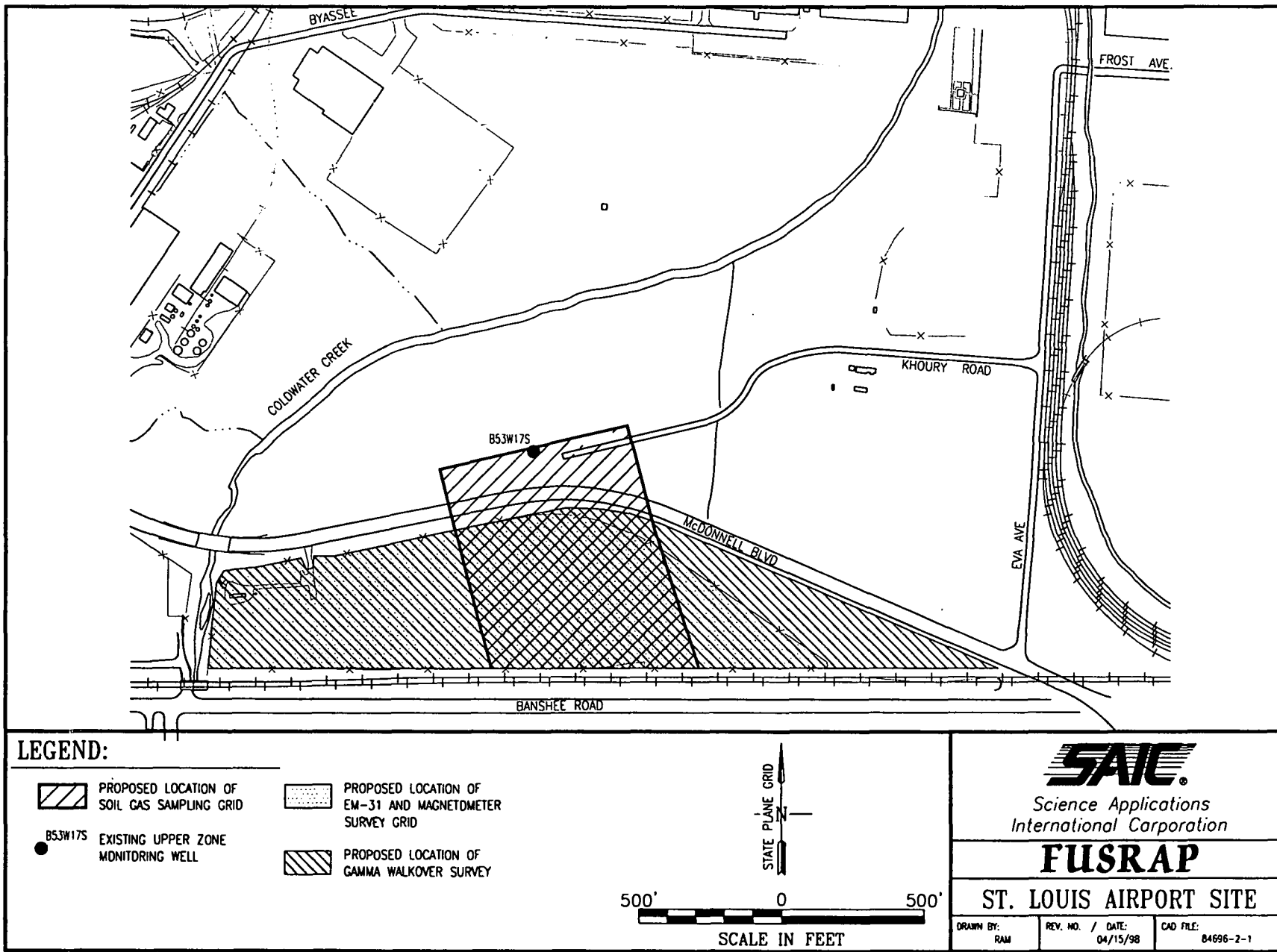


Figure 2-1  
Location of Proposed  
Screening Activities

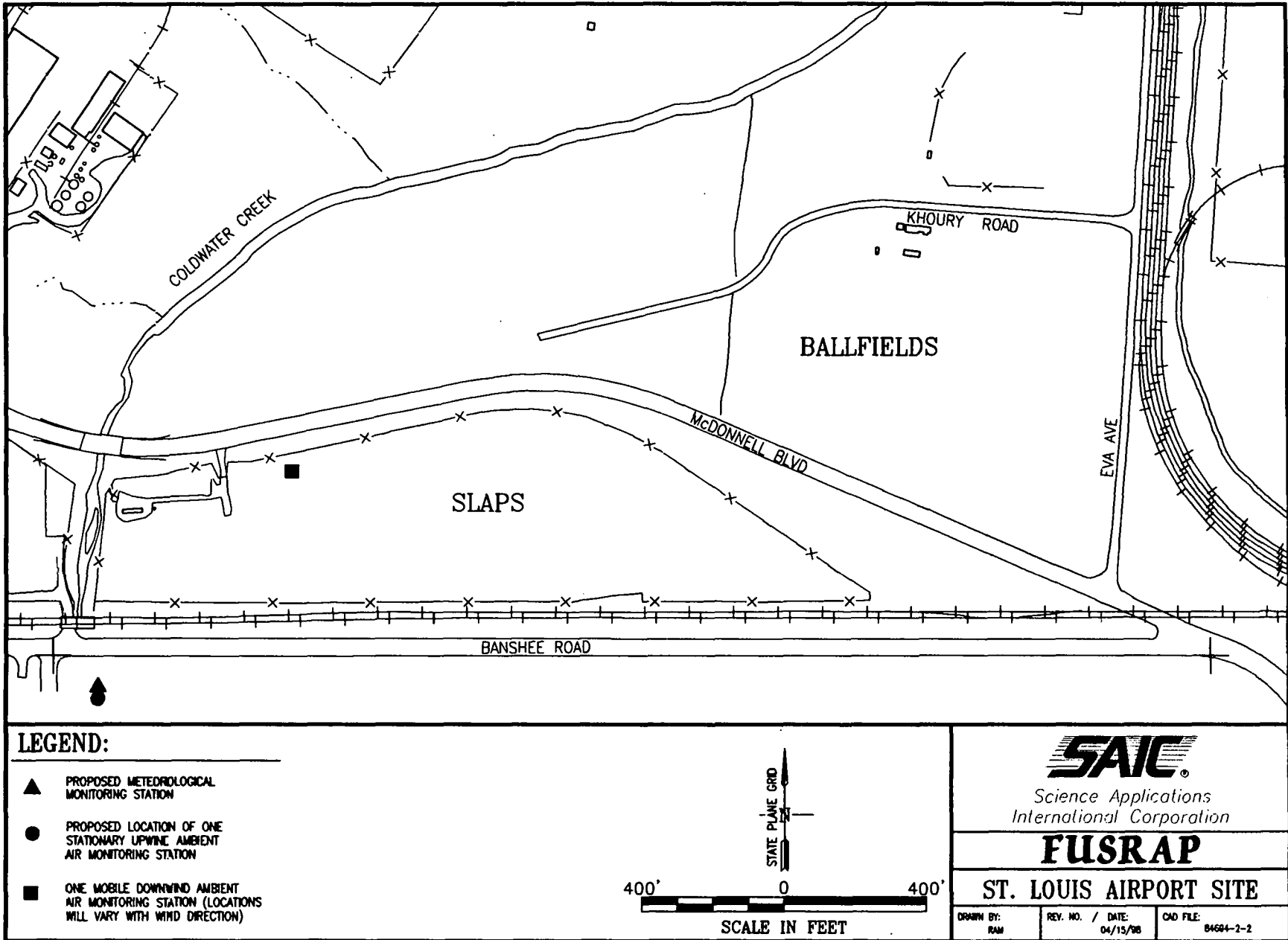


Figure 2-2  
Location of Proposed Ambient Air/  
Meteorological Monitoring Stations



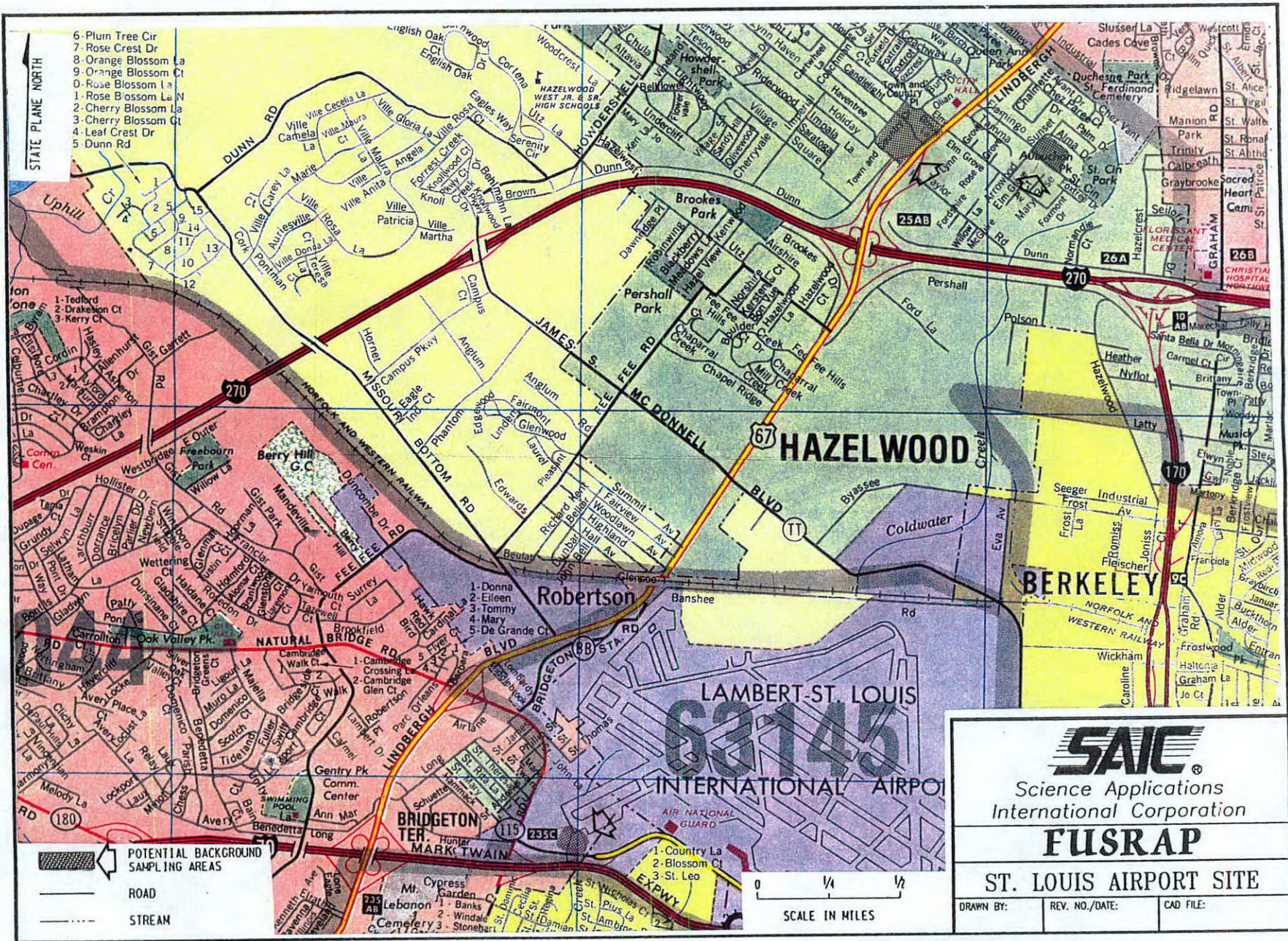


Figure 2-3  
 Potential Locations for  
 Background Soil Samples

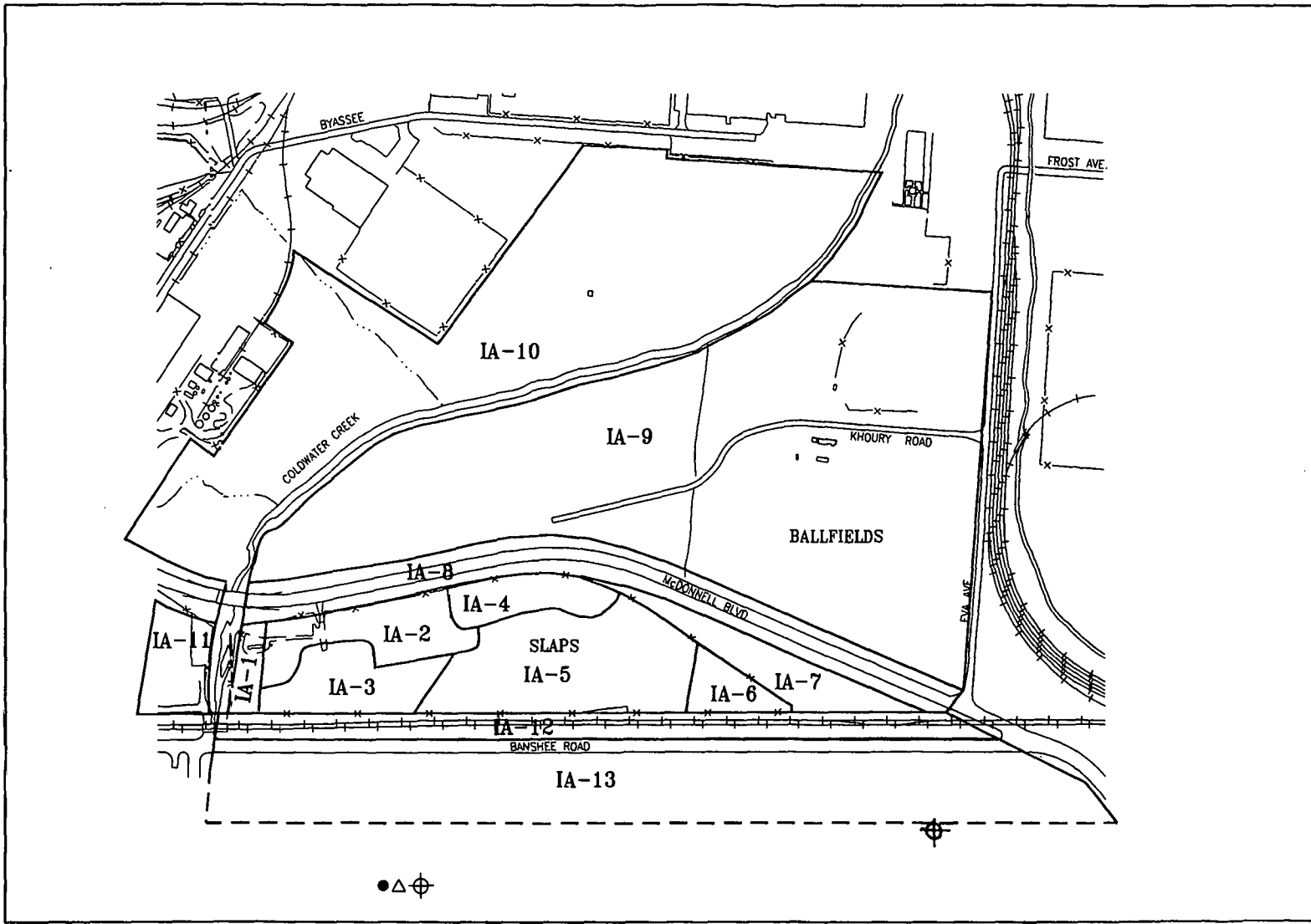
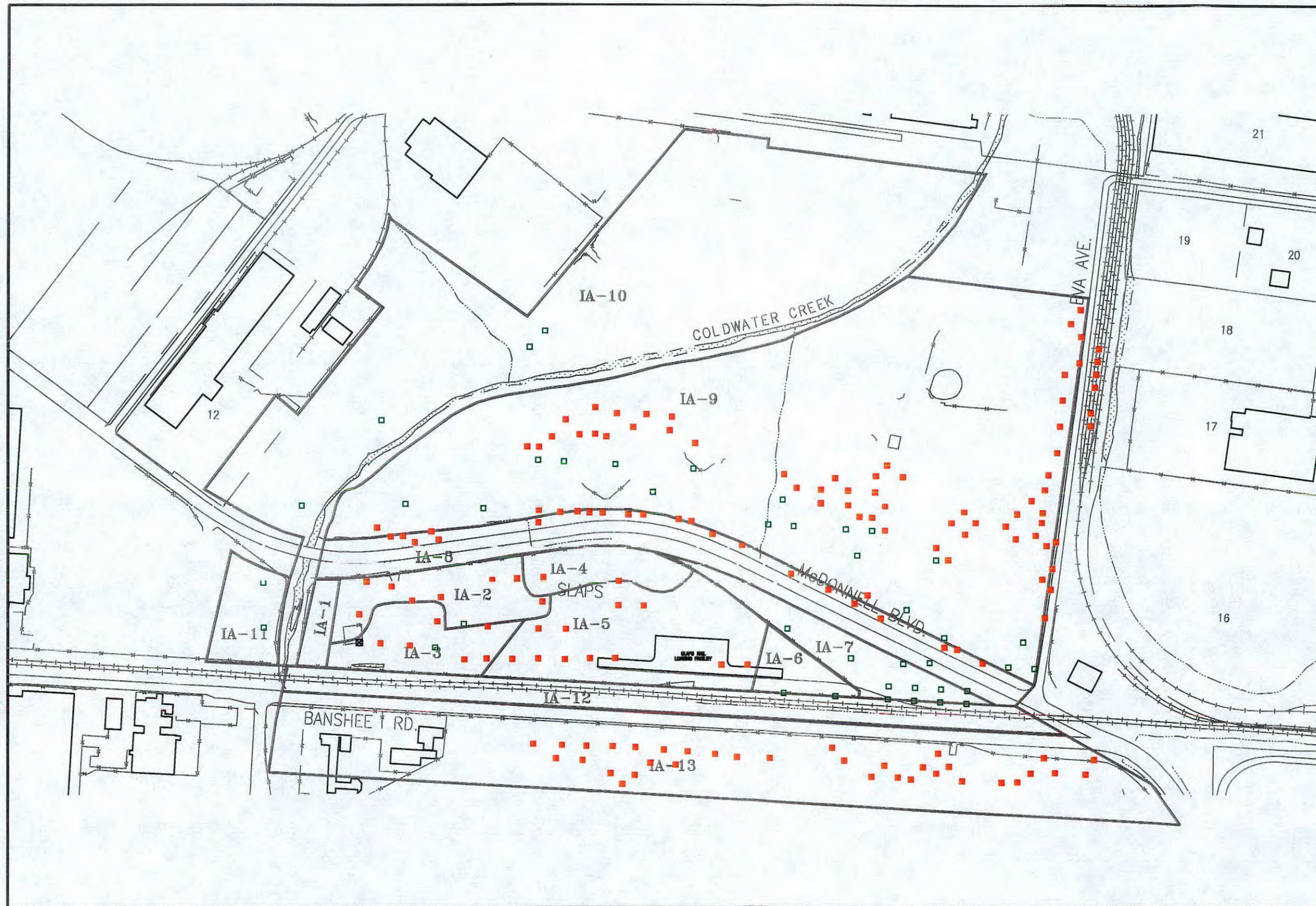


Figure 2-4  
Proposed Locations for  
New Background Monitoring Wells

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**LEGEND:**

- SURFACE SOIL SAMPLES (0-0.5 FEET)
- SHALLOW SOIL SAMPLE (1-2 FEET)
- ⊠ SURFACE/SHALLOW SOIL SAMPLE



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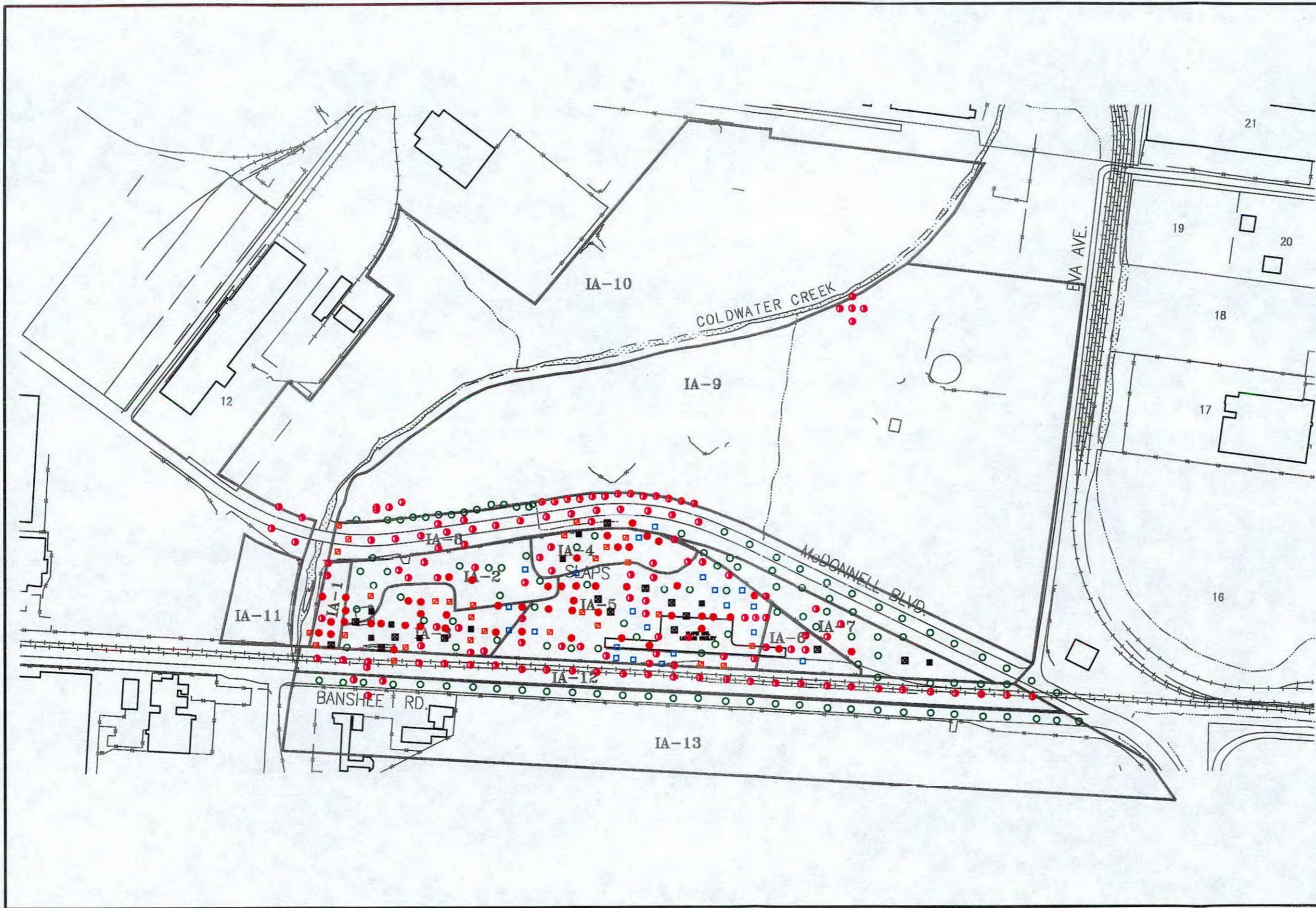
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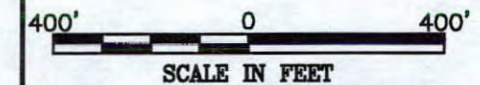
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**Figure 2-5**  
**PROPOSED SURFACE AND SHALLOW SOIL SAMPLING LOCATIONS**

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- LEGEND:**
- SHALLOW BORINGS (TO 5 FEET)
  - MEDIUM BORINGS (TO 10 FEET)
  - DEEP BORINGS (TO 20 FEET)
  - MEDIUM AND SHALLOW BORING LOCATIONS
  - ▣ DEEP AND MEDIUM BORING LOCATIONS
  - DEEP AND SHALLOW BORING LOCATIONS
  - ⊠ DEEP/MEDIUM/SHALLOW BORING LOCATIONS



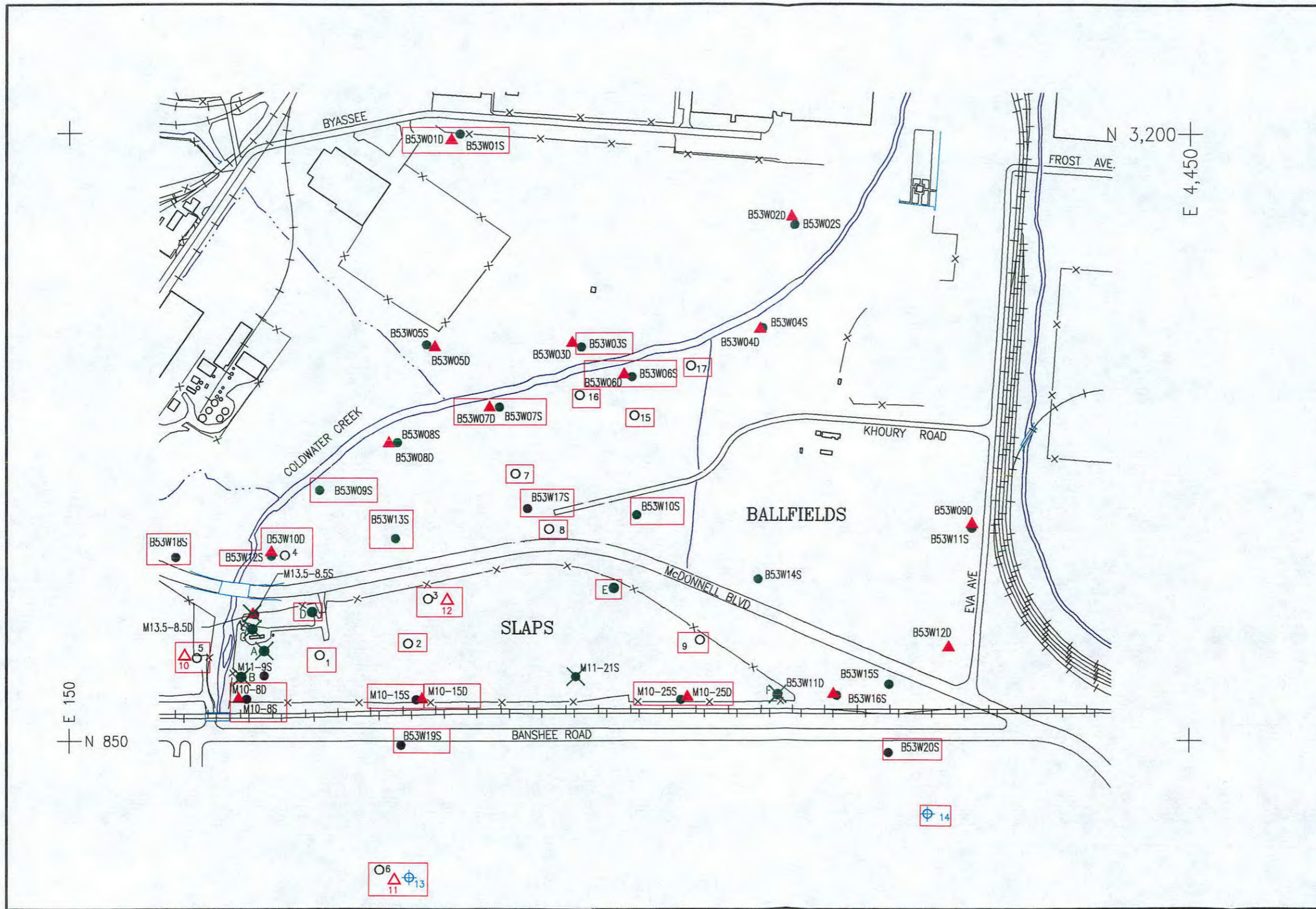
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**Figure 2-6**  
**PROPOSED SHALLOW/INTERMEDIATE/DEEP BOREHOLE LOCATIONS**



**LEGEND:**

- EXISTING UPPER ZONE MONITORING WELL
- ⊗ CLOSED UPPER ZONE MONITORING WELL
- PROPOSED UPPER ZONE MONITORING WELL
- ▲ EXISTING LOWER ZONE MONITORING WELL
- △ PROPOSED LOWER ZONE MONITORING WELL
- ⊕ PROPOSED BEDROCK MONITORING WELLS
- WELLS TO BE SAMPLED (ANTICIPATED)



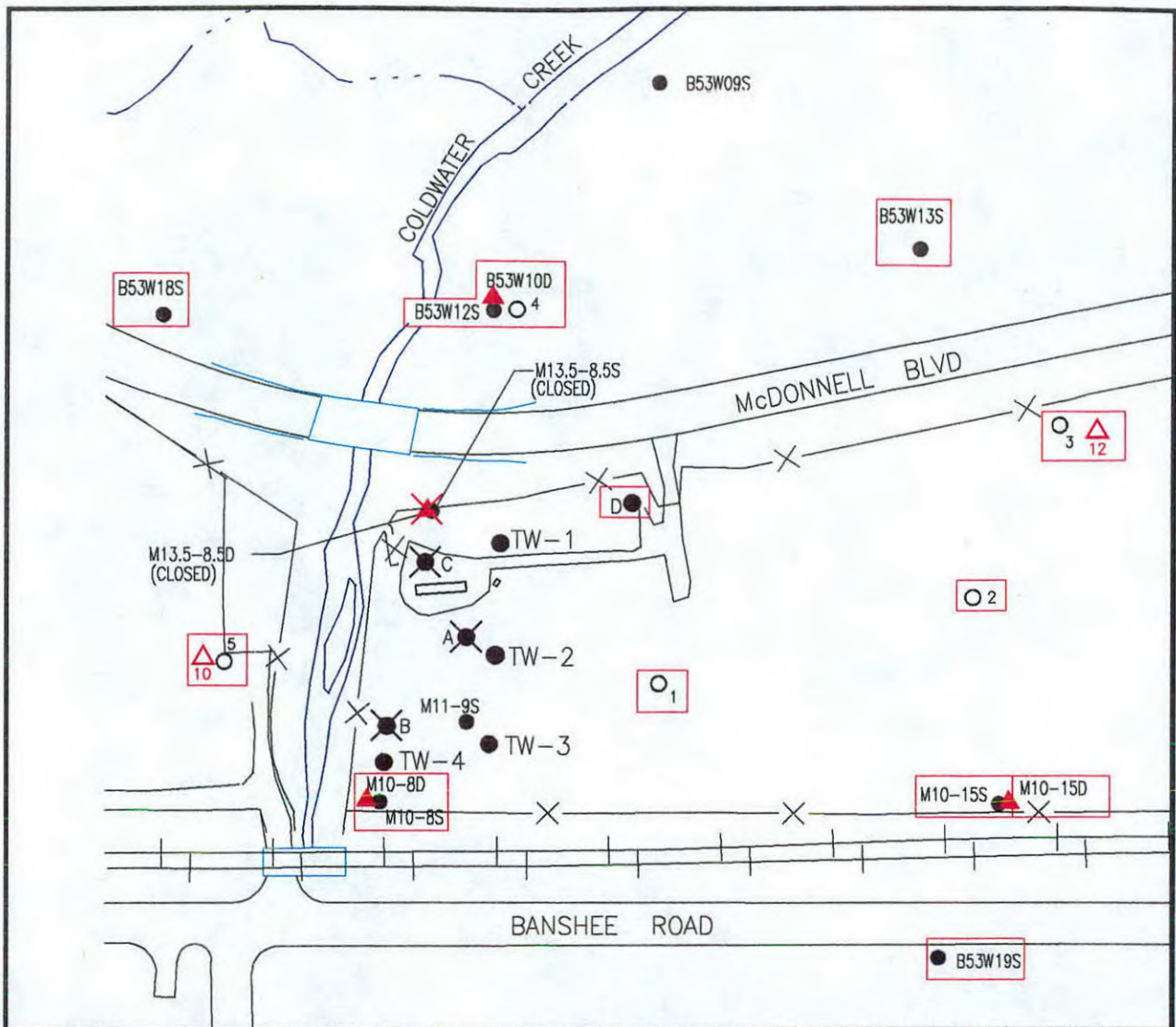
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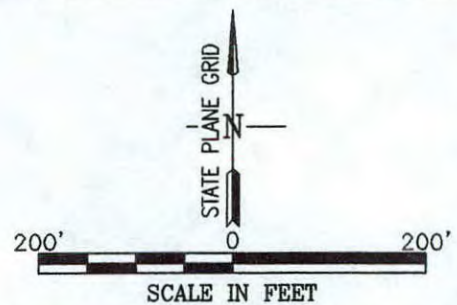
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Figure 2-7  
 Proposed Locations for  
 New Monitoring Wells and Groundwater Sampling



**LEGEND:**

- EXISTING UPPER ZONE MONITORING WELL
- ⊗ CLOSED UPPER ZONE MONITORING WELL
- PROPOSED UPPER ZONE MONITORING WELL
- ▲ EXISTING LOWER ZONE MONITORING WELL
- ⊗ PROPOSED LOWER ZONE MONITORING WELL
- △ PROPOSED LOWER ZONE MONITORING WELL
- WELLS TO BE SAMPLED (ANTICIPATED)



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<b>ST. LOUIS AIRPORT SITE</b>		
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**Figure 2-8**  
**Proposed Locations for Monitoring Wells**  
**and Groundwater Sampling at West End**

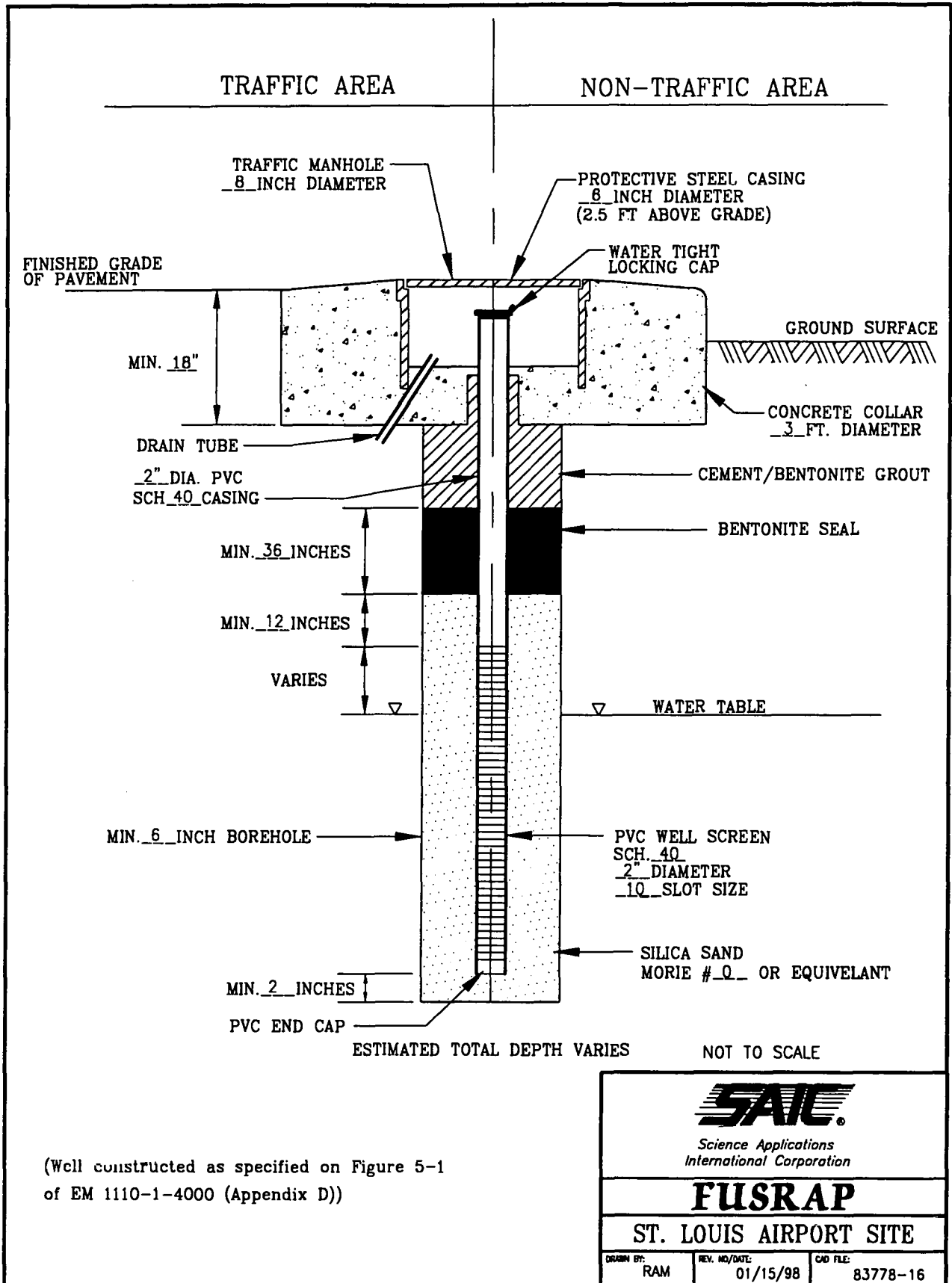


Figure 2-9  
Construction Schematic of  
Overburden Well

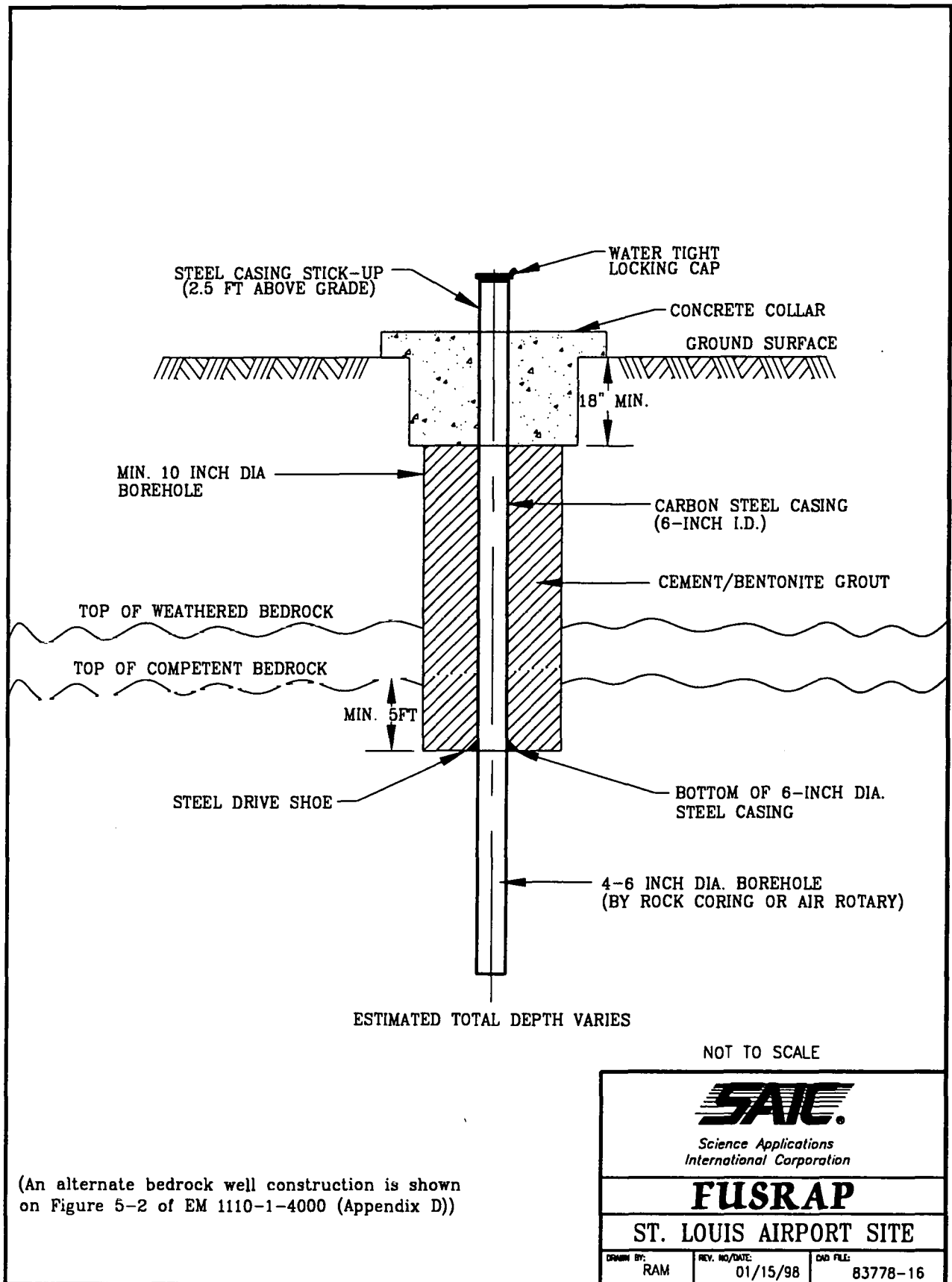


Figure 2-10  
Construction Schematic of  
Open Hole Bedrock Well



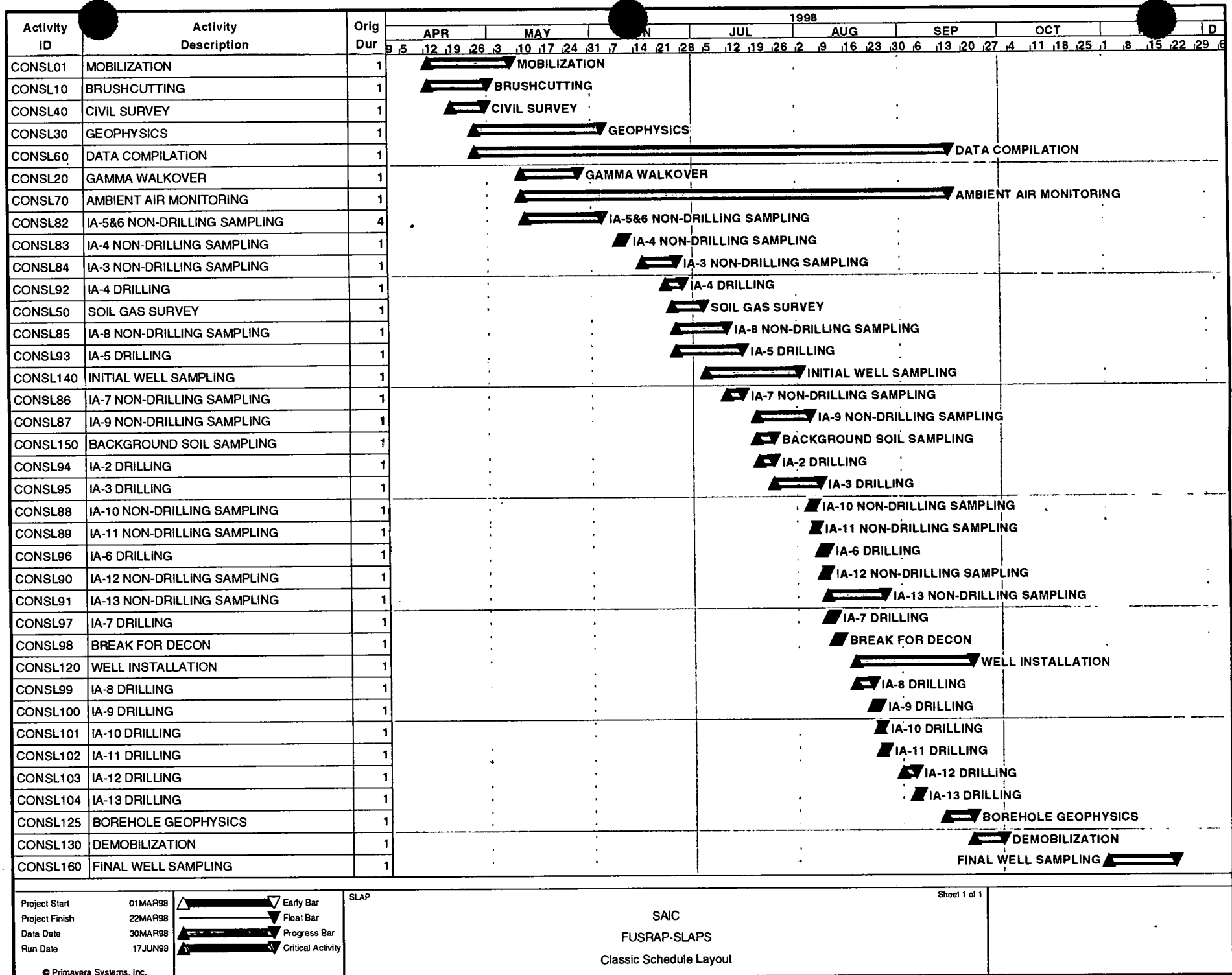


Figure 9-1 Anticipated Project Schedule for SLAPS Sampling and Analysis Activities

# **TABLES**

TABLE 1-1

**Residual Radioactivity in Soil at SLAPS and in the Ditch  
Running North and South of McDonnell Boulevard**

a) Radionuclide concentration for all SLAPS soil samples (pCi/g)

Analyte	Minimum Detection	Maximum Detection	Mean	Number of Detections / Number of Samples
Ac-227	0.11	297	14.4	138/209*
Pa-231	0.10	317	27.7	75/209*
Ra-226	0.5	5,620	58.4	221/448
Th-230	0.0	2,600	134	225/226
Th-232	0.3	63	3.40	137/447
U-238	0.5	1,600	59.1	60/447

b) Radionuclide concentration for all north ditch samples (pCi/g)

Analyte	Minimum Detection	Maximum Detection	Mean	Number of Detections / Number of Samples
Ra-226	0.7	130	4.32	192/198
Th-230	0.9	15,000	228	178/178
Th-232	0.7	6	1.88	174/197
U-238	1.1	66	12.3	60/197

c) Radionuclide concentration for all south ditch samples (pCi/g)

Analyte	Minimum Detection	Maximum Detection	Mean	Number of Detections / Number of Samples
Ra-226	0.7	28	3.01	105/108
Th-230	1.5	1,400	108	70/70
Th-232	0.4	4	1.83	93/108
U-238	1.2	94	13.4	44/108

\*Samples collected during West End remediation.

TABLE 1-2

## Maximum Concentrations Detected for Chemical Constituents in Soil at SLAPS

Constituent	Maximum Detection (mg/kg)
<b><i>Inorganics</i></b>	
Aluminum	7880
Arsenic	668
Barium	13,600
Beryllium	0.56
Boron	761
Cadmium	50.4
Calcium	15,500
Chromium	3240
Cobalt	6050
Copper	4,400
Fluoride	62.9
Iron	15,500
Lead	1,200
Manganese	4690
Magnesium	26,900
Molybdenum	255
Nickel	7,570
Potassium	827
Silver	13.9
Selenium	183
Sodium	76.9
Sulfate	863
Vanadium	862
Zinc	4,330
<b><i>Organics</i></b>	
Acetone	0.017
Anthracene	0.031
Benzo(a)anthracene	0.170
Benzo(b)fluoranthene	0.210
Benzo(k)fluoranthene	0.180
Benzo(ghi)perylene	0.084
Benzo(a)pyrene	0.150
alpha-chlordane	0.030
Chrysene	0.190
Trans-1,2-Dichloroethene	0.0077
Dieldrin	0.230
Dibenzo(a,h)anthracene	0.035
Fluoranthene	0.410
Indeno(123-cd)pyrene	0.130
Naphthalene	0.440
Phenanthrene	0.420
Pyrene	0.340
Toluene	1.200
1,1,1-Trichloroethane	0.0017
Trichloroethene	0.015

**TABLE 1-3****Summary Statistics for TCLP Results for Soil Samples from SLAPS**

<b>Analyte</b>	<b>Minimum Detection (mg/L)</b>	<b>Maximum Detection (mg/L)</b>	<b>Arithmetic Mean* (mg/L)</b>	<b>Number of Detections/Number of Samples</b>	<b>Maximum Allowable Concentrations in Leachate (mg/L)</b>
Barium	0.536	3.400	1.52	34/34	100
Cadmium	0.0051	0.211	0.0103	8/34	1.0
Lead	0.135	0.135	0.0476	1/34	5.0
Mercury	0.43	0.43	0.00011	1/34	0.2
Selenium	0.105	1.18	0.167	14/34	1.0
Heptachlor	0.00004	0.00043	0.00009	8/34	0.008

\*Average includes non-detects at one-half the detection limit.

TABLE 1-4

## Summary of Baseline Risk Assessment Results for SLAPS

Receptor	Radiological Carcinogenic Risk	Chemical Carcinogenic Risk	Hazard Index
SLAPS Trespasser	$9.4 \times 10^{-5}$	$1.0 \times 10^{-6}$	0.051
SLAPS Maintenance Worker	$1.1 \times 10^{-3}$	$4.0 \times 10^{-6}$	0.070
Ditch Construction Worker	$4.4 \times 10^{-4}$	$3.9 \times 10^{-6}$	0.21
Coldwater Creek Recreational User	$3.0 \times 10^{-6}$	$4.6 \times 10^{-6}$	0.067

**Note:** For risk management purposes, the United States Environmental Protection Agency (EPA) and other regulatory agencies typically require remediation goals to achieve a cancer risk within the range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$ , or a hazard index of no greater than 1.0.

TABLE 1-5

## List of PCOCs and IALs for SLAPS and CPs

	Constituent	Media With Elevated Detects*	SSL	Potential Soil IAL	Source	Potential G.W. IAL	Source
Radionuclides	Ra-226	S, W, O	No	5/15 pCi/g	DOE/NRC	20 pCi/L	MCL MDNR (Ra 226 + Ra 228)
	Th-230	S, W, O	No	5/15 pCi/g	DOE/NRC	20 pCi/L	MCL
	Th-232	S, W, O	No	5/15 pCi/g	DOE/NRC	20 pCi/L	MCL
	U-Total (234, 235, 238)	G, S, W, O	No	50/100 pCi/g	DOE/NRC	14 pCi/L (20 ug/L)	MCL
	Ac-227	NT	No	2.7/8.9 pCi/g	EPA PRGs* (Res/Ind)	0.14 pCi/L	EPA PRGs* (Res)
	Pa-231	NT	No	1.3/5.9 pCi/g	EPA PRGs* (Res/Ind)	0.32 pCi/L	EPA PRGs* (Res)
Inorganics	Arsenic (As)	G, S, O	Yes	11; 23/610 mg/kg	Missouri ASL RBC (Res/Ind)	50 ug/L	MCL
	Barium (Ba)	S, W	Yes	3,900; 5,500/140,000 mg/kg	Missouri ASL RBC (Res/Ind)	2000 ug/L	MCL
	Beryllium (Be)	W	Yes	1.2; 0.15/1.3 mg/kg	Missouri ASL RBC (Res/Ind)	4 ug/L	MCL
	Cadmium (Cd)	S, W	Yes	28; 39/1,000 mg/kg	Missouri ASL RBC (Res/Ind)	5 ug/L	MCL
	Chromium (Cr)	O	Yes	280; 50,000; 78,000/100,000 mg/kg	Missouri ASL RBC (Res/Ind)	100 ug/L	MCL
	Cobalt (Co)	S, W	No	4,700/120,000 mg/kg	Missouri ASL RBC (Res/Ind)	250 ug/L	SMCL
	Copper (Cu)	S, W, O	No	3,100/82,000 mg/kg	Missouri ASL RBC (Res/Ind)	1/1.3 mg/L	SMCL/MCL
	Lead (Pb)	S, W, O	No	240; 400 mg/kg	Missouri ASL EPA Guidance	15 ug/L	MCL
	Mercury (Hg)	S	Yes	17; 23/610 mg/kg	Missouri ASL RBC (Res/Ind)	2 ug/L	MCL
	Molybdenum (Mo)	S, W, O	No	280; 390/10,000 mg/kg	Missouri ASL RBC (Res/Ind)	180 ug/L	RBC (tap water)
	Nickel (Ni)	S, O	Yes	1,100; 1,600/41,000 mg/kg	Missouri ASL RBC (Res/Ind)	100 ug/L	MCL
	Nitrate	G	No	130,000/1,000,000 mg/kg	Missouri ASL RBC (Res/Ind)	10 mg/L	MCL
	Selenium (Se)	G, S, W	Yes	280; 390/10,000 mg/kg	Missouri ASL RBC (Res/Ind)	50 ug/L	MCL
	Silver (Ag)	W	Yes	280; 390/10,000 mg/kg	Missouri ASL RBC (Res/Ind)	100 ug/L	SMCL
	Thallium (Tl)	W	Yes	3.9; 6.3/160 mg/kg	Missouri ASL RBC (Res/Ind)	2 ug/L	MCL
	Vanadium (V)	S, O, W	Yes	390; 550/14,000 mg/kg	Missouri ASL RBC (Res/Ind)	260 ug/L	RBC (tap water)
	Zinc (Zn)	S, O, W	Yes	17,000; 23,000/610,000 mg/kg	Missouri ASL RBC (Res/Ind)	5 mg/L	SMCL
Organics	Toluene	S	Yes	490; 16,000/410,000 mg/kg	Missouri ASL RBC (Res/Ind)	1000 ug/L	MCL
	Trichloroethene (TCE)	G, S,	Yes	340; 58/520 mg/kg	Missouri ASL RBC (Res/Ind)	5 ug/L	MCL
	Dichloromethane (methylene chloride)	G	Yes	670; 85/760,000 mg/kg	Missouri ASL RBC (Res/Ind)	5 ug/L	MCL
	trans-1,2-Dichloroethene	S	Yes	1,100; 1,600/41,000 mg/kg	Missouri ASL RBC (Res/Ind)	100 ug/L	MCL
	Heptachlor	S	Yes	1.1; 0.14/1.3 mg/kg	Missouri ASL RBC (Res/Ind)	0.4 ug/L	MCL
	Polychlorinated Biphenyls (PCBs)	NT	Yes	0.32/2.9 mg/kg	Missouri ASL RBC (Res/Ind)	0.5 ug/L	MCL

NA = Not Applicable

G = Groundwater; S = Soil; W = former Wastes; O = original Ores; NT = not tested sufficiently

IAL = Investigation Action Level; ASL = Any use Soil Level; RBC = Risk-Based Concentration Level (Soil Ingestion), EPA Region III; MCL = Maximum contaminant Level, EPA and Missouri Drinking Water Standard; Res = Residential criteria; Ind = Industrial criteria

SMCL = Secondary Maximum Contaminant Level, EPA and Missouri drinking water criteria

SSL = Soil Screening Level; Soil Screening Guidance: Users Guide, EPA, July 1996

\* 10<sup>-6</sup> total pathway risk-based preliminary remediation goals (PRGs) ([http://risk.lsd.oml.gov/homepage/rap\\_tool.htm](http://risk.lsd.oml.gov/homepage/rap_tool.htm)), February 3, 1998, last revision.

<b>TABLE 1-6</b>		
<b>List of Tracer/Indicator Constituents in Soil and Ground Water at SLAPS</b>		
<b>Media</b>	<b>Constituent</b>	
Soil	Inorganics	Aluminum (Al) Boron (B) Calcium (Ca) Fluoride (F) Iron (Fe) Magnesium (Mg) Manganese (Mn) Nitrogen (N) Sodium (Na) Sulfur (S) Titanium (Ti)
Ground Water	Radionuclides	Tritium, C-14, Helium-3
	Inorganics	Chloride Sulfate Nitrate



TABLE 1-7

**IALs for Field Screening, Surface Criteria, and Air  
at SLAPS and CPs**

Constituents	Concentration	Source
<b>Field Screening (Soil)</b>		
Sum of Ratios*	1	DOE 5400.5
Downhole Surveys (Gamma)	2 X Background	FUSRAP Convention
Walkover Surveys (Gamma)	2 X Background	FUSRAP Convention
Soil Gas Survey	Field Determination**	NA
<b>Surface Criteria</b>		
Uranium and Daughters	Average 5,000 dpm/100 cm <sup>2</sup> Maximum 15,000 dpm/100 cm <sup>2</sup> Removable 1,000 dpm/100 cm <sup>2</sup>	DOE 5400.5
Beta-Gamma Dose Rate, 1 cm from surface	Average 0.2 mrad/hr Maximum 1 mrad/hr	DOE 5400.5
<b>Air</b>		
Total Gross Alpha/Beta	$2 \times 10^{-14}$ $\mu$ Ci/mL	10 CFR 20 (Appendix B)
Metal PCOCs	Chemical-specific***	TBD

\* Sum of ratios is the sum of each of the major radionuclides divided by its individual investigative action level.

\*\* Generally, concentrations of 2X background are considered an adequate action level.

\*\*\* Will depend on the constituents detected; source will be published occupational exposure levels for airborne substances (i.e., NIOSH, OSHA, or ACGIH).

NA - Not Applicable

TBD - To Be Determined

**Table 2-1. Summary of BASIC Planned Activities at SLAPS and CPs**

Planned Activity	Rationale/DQO	Description	Approx. Number of Samples	QA/QC Samples	Analyses	Analytical Data Category		
Soil Gas Survey	To determine the probable source area of TCE or other VOCs contributing to ground water near and upgradient of MW-17 for FS and to support preliminary assessment of VOC risks for the PAM.	Collect passive soil gas samples using shallow buried absorbent media at 30-meter (100-ft) grid intervals focused on area upgradient and surrounding MW-17.	50	QC only; 2 Dups; 1 Field Blank	VOCs (GC or GC/MS method)	Screening		
Surface Geophysical Surveying	To support the IRAs (i.e. to identify buried debris for Engineering Construction planning purposes.	Perform electromagnetic and magnetic surveys over SLAPS site areas (IA-1 through IA-6) over a regular grid (2-meter).	20 acres	NA	Electromagnetics (EM-31, EM-61), and Magnetics	Screening		
Gamma Walkover Surveys	To support the delineation of boundary rad conditions and to guide selection of proposed surface soil samples for Th-230 purposes especially.	Perform gamma walkover surveys on a 1-meter grid pattern over the entire SLAPS site area (IA's 1 - 7) and along the ditches of McDonnell Blvd. and the railroad in IA's 8 and 12	22 acres	NA	Total gamma	Screening		
Meteorological Monitoring	To support HASP	Establish a fixed data collection station. Collect site-specific data for H&S and sampling correlation purposes. Continuous monitoring (data collection) during intrusive activities	1 location	NA	Wind speed, direction, barometric pressure, rainfall, temperature, and evapotranspiration	NA		
Ambient Air	To support HASP	Collect 10 periodic TSP and PM-10 ambient air particulate samples from 1 mobile downwind location and 1 fixed background location.	20-TSP 20- PM-10	1 Dup	Total alpha/beta screening, particulates, and TAL metals	Screening and Definitive		
Background Surveys	To support the PAM, FS, and ROD, for both rad and non-rad constituents, assists in developing applicable site-specific cleanup criteria.	Surface Soil: Collect off-site similar soil types at 0 to 0.5 ft depth, 12 samples per soil type, assuming 2 soil types.	24	5% QA and 5% QC per media	Radiological constituents, full-suite organics (VOCs, SVOCs, PCBs, herbicides, and pesticides), TAL metals, and indicator parameters	Definitive		
		Subsurface Soil: 4 borings at 0.5 - 2.0 ft, 4 to 6 ft, 10 to 12 ft, and 14 to 16 ft depths.	16					
		Upper Zone Ground water: 1 new off-site well (upgradient)	1				Same as ground water well sampling	Definitive
		Lower Zone Deep Ground water: 1 new off-site well (upgradient)	1				Same as ground water well sampling	Definitive
		Bedrock Ground water: 2 new off-site wells (upgradient)	2				Same as ground water well sampling	Definitive
		Gamma Walkover Survey: 6 locations, 2,500 sq.ft. each	15,000 sq.ft.				NA	Total Gamma
Gamma Spectroscopy: at selected background soil sampling locations	40	NA	Gamma spec.	Screening				

Table 2-1 (cont'd)

Planned Activity	Rationale/DQO	Description	Approx. Number of Samples	QA/QC Samples	Analyses	Analytical Data Category
Soil Sampling	To support the IRAs for delineation of radionuclide contamination above SOR's and disposal criteria; to better quantify volumes for removal; and to support the PAM to evaluate PCOC list (primarily non-rads.)	IA-1: 9 deep borings; 4 medium borings; 1 shallow boring.	27	5% QA and 5% QC samples	Radiological and non-radiological constituents  100% - Uranium (total), Radium-226, Thorium-230 and 232, Protactinium-231, Actinium-227; 10% - total TAL metals, VOCs, SVOCs, pesticides/herbicides, PCBs (IA-10 and IA-11 - non-radiological constituents only)	Definitive for all soil samples
		IA-2: 10 deep borings; 9 medium borings; 14 shallow borings; 1 shallow soil sample; 8 surface soil samples.	61			
		IA-3: 22 deep borings; 14 medium borings; 14 shallow borings; 2 shallow soil samples; 7 surface soil samples.	95			
		IA-4: 13 deep borings; 10 medium borings; 5 shallow borings; 2 surface soil samples.	53			
		IA-5: 27 deep borings; 36 medium borings; 34 shallow boring; 11 surface soil samples.	161			
		IA-6: 2 deep borings; 6 medium borings; 3 shallow borings.	19			
		IA-7: 3 deep borings; 6 medium borings; 12 shallow borings; 1 shallow soil sample; 7 surface soil samples.	38			
		IA-8: 6 deep borings; 38 medium borings; 30 shallow borings; 1 shallow soil sample; 19 surface soil samples.	138			
		IA-9: 9 medium borings; 4 shallow soil samples; 71 surface soil samples; 19 shallow soil samples.	110			
		IA-10: 2 medium borings; 4 shallow soil samples.	8			
		IA-11: 2 medium borings; 2 shallow soil samples.	6			
		IA-12: 1 deep boring; 30 medium borings; 7 shallow borings; 6 shallow soil samples.	74			
		IA-13: 3 medium borings; 31 shallow borings; 35 surface soil samples.	72			
TOTAL	862					

Table 2-1 (cont'd)

Planned Activity	Rationale/DQO	Description	Approx. Number of Samples	QA/QC Samples	Analyses	Analytical Data Category
Sampling of Storm Water	To monitor the potential impacts to Coldwater Creek from surface water runoff from SLAPS during intrusive site activities.	Collect 1 sample of storm water following each of four significant rain events from an established outfall or weir location.	4	QC only; 1 Dup, 4 Trip Blanks	Radiological and non-radiological constituents; alkalinity, total suspended solids, total dissolved solids, hardness, sulfate, nitrate, nitrite, ammonia, and chloride.  Field parameters - DO, screening (Level I), temp., Eh, conductivity, pH, turbidity, flow (weir height)	Definitive  Screening
Sampling of Waste Materials for Commercial Disposal	To support the IRAs for processing potentially excavated soil and IDW for off-site disposal.	Collect 4 soil samples from in-place "hot spot" locations where future excavation and off-site disposal of soils will occur. Sample collection and characterization for disposal.	4	NA	Gamma spec., U-and Th-isotopes, full TCLP + Cu and Zn, pH, paint filter, permeability, CN, ignitability, reactivity, moisture content, size class	Definitive
		Up to 10 samples of IDW (soil/rock cuttings, and decontamination fluids) are anticipated for characterization and disposal at Envirocare of Utah, Inc.	10	N/A	Gamma spec., U-and Th-isotopes, full TCLP + Cu and Zn, pH, paint filter, permeability, CN, ignitability, reactivity, moisture content, size class	Definitive
		Additional swipe samples may be required of any debris material encountered for radiological characterization.	Up to 20	N/A	Radiological constituents	Definitive
Sampling for Determination of Geotechnical and Engineering Properties	For engineering evaluation purposes and to assess potential migration pathways of PCOCs for FS.	The physical and chemical properties of each unconsolidated unit will be characterized in three (3) deep boreholes to determine site specific ground water flow potentials and aqueous modeling parameters. One sample will be collected from each of the six units (1,2,3T,3M,3B, and 4) in each borehole from coring.	18	5% QC (metals, rads.)	Porosity, permeability, percent moisture, bulk density, plasticity, particle size, metals, pH, Eh, radionuclides, anions, , total organic carbon, specific conductance	Definitive (metals, rads.)
		Also in-situ falling head hydraulic conductivity testing of the loess unit, which underlies the fill, will be conducted in two (2) excavated pits off-site to determined ground water recharge potentials.	2	NA	In-situ hydraulic conductivity	Screening

Table 2-1 (cont'd)

Planned Activity	Rationale/DQO	Description	Approx. Number of Samples	QA/QC Samples	Analyses	Analytical Data Category
Monitoring Well Installation and Surveying	To allow ground water sample collection and assess potential risks to ground water from primarily non-rad. constituents in support of FS.	Twelve shallow wells installed to a depth of 15 to 25 feet bgs. (including two off-site background). Three deep wells (including one background) installed to a depth of 70 to 90 feet bgs. Two background bedrock wells installed, one in limestone and one in shale.	NA	NA	Lithologic descriptions	NA
Downhole Borehole Geophysical Surveys	To evaluate and confirm construction hypothesis. Note: existing wells recently logged - data should be reviewed/summarized.	Downhole gamma and conductivity induction logging will be performed in all boreholes for all new monitoring wells (including background boreholes).	All new wells	NA	Total Gamma Electrical Conductivity	Screening
Ground water Well Sampling	For FS (see Well Installation, above) and to confirm 1997 baseline sampling results.	Initially, ground water samples will be collected from 24 existing monitoring wells including 5 background wells. After installation and development of 17 new wells, ground water samples will be collected from all 41 wells.	65	5% QA and 5% QC samples	Radiological and non-radiological constituents, ions, anions, tracers,  pH, temperature, redox, conductivity, DO and turbidity	Definitive  Screening

Table 2-2. Summary of OPTIMUM Planned Activities at SLAPS and CPs

Planned Activity	Rationale/DQO	Description	Approx. Number of Samples	QA/QC Samples	Analyses	Analytical Data Category
Soil Gas Survey	To focused potential VOC-source areas based on previous (BASIC) data, and to identify confirmatory (discretionary) soil sampling locations.	Collect additional passive soil gas samples in shallow buried absorbent media at 30-meter (100-ft) grid intervals or less.	up to 50 discretionary locations	QC only; 2 Dups, 1 Field Blank	VOCs (GC or GC/MS method)	Screening
Surface Geophysical Surveying	To support the IRAs (i.e. to identify buried debris) for Engineering Construction planning purposes based on aerial photograph information or other Geophysical data collected during BASIC data collection.	Perform electromagnetic survey over additional site areas over a regular grid (2-meter). An optional magnetic and GPR survey may be performed over the same area. An optional Electrical Imaging survey may be performed on four-1300 foot traverses.	10 acres of discretionary area	NA	Electromagnetics (EM-31, EM-61), Magnetics, GPR, Resistivity	Screening
Gamma Walkover Surveys	To support the delineation of boundary rad conditions and to guide selection of proposed surface soil samples for Th-230 purposes especially.	Perform gamma walkover surveys on a 1-meter grid pattern over additional site areas. In-situ gamma spectroscopy will be performed in areas having elevated gamma readings.	2 acres of discretionary area	NA	Total gamma	Screening
Soil Sampling	Data to be collected from unspecified, discretionary locations (approximately 20% of BASIC samples) to achieve adaptive sampling objectives per Data Management Plan. Allows on-site decision-making and collection of additional data as deemed necessary to supplement the FS or PAM.	19 deep borings; 34 medium borings; 29 shallow borings; 7 shallow soil samples 32 surface soil samples. <b>TOTAL</b>	38 68 29 7 32 174	5% QA and 5% QC samples	Radiological and non-radiological constituents  Radionuclides - Uranium (total), Radium-226, Thorium-230 and 232, Protactinium-231, Actinium-227; chemicals/metals - total TAL metals, VOCs, SVOCs, pesticides/PCBs, herbicides	Definitive
Soil Sampling for Remedial Indicator Parameter Correlation	Data will be used to determine if an indicator parameter may be used to screen rad.-contaminated soil with conventional field instruments (i.e. LIBS or XRF) Note: Existing data from BNI will also be used to evaluate potential correlation.	Soil samples will be collected and analyzed for metals and radiological parameters during the soil boring program. If a correlation exists, based on analytical testing, XRF/LIBS will be calibrated to analyze selected samples.	25	NA	Total TAL metals, indicator parameters, and radiological constituents  Metals - LIBS or XRF	Definitive  Screening

**Table 2-2 (cont'd)**

Planned Activity	Rationale/DQO	Description	Approx. Number of Samples	QA/QC Samples	Analyses	Analytical Data Category
<p>Sampling of Waste Materials for Commercial Disposal</p>	<p>To determine unexpected waste characteristics and evaluate additional IDW or other unexpected waste types.</p>	<p>Collect 4 soil samples from in-place "hot spot" locations where future excavation and off-site disposal of soils will occur. Sample collection and characterization for disposal.</p>	2	NA	<p>Gamma spec., U-and Th-isotopes, full TCLP + Cu and Zn, pH, CN, paint filter, permeability, ignitability, reactivity, density, moisture content, size class</p>	Definitive
		<p>Up to 10 samples of IDW (soil/rock cuttings, and decontamination fluids) are anticipated for characterization and disposal.</p>	5	NA	<p>Gamma spec., U-and Th-isotopes, full TCLP + Cu and Zn, pH, CN, paint filter, permeability, ignitability, reactivity, density, moisture content, size class</p>	Definitive
		<p>Additional swipe samples may be required of any debris material encountered for radiological characterization.</p>	Up to 10	NA	Radiological constituents	Definitive

TABLE 2-3

## List of Analytes for Air Sampling at SLAPS and CPs

Constituent	Location of Analysis	Analytical Method	Target Detection Limit <sup>1</sup>	Analytical Data Category	Data Use <sup>2</sup>
TAL Inorganics	Off-site laboratory	EPA SW-846 6010	Chemical specific as per method	Definitive	2, 3, 4
Total Suspended Particulates	Off-site laboratory	40 CFR, Part 50, Appendix B	NA	Definitive	2, 3, 4
PM-10	Off-site laboratory	40 CFR, Part 50, Appendix J	NA	Definitive	2, 3, 4
Total Alpha/Beta Radiation	Portable instrument/on-site laboratory	Ludlum 4310 Zinc Scintillator Detector with Ludlum 2929 Alpha/Beta Scales or Automated Gas Flow Proportional Counter/ Alpha Spectroscopy ML-005	1 pCi/g (on filter)	Screening/Definitive	4

<sup>1</sup> Target detection limits are analyte specific and matrix dependent. Detection limits for soils and sediments can be influenced greatly by matrix interferences.

<sup>2</sup> Data Use:

- 1 - Support interim removal actions.
- 2 - Support site-wide FS and ROD.
- 3 - Support PAM.
- 4 - Support health and safety activities.

NA - Not Applicable



TABLE 2-4

## List of Analytes for Soil, Soil Gas, and Waste at SLAPS and CPs

Constituent	Location of Analysis	Analytical Method	Target Detection Limit <sup>1</sup>	Analytical Data Category	Data Use <sup>2</sup>
TCL Volatile Organics	Off-site laboratory	EPA SW-8260	Chemical specific as per method	Definitive	1,2,3
Soil Gas - Charcoal Tube	Off-site laboratory	EPA SW-8260	Chemical specific as per method	Screening	3
TCL Semi-Volatile Organics	Off-site laboratory	EPA SW-8270 or SW-8010/8020	Chemical specific as per method	Definitive	1,2,3
TCL Pesticides	Off-site laboratory	EPA SW-8080	Chemical specific as per method	Definitive	1,2,3
TCL Polychlorinated Biphenyls	Off-site laboratory	EPA SW-8081	Chemical specific as per method	Definitive	1,2,3
Herbicides	Off-site laboratory	EPA SW-8150	Chemical specific as per method	Definitive	1,2,3
TAL Inorganics	Off-site laboratory	EPA 6010	Chemical specific as per method	Definitive	1,2,3
Mercury	Off-site laboratory	EPA SW-7471	0.2 ug/kg	Definitive	1,2,3
Total Nitrogen	Off-site laboratory	ASA - Methods of Soil Analysis	NA	Definitive	2
Boron	Off-site laboratory	EPA 6010	100 ug/kg	Definitive	2
Fluoride	Off-site laboratory	EPA 300 Ion chromatology or EPA SW-846 9056	1,000 ug/kg	Definitive	2
Sulfur (Sulfide)	Off-site laboratory	EPA SW-9030	TBD	Definitive	2
Titanium	Off-site laboratory	EPA 6010	TBD	Definitive	1
<b>Radionuclides</b>					
Ra-226	On-site laboratory	Gamma Spectroscopy ML-005	1 pCi/g	Definitive	1,2
Isotopic Th (227, 228, 230, 232)	On-site laboratory	Alpha Spectroscopy ML-005*	1 pCi/g	Definitive	1,2
Isotopic U (234, 235, 238)	On-site laboratory	Gamma Spectroscopy ML-005	1 pCi/g	Definitive	1,2
Ac-227	On-site laboratory	Gamma Spectroscopy ML-005	1 pCi/g	Definitive	1,2,3
Pa-231	On-site laboratory	Gamma Spectroscopy ML-005	3 pCi/g	Definitive	1,2,3
Soil Hydraulic Conductivity	Field test/off-site laboratory	See Appendix B/ASTM D 5084-90	NA	Screening/Definitive	2
Porosity	Off-site laboratory	ASTM E 1294	NA	Definitive	2
Permeability (standard proctor)	Off-site laboratory	ASTM D 698-91	NA	Definitive	1,2
Moisture Content	Off-site laboratory	ASTM D 2216-90	NA	Definitive	1,2
Bulk Density	Off-site laboratory	ASTM D 5057	NA	Definitive	2
Total Petroleum Hydrocarbons	Off-site laboratory	EPA 418.1	10 mg/kg	Definitive	1
Liquid Limit/Plasticity	Off-site laboratory	ASTM D4318-84	NA	Definitive	1
Particle Size	Off-site laboratory	ASTM D 422-63	NA	Definitive	1,2
Anions (SO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , CO <sub>3</sub> , HCO <sub>3</sub> )	Off-site laboratory	ASA Methods of Soil Analysis	Analyte specific as per method	Definitive	2
Eh	Field analysis	Electrometric	NA	Screening	2
Cyanide (total)	Off-site laboratory	EPA SW-9010	1,000 ug/kg	Definitive	1
Reactivity - Cyanide	Off-site laboratory	EPA SW-846-7-3/9010/9030	100 ug/kg	Definitive	1
Reactivity - Sulfide	Off-site laboratory	EPA SW-846-7-3/9010/9030	500 ug/kg	Definitive	1
Corrosivity (pH)	Off-site laboratory	EPA SW-846 9045	NA	Definitive	1
Flashpoint (ignitability)	Off-site laboratory	SW-1010	NA	Definitive	1
Paint Filter Test	Off-site laboratory	EPA SW-846 9095	NA	Definitive	1
Extractable Organic Halides	Off-site laboratory	EPA SW-846 9020	NA	Definitive	1
TCLP Regulated Chemicals (plus Cu and Zn)	Off-site laboratory	EPA 1311/6010/7471/8270/ 8081/8150/8260	Chemical specific as per method	Definitive	1,2
Specific Conductance	Field analysis	TBD	TBD	Screening	2

<sup>1</sup> Target detection limits are analyte specific and matrix dependent. Detection limits for soils and sediments can be influenced greatly by matrix interferences.

<sup>2</sup> Data Use:

1 - Support interim removal actions.

2 - Support site-wide FS and ROD.

3 - Support PAM.

4 - Support health and safety activities.

\*If the sample contains greater than 500 pCi/g of Th-230, based upon the gamma spectroscopy scan, then alpha spectroscopy will not be conducted and the results will be quantified by gamma spectroscopy only.

NA - Not Applicable

TBD - To Be Determined

TABLE 2-5

## List of Analytes for Ground Water and Stormwater at SLAPS and CPs

Constituent	Location of Analysis	Analytical Method	Target Detection Limit <sup>1</sup>	Analytical Data Category	Data Use <sup>2</sup>
TCL Volatile Organics	Off-site laboratory	EPA SW-846 8260	Chemical specific as per method	Definitive	2,3
TCL Semi-Volatile Organics	Off-site laboratory	EPA SW-846 8270	Chemical specific as per method	Definitive	2,3
TCL Pesticides	Off-site laboratory	EPA SW-846 8080	Chemical specific as per method	Definitive	2,3
TCL Polychlorinated Biphenyls	Off-site laboratory	EPA SW-846 8081	Chemical specific as per method	Definitive	2,3
TAL Inorganics	Off-site laboratory	EPA SW-846 6010	Chemical specific as per method	Definitive	2,3
Mercury	Off-site laboratory	EPA 245.1	0.2 ug/L	Definitive	2,3
Nitrate	Off-site laboratory	EPA 352.1	500 ug/L	Definitive	2
Nitrite	Off-site laboratory	EPA 354.1	500 ug/L	Definitive	2
Ammonia	Off-site laboratory	EPA 3501 or equivalent	500 ug/L	Definitive	2
Fluoride	Off-site laboratory	EPA 300.0 or equivalent	100 ug/L	Definitive	2
Chloride	Off-site laboratory	EPA 300.0 or equivalent	500 ug/L	Definitive	2
Phosphorous (total)	Off-site laboratory	EPA 365.1	500 ug/L	Definitive	2
Sulfate	Off-site laboratory	EPA 300	500 ug/L	Definitive	2
<b>Radionuclides</b>					
Isotopic Ra (226, 228)	On-site laboratory	Alpha spectroscopy ML-005	1 pCi/L	Definitive	2
Isotopic Th (227, 228 230, 232)	On-site laboratory	Alpha spectroscopy ML-005	1 pCi/L	Definitive	2
Isotopic U (234, 235, 238)	On-site laboratory	Alpha spectroscopy ML-005	1 pCi/L	Definitive	2
Total Uranium	On-site laboratory	EPA 908.0	1 ug/L	Definitive	2
Tritium, Carbon-14, Helium-3	Off-site laboratory	EPA 906.0	0.1 pCi/L	Definitive	2
Carbon-14	Off-site laboratory	TBD	TBD	Definitive	2
Helium-3	Off-site laboratory	TBD	TBD	Definitive	2
<b>Other Parameters</b>					
Alkalinity (as CaCO <sub>3</sub> )	Off-site laboratory	EPA 310.1	1 mg/L	Definitive	2
Hardness	Off-site laboratory	EPA 130.1 or 130.2	1 mg/L	Definitive	2
Total Suspended Solids	Off-site laboratory	EPA 160.2	4 mg/L	Definitive	2
Total Dissolved Solids	Off-site laboratory	EPA 160.1	10 mg/L	Definitive	2
Total Organic Carbon	Off-site laboratory	EPA 415.2	1 mg/L	Definitive	2
Eh	Field analysis	Electrometric		Screening	2
Temperature	Field analysis	Thermister	NA	Screening	2
Dissolved Oxygen	Field analysis	Meter	NA	Screening	2
pH	Field analysis	Meter	NA	Screening	2
Conductivity	Field analysis	Meter	NA	Screening	2
Turbidity	Field analysis	Nephelometer	NA	Screening	2

<sup>1</sup> Target detection limits are analyte specific and matrix dependent. Detection limits can be influenced greatly by matrix interferences.

<sup>2</sup> Data Use:

1 - Support interim removal actions; 2 - Support site-wide FS and ROD; 3 - Support PAM; 4 - Support health and safety activities.

NA - Not Applicable

TBD - To Be Determined

**APPENDIX A**

**Screening Procedures**

## Appendix A

### Screening Technologies to be Used at SLAPS

#### 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 R.E. Wright Environmental, Inc. (R.E. Wright). The dominant phase of the induced magnetic field



from normal earth materials is 90 degrees out of phase with the primary field, and 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 this, 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, R.E. Wright 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 used for data acquisition at this site was an EM terrain conductivity meter Model EM-31DL, by Geonics Limited of Mississauga, 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 was 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 was 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 went through a complete function check to assure proper operating conditions. The operator cataloged 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 were marked in such a fashion that the operator would be able to start at one marker and walk toward the second target. These markers consisted 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 could be located with reasonable accuracy. In the event a line of sight was not available from one end of the traverse to the other, or an abnormally long traverse was necessary, a set of mid-traverse markers was established to assist in survey location accuracy.

The survey was 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 orientation was oriented along the in-line axis. In the event of an obvious cultural interference such as fence, utility, or drain pipe, the boom was rotated until the interference reached a minimum. When the operator was 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 were transmitted to the data logger. During the course of the traverse, when a physical marker or anomaly was apparent, the operator was able to make note of the feature in the data file stored within the data logger. This permanent record would be available for

future reference. When this was completed, the operator moved to the next survey station location, typically 10 feet away. In the event of high winds, a helper attempted 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 were down-loaded from the data logger to a personal computer. These data were plotted out in tabular form for reference and profiled for initial interpretation and evaluation. All traverses were 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 could be maintained with a guarantee of data availability. By reviewing and performing an initial interpretation of the data, additional surveying could be planned to encompass any unusual findings brought to light by the survey. In this fashion, if additional data appeared necessary, or an unaccountable anomaly was present that needed to be resurveyed for verification, these activities could be planned and performed.

During the course of the traverse, the vertical dipole orientation was always recorded. At sites where depth-discriminatory information is believed to be useful, horizontal dipole orientation data are collected. The horizontal dipoles are 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 are 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 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. R.E. WRIGHT 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.

## **PROTOCOL AND PROCEDURES**

### **Electromagnetic Investigation**

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.

#### **Basic Principles**

Like all electromagnetic 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 (Figure B-1) 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. Terrain conductivity, measured in millimhos per meter (mmhos/m), is the inverse of resistivity, which is normally measured in ohms per meter.

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 electromagnetic field are measured. The quadrature phase of the electromagnetic field is measured to determine conductivity. In addition, the in-phase data are sometimes used to determine the existence of a very good subsurface conductor, such as metals. These data are normally presented in parts per thousand (ppt) of the primary field strength.

In some instances, the conductivity is recorded at varying intercoil spacings. It is sometimes useful to vary the dipole (transmitter and receiver antenna coils) to be horizontal or vertical. By changing

these two parameters, the subsurface may be investigated in a number of ways (Figure B-2). Typically, the further apart the coils are, the deeper the investigation. The horizontal dipole orientation is very near-surface sensitive, with 70 percent of the secondary field strength originating from (0.75 times the intercoil spacing). The vertical dipole orientation discriminates against the near surface, with the greatest sensitivity being 0.4 times the intercoil in the subsurface. With the vertical dipole orientation, 70 percent of the secondary field strength originates from 1.5 times the intercoil spacing. These sensitivities are shown on the Table A below:

TABLE A

Equipment	Intercoil Distance	Maximum Sensitivity		70% Signal Depth	
		H	V	H	V
EM-31	4.0 m 13.2 ft	0 ft	5.3 ft	9.0ft	19.8ft
EM-34	10.0 m 32.8 ft	0 ft	13.2 ft	24.6	49.2
EM-34	20.0 m 65.6 ft	0 ft	26.2 ft	49.2	98.4
EM-34	40 m 131.2 ft	0 ft	52.5 ft	98.4	196.8

#### 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, R.E. Wright Environmental, Inc. (R.E. Wright) personnel are highly experienced in the interpretation and evaluation of electromagnetic data. To be quantitatively meaningful, the survey results must be correlated with the results from confirmatory test borings, test pits, or other secondary evaluation technique.

#### Protocol

At the initiation of each day's surveying, the conductivity meter goes through a complete function check to assure proper operating conditions. The operator catalogs 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 are marked in such a fashion that the operator would be able to start at one marker and walk toward the second target marker. These markers frequently consist of wooden stakes or push flags driven into the ground, spray paint marks, or bits of flagging placed on nearby fencing or trees. Utilizing the hip chain for in-line distance measurements when using the EM-31, and knowledge of the location of the survey traverse end points, all geophysical data can be located with reasonable accuracy. The EM-34 utilizes a portion of the signal to define intercoil spacing. The coil locations and spacing provide the in-line positioning with this instrument. In the event 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 is established to assist in survey location accuracy.

The survey is conducted with the operator monitoring the quadrature phase (conductivity) component of the data to ensure proper scale and equipment orientation. Typically, the transmitter/receiver orientation is oriented along the in-line axis. In the event of an obvious cultural interference such as fence or utility, the EM-31 boom may be rotated until the interference reaches a minimum. When the operator is satisfied that the conductivity of the station being surveyed represented subsurface conditions, the information for the data are transmitted to the data logger. During the course of the traverse, when a physical marker or anomaly is apparent, the operator is able to make note of the feature in the data file stored within the data logger. This permanent record is available for future reference. When this is completed, the operator moves to the next survey station location, typically 10 feet away with the EM-31 or 10 meters (32 feet) using the EM-34. To minimize in-line distance distortions due to wind, the hip chain string can be weighted down using available sticks, stones, and rocks.

At the conclusion of the day, all data collected are down-loaded from the data logger to a personal computer. These data are plotted out in tabular form for reference and profiled for initial interpretation and evaluation. All traverses are 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, the surveying for the following day can be planned to encompass any unusual findings brought about by the day's activities. In this fashion, if additional data appeared necessary, or an unaccountable anomaly is present that needed to be resurveyed for verification, these activities can be planned and performed in a timely fashion.

### **Qualitative Interpretation Considerations**

The horizontal and vertical dipole orientations of the conductivity meter result in two different views of the subsurface. The vertical dipole orientation discriminates against near-surface anomalies. The horizontal dipole data are near-surface sensitive. By observing the similarities or the differences between the horizontal and vertical dipole data sets, a vertical sense of the subsurface can be gathered.

Metals in the subsurface dramatically increase the conductivity measured. 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 millimohs per meter. While the electronics of the instrument allow for conductivities up to 300 millimohs per meter 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 millimohs per meter to appear as negative conductivities. Although it is technically incorrect to present negative conductivity values, the availability of this information provides a rapid interpretive tool with relatively high accuracy.

The in-phase data set from the EM-31 is especially sensitive to metals. The response of this data set provides a screening tool to separate cultural interferences due to metals, from conductivity changes due to subsurface condition changes caused by other factors.



# **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 also connected to the backpack. The entire system is run from the polycorder which is also attached to the backpack. System power comes from the 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, change in surface characteristics, etc.).

### **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 just the depth to a particular reflector, but 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, but 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 (i.e. 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 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 (i.e. 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 (i.e. utility lines, etc.).

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. Mark 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*

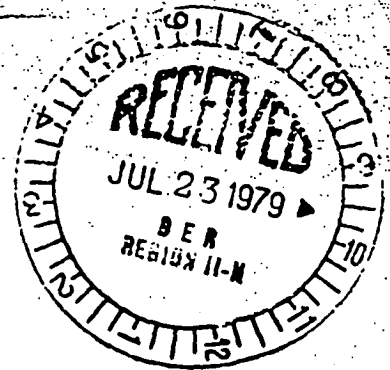
Actual data should be acquired in the same manner as the preliminary data but only after the preliminary tests have been conducted. When acquiring data, the strain relief clip must be attached to the antenna and the antenna must never be dragged over the cable when surveying. The record is annotated with fiducial markers at regular increments and at any notable point along a line (e.g. surface features, line direction change, change in surface characteristics, etc.). 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.

FIELD AND LABORATORY MEASUREMENT OF THE  
PERMEABILITY OF SATURATED AND PARTIALLY  
SATURATED FINE-GRAINED SOILS

State of the Art Paper for the  
ASTM Symposium on  
PERMEABILITY AND GROUNDWATER CONTAMINANT TRANSPORT



By:

Roy E. Olson and David E. Daniel

June 1979

Geotechnical Engineering Report GE79-1  
Department of Civil Engineering  
University of Texas at Austin



(1948) and applications discussed by van Bavel and Kirkham (1948), and Kirkham (1954). The relevant equation is:

$$k = \frac{\pi^2}{16} \frac{r}{Sd} \frac{\Delta h}{\Delta t} \quad (28)$$

where  $k$  is the coefficient of permeability (L/T),  $r$  is the radius of the well (L),  $S$  is a shape factor (dimensionless),  $d$  is the depth of the bottom of the hole below the water table (L),  $h$  is the height of water in the hole (L), and  $t$  is the time elapsed since the cessation of pumping (T). Values for the shape factor are shown in Fig. 17 (Spangler, 1951, p. 141). The solution applies only for an incompressible soil, a hole drilled down to an impervious base, and no drawdown of the water table (keep  $h/d$  less than 0.2). To simplify analysis, most users of the auger method appear to assume presence of an impervious base. Boersma (1965, pp. 223-229) has presented shape factors for an impervious base below the bottom of the hole but only for a range in values of  $d/r$  from 6 to 14.

The auger method is generally used only near the water table because of a tendency of the soil to fail by piping or sloughing. Further, the test can be used only in moderately pervious soils because of the slow rate at which the water level rises for less pervious soils. For example, if a four-inch diameter hole is drilled to a depth of six feet below the water table, the time needed for the water to rise from a depth of four feet to three feet, for a soil with  $k = 1 \times 10^{-6}$  cm/sec, is about 30 hours.

Testing using cased holes. For applications in geotechnical engineering it is common practice to case the soil either to prevent sloughing or to isolate flow to a single layer. Equations have been derived in a number of forms. For a constant head test a common form is:

$$k = q/FDh \quad (29)$$

where  $q$  is the flow rate ( $L^3/T$ ),  $F$  is a shape factor (dimensionless),  $D$  is hole diameter ( $L$ ), and  $h$  is the head loss ( $L$ ). For cases in which the bottom of the borehole is beneath the water table,  $h$  is the difference between the elevations of the water in the bore hole (use the equivalent elevation if the water has been pressurized) and the water table. If the base of the bore hole is above the water table then  $h$  is often taken as the depth of water in the bore hole. For falling head or rising head tests a common form for the equation is:

$$k = \frac{A}{FDt} \ln \frac{h_1}{h_2} \quad (30)$$

where  $A$  is the area of the standpipe and  $t$  is the time for the head to change from  $h_1$  to  $h_2$ .

For incompressible, homogenous, isotropic soils, Hvorslev (1951) tabulated the shape factors shown in Table 2. The factors for cases 4 through 6 are approximate. Case 6 is the one of major interest to geotechnical engineers.

Testing using porous probes. Field permeability tests are probably most easily performed by sealing a more-or-less cylindrical cavity at an appropriate depth with one or two tubes extending to the surface (Casagrande, 1949). The cylinder may be formed by drilling a bore hole and sealing a well point or porous stone in a sandfilled lower cylindrical portion (Casagrande, 1949) or by forcing into place a more-or-less cylindrical probe (Bjerrum and Johannessen, 1960; Wilkes, 1970; and Parry, 1971). The bore hole is often sealed just above the probe with bentonite, grout, or some other reasonably impervious material. Theoretical work by Vaughan (1969,

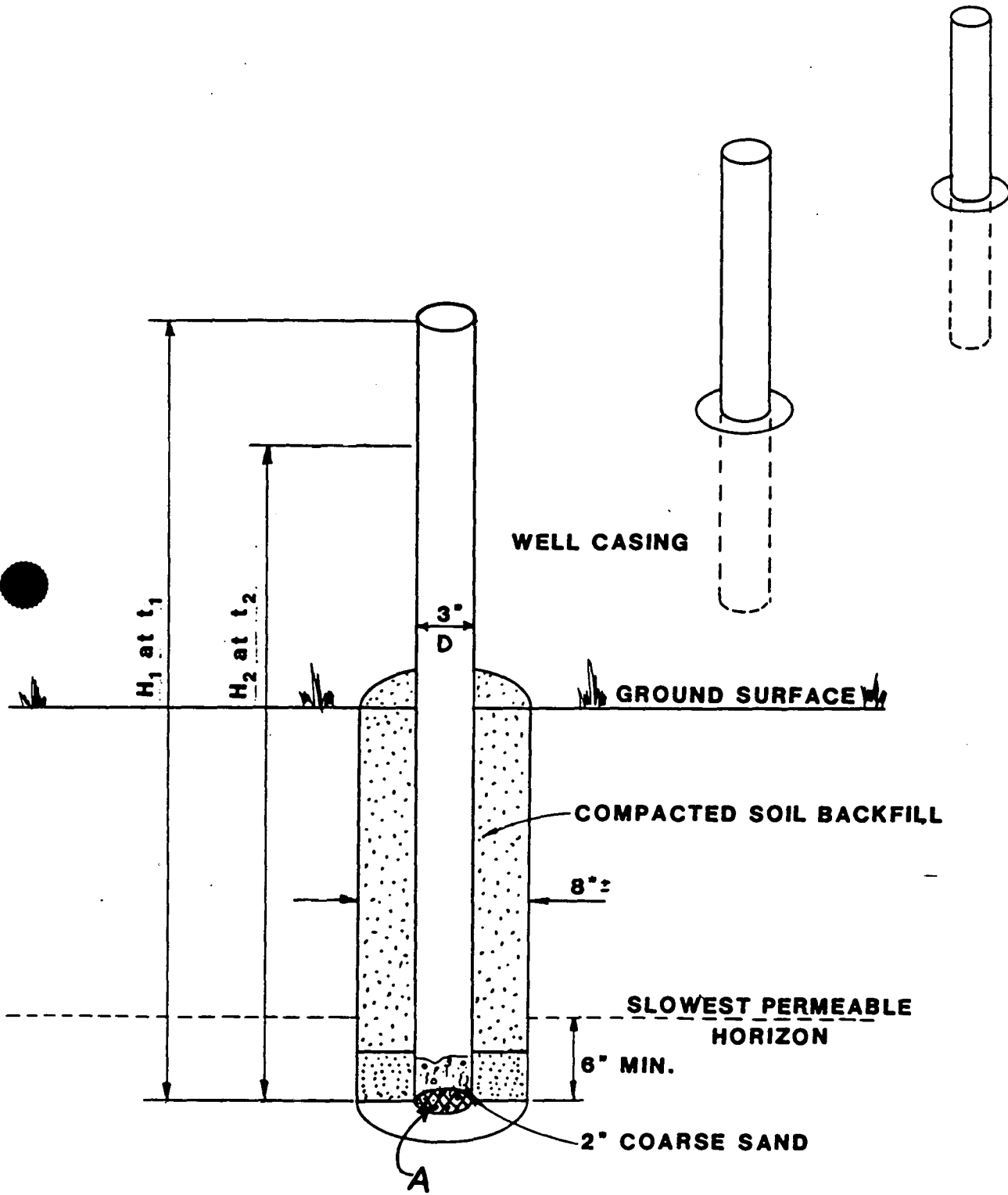
TABLE 2  
SHAPE FACTORS

Case	F	Condition	Source
1	$2\pi$	spherical tip in an infinite soil	Samsioe (1931) Dachler (1936)
2	$\pi$	hemispherical tip extending below an impervious upper boundary	Samsioe (1931) Dachler (1936)
3	2	borehole with a flat bottom at an upper impervious boundary	Forchheimer (1930) Dachler (1936)
4	2.75	cased borehole with a flat bottom in the middle of a deep soil layer	Hvorslev (1951) Harza (1935) Taylor (1948)
5	$\frac{2\pi(L/D)}{\ln(2L/D + \sqrt{1+(\frac{2L}{D})^2})}$	borehole with a flat bottom extending a distance L below an impervious upper boundary, no casing	Dachler (1936)
6	$\frac{2\pi(L/D)}{\ln(L/D + \sqrt{1+(\frac{L}{D})^2})}$	cased hole in a semi-infinite soil with an uncased section of length L below the casing	Dachler (1936)

FIGURE 1

# PERMEABILITY TEST

Dimensions and Illustration of the Units Used to Determine Soil Hydraulic Conductivity in a Falling Head Test



**APPENDIX C**

**Field Technical Procedures**

**APPENDIX C-1**

**SAIC Field Technical Procedures**

# SCIENCE APPLICATIONS INTERNATIONAL CORPORATION FIELD TECHNICAL PROCEDURE

**Title: Cleaning and Decontaminating Sample Containers and Sampling Equipment**

**Procedure No: FTP-405**

**Revision: 0**

**Date: 8/30/96**

**Page 1 of 14**

**Group Manager:**

**Date:**

**QA/QC Officer:**

**Date:**

*Walter C. Tibbitts*

*8/27/96*

*C. A. Conant*

*8/27/96*

## 1.0 PURPOSE

The purpose of this procedure is to describe decontamination methods and related issues involving the physical removal of chemical and radioactive contaminants from sample containers and sampling equipment.

## 2.0 SCOPE

This procedure is specifically applicable to the decontamination of the surfaces of sample containers and equipment that come in direct contact with actual samples during sample collection and processing. FTP-400 "Equipment Decontamination" addresses the decontamination of sampling and field equipment that does not directly contact samples.

## 3.0 REFERENCES, RELATED READING, AND DEFINITIONS

### 3.1 REFERENCES

- 3.1.1 Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, U.S. Environmental Protection Agency, Region IV Environmental Services Division, Georgia, February 1, 1991.
- 3.1.2 Science Applications International Corporation Quality Assurance Administrative Procedures (SAIC QAAPs).
- 3.1.3 Science Applications International Corporation Quality Assurance Program Plan (SAIC QAPP).
- 3.1.4 Science Applications International Corporation, Field Technical Procedure (SAIC FTP) 400, Equipment Decontamination.

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### 3.2 DEFINITIONS

- 3.2.1 Deionized Water - Tap water treated by passing through a standard deionizing resin column. The deionized water should contain no heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard Inductively Coupled Argon Plasma Spectrophotometer scan.
- 3.2.2 Equipment Those items (variously referred to a "field equipment" or "sample equipment") necessary for sampling activities which do not directly contact the samples.
- 3.2.3 Laboratory Detergent - A standard brand of phosphate-free laboratory detergent, such as Liquinox, or the equivalent.
- 3.2.4 Organic-free Water - Tap water treated with activated carbon and deionizing units or water from a Milli-Q system (or equivalent). This water should not contain pesticides, herbicides, extractable organic compounds, and less than 50 µg/l of purgeable organic compounds as measured by a low-level GC/MS scan. Organic free water should be stored only in glass or Teflon containers and dispensed from only glass, Teflon, or stainless steel containers.
- 3.2.5 Sampling Devices - Utensils and other implements used for sample collection and processing that directly contact actual samples.
- 3.2.6 Solvent - Pesticide grade isopropanol is the standard solvent used for decontamination in most instances. The use of any other solvent must be justified and approved by the responsible project personnel and documented in the field logbooks.
- 3.2.7 Tap Water - This refers to tap water from a tested and approved water system.



**4.0 RESPONSIBILITIES**

**4.1 GROUP MANAGER**

The Group Manager is responsible for approving this procedure.

**4.2 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) OFFICER**

The QA/QC Officer is responsible for:

4.2.1 approving this procedure; and

4.2.2 verifying that this and all appropriate procedures are followed.

**4.3 HEALTH AND SAFETY (H&S) OFFICER**

The H&S Officer is responsible for ensuring that appropriate SAIC and contractual H&S policies and procedures are in effect and verifying enforcement of same by line management.

**4.4 PROGRAM OR PROJECT MANAGER**

The Program or Project Manager is responsible for:

4.4.1 designating a qualified person to train personnel who will be using this procedure;

4.4.2 ensuring that all personnel are properly trained;

4.4.3 ensuring that this and all appropriate procedures are followed;

4.4.4 verifying that the appropriate training records are submitted to the Central Records Facility (CRF); and

4.4.5 ensuring that the program/ project has adequate and appropriate resources to be performed safely.

**4.5 FIELD MANAGER**

The Field Manager or designee is responsible for:

- 4.5.1 ensuring compliance with the Sampling and Analysis Plan (SAP);
- 4.5.2 ensuring that all personnel perform their assigned duties in accordance with this procedure when it is applicable;
- 4.5.3 overall management of field activities; and
- 4.5.4 ensuring that decontamination activities are performed safely.

**5.0 GENERAL**

- 5.1 It is SAIC policy to maintain an effective program to control employee exposure to chemical, radiological, and physical stress which is consistent with Occupational Safety and Health Administration (OSHA) established standards and requirements. Client specific (e.g., Department of Defense) requirements apply on a project specific basis.
- 5.2 Any deviations from specified requirements will be justified to and authorized by the Project Manager and/or the relevant Program Manager, and should be documented on the appropriate field change forms.
- 5.3 Deviations from requirements will be sufficiently documented to allow re-creation of the modified process.
- 5.4 Refer to the site- or project-specific H&S plan for relevant H&S requirements.
- 5.5 Refer to the SAP for project/task-specific sampling and analysis requirements.
- 5.6 SAIC and subcontractor personnel who use this procedure must provide documented evidence of having been trained in the procedure to the Program or Project Manager for transmittal to the CRF.
- 5.7 The objectives of decontamination are: to remove contamination from contaminated surfaces; to minimize the spread of contamination to uncontaminated surfaces; to avoid any cross-contamination of samples; and to minimize personnel exposures. The intent is to accomplish the required level of decontamination while minimizing the generation of additional solid and liquid waste.

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- 5.8 As a minimum, safety glasses or goggles, and nitrile or equivalent gloves will be worn while decontaminating equipment. Uncoated Tyvek coveralls, laboratory coat, or splash apron will be worn if justified by contaminant concentration and potential adverse effects. Face shield, heavy duty PVC or equivalent gloves, coated Tyvek or equivalent coveralls will be worn while cleaning with steam or high temperature water. Ground fault circuit interrupters will be used to supply power to any portable electrical equipment in the equipment decontamination area. Solvent rinsing will be conducted in an open, well ventilated area or under a fume hood. No eating, smoking, drinking, chewing, or hand to mouth contact will be permitted during decontamination activities. Refer to the site- or project-specific H&S plan for other relevant H&S requirements. A fifteen minute eyewash will be available within 100 feet of corrosive (concentrated acids or bases) decontamination fluids are used.
- 5.9 Refer to the SAP for project specific decontamination methods and schedules.
- 5.10 Procedures for packaging and disposal of all waste generated during field activities will be described in the project-specific SAP, Waste Management plan (WMP), or other applicable guidelines.
- 5.11 Decontamination of sampling devices will be performed in a designated decontamination area, removed from any sampling location. This designated area must also be in a location free of direct exposure to airborne and radiological surface contaminants.
- 5.12 Decontamination activities will be conducted downwind of the location where clean field equipment, clean sample devices, and sample containers are stored.
- 5.13 Contaminated or dirty sampling devices/sample containers are not stored with clean (decontaminated) sampling devices/sample containers.
- 5.14 Sample containers and sampling devices are segregated from all other equipment and supplies.
- 5.15 Paint or any other coatings must be removed from any part of a sampling device which may either contact a sample or which may otherwise affect sample integrity. After removal of such coatings, the sampling device will then require decontamination by the appropriate method.

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- 5.16 The brushes used to clean sampling devices must not be of the wire-wrapped type.
- 5.17 For any of the specific decontamination methods that may be used, the substitution of a higher grade water is permitted (e.g., the use of organic-free water in place of deionized water). However, it must be noted that deionized water and organic-free water are less effective than tap water in rinsing away the detergent during the initial rinse.
- 5.18 When appropriate, it may be required that decontaminated equipment be surveyed, inspected, and tagged by designated personnel.
- 5.19 Decontaminated sampling devices and all filled and empty sample containers will be stored in locations that are protected from exposure to any contaminant.
- 5.20 The method for decontamination of sampling devices and the exterior of sample containers which have been exposed to radioactive material is based on the material contaminated, the sample medium, the radiation levels, and the specific radionuclides to be removed.
- 5.21 In reference to decontaminated sampling devices and sample containers, their release for unrestricted use is based on site-specific criteria. These site-specific criteria should be found in the project work plans.
- 5.22 Rags used during decontamination may become a hazardous waste and require segregation. Refer to the project work plans for hazardous waste requirements.

## **6.0 PROCEDURE**

### **6.1 DECONTAMINATION SCHEDULES**

- 6.1.1 Sampling devices must be decontaminated prior to being used in the field, in order to prevent potential contamination of a sample.
- 6.1.2 Sampling devices must be decontaminated between samples to prevent cross-contamination.
- 6.1.3 Sampling devices must be decontaminated at the close of the sampling event prior to being taken off-site.

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6.1.4 An acceptable alternative to cleaning and decontaminating sampling devices is the use of items cleaned or sterilized by the manufacturer that are discarded after use. Care must be exercised to ensure such previously cleaned or sterilized items do not retain residues of chemical or radioactive sterilizing agents that might interfere with analytical techniques.

6.1.5 Whenever visible dirt, droplets of liquid, stains, or other extraneous materials are detected on the exterior of a sample container, the exterior surfaces must be decontaminated. This should be done before placing in a sample cooler or shipping container.

6.1.6 For sample containers used in controlled access areas, a more rigorous cleaning and/or radiation monitoring may be required before removal from the site. Refer to the project-specific work plan for details.

## 6.2 DECONTAMINATION METHODS

The following decontamination methods are examples of some of those most commonly used in field investigations. For the specific procedural requirements for any one project, task, or site, refer to the appropriate SAP.

Note: The decontamination methods described in this section are for guidance only; the Field Operations Manager will adjust decontamination practices to fit the sampling situation and applicable requirements.

### 6.2.1 Decontaminating the Exterior of Sample Containers in Use

6.2.1.1 Wipe the exterior surfaces of the sample container with disposable rags/toweling or rinse with deionized water.

6.2.1.2 If rinsing with deionized water, then the exterior of the sample container must be wiped dry with disposable rags/toweling.

6.2.1.3 All visible dirt, droplets of liquid, or other extraneous materials must be removed.

6.2.1.4 For containers used in controlled access areas or where the sample media is difficult to remove (e.g., sludge), a more rigorous cleaning and/or radiation monitoring may be required. Refer to the project-, task-, or site-specific Work Plan for details.

6.2.1.5 This decontamination procedure will be performed at the sample location before placing the sample container in the sample cooler or shipping container.

**6.2.2 Decontaminating Stainless Steel, Teflon, or Metal Sampling Devices Used to Collect Samples for Trace Organic Compounds and /or Metals Analyses.**

6.2.2.1 Clean with a tap water and laboratory detergent solution. Use phosphate-free detergent, such as Liquinox, or equivalent. Use a brush to remove particulate matter and surface film.

6.2.2.2 Rinse thoroughly with organic-free water.

6.2.2.3 Rinse twice with solvent (pesticide-grade isopropanol).

6.2.2.4 Allow to air dry for 24 hours, if possible.

6.2.2.5 If it is not possible to air dry for 24 hours, then rinse twice with organic-free water and allow to air dry as long as possible.

6.2.2.6 Wrap sampling devices with aluminum foil (with shiny side facing outward). This is done to prevent contamination of sampling devices during transport and storage.

6.2.2.7 When a sampling device is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the device several times with an approved solvent (one which meets the requirements of the SAP) before initiating decontamination. In extreme cases it may be necessary to steam clean, wire brush, or sandblast the sampling device prior to using this decontamination method. If the sampling device cannot be adequately cleaned utilizing the above means, it must be discarded.

**6.2.3 Decontaminating Glass Sampling Devices Used for the Collection of Samples for Trace Organic Compounds and/or Metals Analyses.**

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	<p>6.2.3.1 Glass sampling devices will be washed thoroughly with laboratory detergent and hot water using a brush to remove any particulate matter or surface film.</p> <p>6.2.3.2 Rinse thoroughly with hot tap water.</p> <p>6.2.3.3 Rinse thoroughly with tap water.</p> <p>6.2.3.4 Rinse twice with solvent and allow to air dry for at least 24 hours.</p> <p>6.2.3.5 Wrap with aluminum foil (with shiny side facing outward). This is done to prevent contamination during storage and/or transport to the field.</p>		
	<p><b>Note:</b> When a sampling device is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the device several times with an approved solvent (one which meets the requirements of the SAP) before initiating decontamination. In extreme cases it may be necessary to steam clean, wire brush, or sandblast the sampling device prior to using this decontamination method. If the sampling device cannot be adequately cleaned utilizing the above means, it must be discarded.</p>		
	<p>6.2.4 Decontamination of Silastic Rubber Pump Tubing Used in Automatic Samplers and Other Peristaltic Pumps.</p> <p>New cleaned tubing must be used for each automatic sampler set-up. The silastic rubber pump tubing need not be replaced in peristaltic pumps where the sample does not contact the tubing or where the pump is being used for purging purposes (i.e., not being used to collect samples).</p> <p><b>Note:</b> New tubing (certified clean by the manufacturer, or medical grade) may be used in lieu of cleaning. New tubing may be dedicated to a well or new tubing used for each sampling event or location.</p> <p>6.2.4.1 Flush tubing with hot tap water and phosphate-free laboratory detergent.</p> <p>6.2.4.2 Rinse tubing thoroughly with hot tap water.</p> <p>6.2.4.3 Rinse tubing with deionized water.</p>		

6.2.4.4 Install tubing in automatic sampler or peristaltic pump.

**6.2.5 Decontamination of Teflon Sample Tubing.**

Use only new Teflon tubing decontaminated as follows for collection of samples for organic compounds analyses:

6.2.5.1 Teflon tubing may be pre-cut in convenient lengths before cleaning to simplify handling.

6.2.5.2 Rinse outside of tubing with solvent.

6.2.5.3 Flush interior of tubing with solvent.

6.2.5.4 Dry overnight using a drying oven, if applicable.

6.2.5.5 Wrap tubing and cap ends with aluminum foil, or store in a plastic bag to prevent contamination during storage.

**6.2.6 Decontamination of Polyvinyl Chloride (PVC) Sample Tubing**

Use only new tubing

6.2.6.1 Polyvinyl chloride tubing will be used selectively where organic compounds are not of concern.

6.2.6.2 Tubing will be stored in its original container and not removed from this container until needed.

6.2.6.3 The tubing will be flushed immediately before use to remove any residues from the manufacturing or extruding process.

6.2.6.4 Discard tubing after use in sampling.

**6.2.7 Decontamination of Stainless Steel Tubing**

6.2.7.1 Wash with laboratory detergent and water using a long, narrow, bottle brush. Use hot water, if available.



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6.2.7.2 Rinse thoroughly with tap water. Use hot water, if available.

6.2.7.3 Rinse thoroughly with deionized water.

6.2.7.4 Rinse twice with solvent.

6.2.7.5 Allow to air dry for 24 hours, if possible.

6.2.7.6 If it is not possible to air dry for 24 hours, then rinse thoroughly with organic-free water and allow to dry for as long as possible.

6.2.7.7 Wrap with aluminum foil (with the shiny side facing outward). This is done to prevent contamination of tubing during transport and storage.

**Note:** When the tubing is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse it several times with an approved solvent before initiating decontamination. In extreme cases, it may be necessary to steam clean, wire brush, or sandblast the tubing prior to using this decontamination method. If it cannot be adequately cleaned utilizing the above means, it must be discarded.

#### 6.2.8 Decontamination of Glass Tubing

Use only new glass tubing, decontaminated as follows prior to use:

6.2.8.1 Rinse thoroughly with approved solvent.

6.2.8.2 Air dry for at least 24 hours.

6.2.8.3 Wrap tubing with aluminum foil (with shiny side facing outward) to prevent contamination during storage.

6.2.8.4 Discard tubing after use in sampling.

### 6.3 QUALITY CONTROL

6.3.1 The quality of the deionized and organic-free water used may be monitored by collecting samples in standard precleaned, sample containers and submitting them to the laboratory for a standard ICP scan. Organic-free water should be submitted for low-level pesticide, herbicide, extractable, or purgeable compounds analyses, as appropriate.

<b>SAIC FIELD TECHNICAL PROCEDURE</b>	<b>Procedure No.:</b>  <b>FTP-405</b>	<b>Revision:</b>  <b>0</b>	<b>Page:</b>  <b>12 of 14</b>
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- 6.3.2 Effectiveness of the decontamination procedures is monitored by submitting rinse water to the laboratory for low-level analysis of the parameters of interest. An attempt should be made to select different sampling devices, each time devices are washed, so that a representative sampling of all devices is obtained over the length of the project. Note in the field logbook the devices being used for the QC rinsate.

## 7.0 RECORDS

Documentation generated as a result of this procedure is collected and maintained in accordance with requirements specified in QAAP 17.1, Records Management.

## 8.0 ATTACHMENTS

- 8.1 Attachment I - Field Checklist
- 8.2 Attachment II - Allowable Residual Surface Contamination Limits for Unrestricted Release

**Attachment I  
Field Checklist**

- Logbook
- Safety Glasses or  
Monogoggles
- Gloves
- Safety Shoes
- Black, Indelible Pen
- Plastic Sheets
- Decontamination Equipment
- Health and Safety Plan
- Sampling and Analysis Plan
- Appropriate Containers for Waste  
and Equipment
- Monitoring Instruments

**Attachment II  
Allowable Residual Surface Contamination Limits for Unrestricted Release**

<b>Nuclide</b>	<b>Average<sup>b,c</sup> (dpm/100 cm<sup>2</sup>)</b>	<b>Maximum<sup>b,c</sup> (dpm/100 cm<sup>2</sup>)</b>	<b>Removeable<sup>b,e</sup> (dpm/100 cm<sup>2</sup>)</b>
U-nat, U-235, U-238, and associated decay products	5,000 alpha	15,000 alpha	1,000 alpha
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231	100	300	20
Ac-227, I-125, I-129, Th-nat, Th-232, Sr-90, Ra-223, Ra-234, U-232, I-126, I-131, I-133	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except SR-90 and others noted above.	5,000 beta- gamma	15,000 beta- gamma	1,000 beta- gamma

- a Where surface contamination by both alpha- and beta-gamma emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.
- b As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
- c Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.
- d The maximum contamination level applies to an area of not more than 100 cm<sup>2</sup>.
- e The amount of removable radioactive contamination per 100 cm<sup>2</sup> of the surface area should be determined by wiping the area with dry filter paper or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface area should be wiped.

Source: US NRC Regulatory Guide 1.86. June 1974.

# SCIENCE APPLICATIONS INTERNATIONAL CORPORATION FIELD TECHNICAL PROCEDURE

Title: Packaging and Shipping of Environmental Field Samples

Procedure No: FTP-650

Revision: 0

Date: 8/30/96

Page 1 of 12

Group Manager:

Date:

QA/QC Officer:

Date:

*Walter C. Tidwell* 8/27/96

*C. E. Conroy* 8/27/96

## 1.0 PURPOSE

The purpose of this procedure is to describe the minimum requirements to properly package containers of samples for transport.

## 2.0 SCOPE

This procedure applies to samples collected in the course of environmental field investigations and monitoring activities.

## 3.0 REFERENCES, RELATED READING, AND DEFINITIONS

### 3.1 REFERENCES

3.1.1 Code of Federal Regulations, Title 40, Protection Of Environment.

3.1.2 Code of Federal Regulations, Title 49, Transportation.

3.1.3 Dangerous Goods Regulations. International Air Transport Association (IATA), latest revision.

3.1.4 Science Applications International Corporation, Quality Assurance Administrative Procedures (SAIC QAAP).

3.1.5 Science Applications International Corporation, Quality Assurance Program Plan (SAIC QAPP).

3.1.6 Science Applications International Corporation, Field Technical Procedures (SAIC FTP) 405, Cleaning and Decontaminating Sample Containers and Sample Equipment.

3.1.7 Science Applications International Corporation, Field Technical Procedures (SAIC FTP) 625, Chain of Custody.

### **3.2 DEFINITIONS**

None.

### **4.0 RESPONSIBILITIES**

#### **4.1 GROUP MANAGER**

The Group Manager is responsible for approving this procedure.

#### **4.2 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) OFFICER**

The QA/QC Officer is responsible for:

4.2.1 approving this procedure; and

4.2.2 verifying that this procedure is being implemented.

#### **4.3 HEALTH AND SAFETY (H&S) OFFICER**

The H&S Officer is responsible for ensuring that appropriate SAIC and contractual H&S policies and procedures are in effect and verifying enforcement of same by line management.

#### **4.4 PROGRAM OR PROJECT MANAGER**

The Program or Project Manager is responsible for:

4.4.1 designating a qualified person to train personnel who will be using this procedure;

4.4.2 ensuring that all personnel are properly trained;

4.4.3 ensuring that this and all appropriate procedures are followed;

4.4.4 verifying that the appropriate training records are submitted to the Central Records Facility (CRF); and

4.4.5 ensuring that the program/project has adequate and appropriate resources to be performed safely.

**4.5 FIELD MANAGER**

The Field Manager is responsible for:

- 4.5.1 ensuring that all personnel perform their assigned duties in accordance with this procedure when it is applicable;
- 4.5.2 ensuring compliance with the Sampling and Analysis Plan (SAP);
- 4.5.3 overall management of field activities; and
- 4.5.4 ensuring that sample packaging and shipping is performed safely.

**5.0 GENERAL**

- 5.1 It is SAIC policy to maintain an effective program to control employee exposure to chemical, radiological, and physical stress which is consistent with Occupational Safety and Health Administration (OSHA) established standards and requirements. Client specific (e.g., Department of Energy or Department of Defense) requirements apply on a project-specific basis.
- 5.2 Any deviations from specified requirements will be justified to and authorized by the Project Manager and/or the relevant Program Manager.
- 5.3 Deviations from requirements will be sufficiently documented to allow re-creation of the modified process.
- 5.4 Refer to the site- or project-specific H&S Plan for relevant H&S requirements.
- 5.5 SAIC and subcontractor personnel who use this procedure must provide documented evidence of having been trained on the procedure to the Program or Project Manager for transmittal to the CRF.
- 5.6 Receivers and carriers are to be contacted prior to packaging to ascertain any specific restrictions, such as weight limits, delivery and pick up schedules, receiving hours, or sample disposal terms.
- 5.7 Individual sample containers are checked against accompanying chain-of-custody and analytical request forms prior to signing for receipt from sample collection personnel.

- 5.8 Site samples are placed in strong exterior shipping packages and surrounded with compatible cushioning/absorbent material, if necessary.
- 5.9 The shipping package is labelled and marked in accordance with U.S. Department of Transportation (DOT) and/ or International Air Transport Association (IATA) regulations and carrier or receiver-specific instructions. DOT applies primarily to ground transport and IATA applies to air cargo transport.
- 5.10 The chain-of-custody form must accompany the package as specified in the approved Chain-of-Custody procedure. The package is closed and sealed, as appropriate, and any required shipping papers prepared.
- 5.11 An example (non-mandatory) Cooler Shipping Description Log is provided as Attachment III, which may be useful for projects which require detailed cooler contents information in a logbook.

## **6.0 PROCEDURE**

### **6.1 SAMPLE CLASSIFICATION**

The sample team leader classifies each sample as environmental or one of several categories of hazardous material/ dangerous goods as defined by the DOT (49 CFR) and the IATA Dangerous Goods Regulations.

#### **6.1.1 Environmental Samples**

A sample that does not meet the criteria for any of the nine hazard classes identified in this section is an environmental sample.

**Note:** The vast majority of soil, groundwater, and surface water samples are environmental samples.

#### **6.1.2 Hazardous Materials/ Dangerous Goods**

A sample that meets the criteria for one or more of the following classes of hazardous materials/ dangerous goods must be shipped per the requirements of 49 CFR if a surface shipment or by the requirements of the IATA Dangerous Goods regulations if an air shipment.



**Note:** There are additional requirements beyond the mechanics of shipping including hazardous materials awareness, safety, and function specific training every two years.

**Class 1. Explosives-** any substance or article which is designed to explode or capable of exploding. If the sample team leader has knowledge that a sample contains a sufficient quantity/ concentration of explosive compound(s) to meet this criterion, the sample must be shipped as an explosive.

**Note:** Notification must be made to the Project Manager and Group H&S Officer prior to shipment or handling. Under no circumstances ship or otherwise handle explosive devices.

**Class 2. Gases-** cylinders of compressed gasses such as acetylene, nitrogen, air, oxygen, etc.

**Note:** Field samples do not normally include compressed gases.

**Class 3. Flammable liquids-** liquids with flash points less than 140°F such as gasoline, toluene, isopropyl alcohol, or a mixture known to contain more than 1% (10,000 ppm) of a flammable liquid [49 CFR 173.120(ii)].

**Note:** A useful field indicator that a sample may be a flammable liquid is a reading with a combustible gas indicator greater than 20% LEL in the head space of the sample container.

**Class 4. Flammable solids-** substances liable to spontaneous combustion, substances which, in contact with water, emit flammable gases- wetted explosives, self reactive materials, readily and spontaneously combustible materials. If the sample team leader has knowledge that a sample contains a sufficient quantity/ concentration of such materials to meet any of these criteria, the sample must be shipped as Class 4.

**Note:** These are highly reactive materials and will generally not be encountered in an unreacted state during environmental sampling unless samples are collected from intact containers. Notification must be made to the Project Manager and Group H&S Officer prior to shipment or handling.

**Class 5. Oxidizing substances and organic peroxides-** materials such as swimming pool chlorine, that will release oxygen in contact with organic materials and organic compounds containing the -O-O- structure which may be considered as derivatives of hydrogen peroxide (at greater than

1% concentration). If the sample team leader has knowledge that a sample contains a sufficient quantity/ concentration of such materials to meet either of these criteria, and has not previously reacted with materials in the immediate environment, the sample must be shipped as Class 5. **Note:** These are highly reactive materials and will not generally be encountered in an unreacted state in environmental sampling unless samples are collected from intact containers. Notification must be made to the Project Manager and Group H&S Officer prior to shipment or handling.

**Class 6. Poisonous and infectious substances-** materials with an acute oral LD<sub>50</sub> of not more than 500 mg/kg (liquid) or 200 mg/kg (solid) or a viable organism that causes or may cause disease in humans or animals. **Note:** Potentially poisonous samples are samples known to contain percent (not ppm) concentrations of mercury, tetrachloroethane, or other DOT defined poisonous materials. Potentially infectious substances are hospital (and related) wastes, and biological warfare agents.

**Class 7. Radioactive materials-** a material with > 0.002  $\mu$ Ci/ gram. **Note:** A sample may meet the definition of radioactive material if it produces a radiological survey instrument reading (in counts per minute) in excess of 200% of regional background readings. Note that this is a conservative number and should be considered as a flag indicating the need for further investigation. Notification must be made to the Project Manager and Group H&S Officer prior to shipment.

**Class 8. Corrosive material-** materials capable of causing destruction or irreversible skin damage from a contact period of four hours or less. **Note:** Generally, this applies to materials with a pH of less than 2 or more than 12. DOT letters of interpretation specifically exclude preserved water samples from this class if the weight percent of preservative(s) in the samples is less than specified limits. (See Attachment I).

**Class 9. Miscellaneous Hazardous Material-** a material that has a property that would impair the performance of an aircraft crew member, a hazardous waste requiring a manifest, a hazardous substance that exceeds the reportable quantity in one package, and dry ice, among many other things.

**Note:** A soil or water sample containing unknown concentrations of contaminants does not meet this definition. Samples of a material that is known (identified) as hazardous waste do meet this definition. A sample preserved with dry ice also fits this class.

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## **6.2 SAMPLE PACKAGING, LABELING, AND MARKING**

### **6.2.1 Environmental Samples**

Samples shipped to a laboratory for the purpose of testing are exempt from the requirements of 40 CFR 261 through 268 or Part 270 or Part 124 or the notification requirements of section 3010 of the Resource Conservation and Recovery Act (RCRA). Environmental samples will be packaged as follows:

- a) Clean exterior of filled sampled container (See FTP-405);
- b) Attach a label to the sample bottle;
- c) Seal the tops of bottles, except VOA vials, with appropriate tape or other secure fastening;
- d) Apply custody seals;
- e) Place each sample bottle in a plastic bag, squeeze as much air as possible from the bag, seal the bag;
- f) Prepare the shipping container (cooler) by taping the drain plug shut from the inside and outside, lining the cooler with a large heavy-duty plastic bag, and placing approximately 1 inch of packing material such as vermiculite, perlite, or bubble wrap in the bottom of the bag liner;
- g) Place the sample container upright in the cooler;
- h) Add sufficient ice to maintain the samples at the required temperature and include a temperature blank, when required;
- i) Fill the cooler with appropriate sorbent/ padding;
- j) Tape the liner shut;
- k) Seal the laboratory paperwork inside a plastic bag and tape it to the inside of the cooler lid;
- l) Place signed custody seals on the front and back of the cooler; and
- m) Assure that the following information accompanies the samples:  
sample collector's name, mailing address, and telephone number,  
laboratory's name, mailing address, and telephone number, quantity  
of sample, date of shipment, and description of the samples.

**Note:** The steps described in a) through m) above are typical, but may be modified by the Field Operations Manager in accordance with a project-specific Sampling and Analysis Plan.

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### 6.2.2 Hazardous Materials/ Dangerous Goods/ Radioactive Materials

Packaging for samples of hazardous materials/ dangerous goods/ radioactive materials must meet the requirements for environmental samples as well as additional requirements of DOT and IATA (if the sample will be shipped by air).

**Note:** This procedure cannot address all the requirements of the regulations. Expert advice must be obtained prior to shipping hazardous materials/ dangerous goods. Shipping firms such as Federal Express and UPS have hazardous materials/ dangerous goods departments which can provide specific guidance on packaging and other shipping requirements.

- a) Identify the appropriate packaging by referring to IATA Dangerous Goods Regulations (for air shipments) or 49 CRF (DOT) for surface shipments, or by contacting other sources such as the air carrier's hazardous materials department;
- b) Pack the sample(s) in the appropriate packaging;
- c) Mark each outer package with the proper shipping name, hazard class, packaging group, UN/ NA ID number, shipper's or consignee's name, address and telephone number, and "this end up" labels if inner containers hold liquid hazardous material;  
**Note:** Most of these marking requirements are fulfilled by the dangerous goods airbill.
- d) Affix a label indicating the DOT/ IATA hazard class on at least two sides of the package and next to the proper shipping name unless there is a limited quantity exemption.

### 6.3 ASSOCIATED DOCUMENTATION

#### 6.3.1 Environmental Samples

Chain of Custody Record (See FTP-625)  
Custody Seal (See Attachment II)  
Sample Label (See Attachment III)

<b>SAIC FIELD TECHNICAL PROCEDURE</b>	<b>Procedure No.:</b>  <b>FTP-650</b>	<b>Revision:</b>  <b>0</b>	<b>Page:</b>  <b>9 of 12</b>
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### 6.3.2 Hazardous Materials/ Dangerous Goods

Bill of Lading- If the sample is hazardous materials/ dangerous goods, the hazardous materials/ dangerous goods bill of lading must be prepared in addition to the documents required for an environmental sample. Information on the bill of lading must include; identity of hazardous materials by proper DOT shipping description, the quantity of each hazardous material, emergency response information, the date, an emergency number (619-546-6965), the shipper, the carrier, and the consignee.

Note: The air carrier's dangerous goods airbill meets the requirements for the bill of lading.

## 7.0 RECORDS

Documentation generated as a result of this procedure is collected and maintained in accordance with requirements specified in QAAP 17.1, Records Management.

## 8.0 ATTACHMENTS

- 8.1 Attachment I - Table 1, Limits of Water Sample Preservative Excluded from DOT Regulation
- 8.2 Attachment II - Custody Seal and Sample Label (Examples)
- 8.3 Attachment III- Cooler Shipping Description Log (Example)

Attachment I  
Table 1

Limits of Water Sample Preservative Excluded from DOT Regulation  
(Water samples that fall within the categories below are not hazardous materials)

Preservative	Weight percent of preservative <sup>1</sup>	Approximate pH <sup>2</sup>	Approximate quantity added to water sample <sup>3</sup>
HCl	≤ 0.04%	≥ 1.96	≤ 1.1 mL of conc. (38%)/L
HgCl <sub>2</sub>	≤ 0.004%	NA	≤ 40mg/L
HNO <sub>3</sub>	≤ 0.15%	≥ 1.62	≤ 2.1 mL of conc. (70%)/L
H <sub>2</sub> SO <sub>4</sub>	≤ 0.35%	≥ 1.15	≤ 2mL of 36 N/L
NaOH	≤ 0.08%	≤ 12.3	≤ 2mL of 10 N/L

- <sup>1</sup> The DOT letters of interpretation exclude water samples from treatment as hazardous material if the weight percent of preservative is less than these concentrations. The numbers in this column are from the EPA regulations (40 CFR 136.3(e) footnote to Table II, revised April, 1994) because that is the reference quoted by DOT Hotline personnel.
- <sup>2</sup> The EPA (40 CFR 136.3(e) footnote to Table II, revised April, 1994) provides these pH levels as corresponding with the maximum concentration of acid or base added to distilled water.
- <sup>3</sup> This column presents the quantity of preservative (calculated by SAIC) required to reach the DOT weight percent limits.

<b>SAIC FIELD TECHNICAL PROCEDURE</b>	<b>Procedure No.:</b>  <b>FTP-650</b>	<b>Revision:</b>  <b>0</b>	<b>Page:</b>  <b>11 of 12</b>
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**Attachment II**

**Sample Label (Example)**

**Lab: Southwest Laboratory of**



**Sample ID: B12ss-001-0378-S0**

**Area: Building 1200**

**Station: B12ss-001**

**Media: Surface Soil**

**Type: Grab Composite**

**Analysis: SVOC, Pest/PCB, Explosives**

**Preserv: Cool, 4C**

**Rad Screen:** \_\_\_\_\_

**Collection Date/Time:** \_\_\_\_\_

**Comment:** \_\_\_\_\_

**Collected by:** \_\_\_\_\_

**Custody Seal (Example)**

<b>SECURITY SEAL</b>	<b>DATE</b> _____
<b>DO NOT TAMPER</b>	<b>INITIALS</b> _____

Attachment III  
(Example)

**COOLER SHIPPING DESCRIPTION LOG**

PROJECT NAME: \_\_\_\_\_ PROJECT NO. \_\_\_\_\_

COOLER NO: \_\_\_\_\_ AIR BILL NO. \_\_\_\_\_ DATE: \_\_\_\_\_

**COOLER CONTENT INFORMATION**

TOTAL NUMBER OF SAMPLES IN COOLER: \_\_\_\_\_

ALL SAMPLES CLASSIFIED AS ENVIRONMENTAL: YES \_\_\_ NO \_\_\_

IF NO, NUMBER OF SAMPLES IN THE FOLLOWING CATEGORIES:

Flammable liquid - DOT/IATA Class 3 \_\_\_\_\_

Poisonous material - DOT/IATA Class 6 \_\_\_\_\_

Radioactive material - DOT/IATA Class 7 \_\_\_\_\_

Corrosive material - DOT/IATA Class 8 \_\_\_\_\_

Hazardous waste/substance - DOT/IATA Class 9 \_\_\_\_\_

APPROVAL TO SHIP: YES \_\_\_ NO \_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

SIGNATURE: \_\_\_\_\_  
(Shipper)



**SCIENCE APPLICATIONS INTERNATIONAL CORPORATION  
QUALITY ASSURANCE TECHNICAL PROCEDURE**

**Title: Handling and Control of Sampling Documentation**

**Procedure No: TP-DM-300-12**

**Revision: 2**

**Date: 9/20/96**

**Page 1 of 10**

**Group Manager:**

*Robert C. Tidwell*

**Date:**

*9/20/96*

**QA/QC Officer:**

*C. B. Covert*

**Date:**

*9/20/96*

**1.0 PURPOSE**

The purpose of this procedure is to describe the process for handling and controlling all sampling documentation from the time the data management team delivers relevant documents to the field team until archival. The documentation system provides the means to individually identify, track, and monitor each sample from point of collection through final data reporting.

**2.0 SCOPE**

This procedure applies to the handling and control of sampling documentation. It does not apply to the proper completion of documentation. Rather than discussing the handling and control of each type of logbook as a separate issue, this procedure treats logbooks as a single item. In addition, the procedure does not discuss in detail handling and control of sampling documentation by the analytical laboratory. The laboratory will follow procedures outlined by the Quality Assurance Project Plan (QAPjP) and Laboratory Quality Assurance Plan (LQAP).

**3.0 REFERENCES AND DEFINITIONS**

**3.1 REFERENCES**

- 3.1.1 See common references at the front of the Data Management Manual.
- 3.1.2 U.S. Department of Energy. 1987. "Field Sampling Protocols and Guidance," The Environmental Survey Manual. Appendix F. Washington: Government Printing Office.
- 3.1.3 U.S. Environmental Protection Agency. 1988. User's Guide to Contract Laboratory Program. EPA/504/8-89/012. Washington: Government Printing Office, December.

<b>SAIC QA TECHNICAL PROCEDURE</b>	<b>Procedure No.:</b>  <b>TP-DM-300-12</b>	<b>Revision:</b>  <b>2</b>	<b>Page:</b>  <b>2 of 10</b>
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3.1.4 U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. 1987. Data Quality Objectives for Remedial Response Activities, Development Process. 9355.0-7B. Washington: Government Printing Office, March.

3.1.5 Federal Records Management Amendments of 1976.

3.1.6 U.S. Environmental Protection Agency. 1986. Example Standard Operating Procedures for Contract Laboratory Program (CLP) Laboratories. Lakewood, Colorado: National Enforcement Investigations Center, March.

3.1.7 U.S. Department of Energy. 1991. "Records Management Program," DOE Order 1324.5A. Washington: Government Printing Office, September.

3.1.8 U.S. Environmental Protection Agency. 1989. RCRA Facility Investigation Guidance. EPA 530/SW-89-031. Washington: Government Printing Office.

### 3.2 DEFINITIONS

3.2.1 Chain-of-Custody (COC) Form - A form (usually pressure sensitive and duplicate or triplicate) that is used to document all transfers of possession of an environmental sample from time of collection until final disposition. A COC form is identified by a unique number printed or entered on the form.

3.2.2 Custody - The U.S. EPA National Enforcement Investigations Center defines custody of evidence in the following ways: (1) it is in your actual possession; (2) it is in your view, after being in your physical possession; (3) it was in your possession and then you locked or sealed it up to prevent tampering; or (4) it is in a secure area.

3.2.3 Environmental Sample - Physical evidence collected for environmental measuring and monitoring.

3.2.4 Field Logbook - A bound book with numbered pages containing at a minimum, a table of contents, task team activity log sheets, and sample log sheets. Field logbooks are used to permanently record information pertaining to the actual sample collection event.

<b>SAIC QA TECHNICAL PROCEDURE</b>	<b>Procedure No.:</b>  <b>TP-DM-300-12</b>	<b>Revision:</b>  <b>2</b>	<b>Page:</b>  <b>3 of 10</b>
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- 3.2.5 Nonconformance Report (NCR) - Formal documentation of a condition adverse to quality that includes a summary of the problem, the recommended corrective action, the organization or person who will implement the corrective action, and the completion date.
- 3.2.6 Sample Container Label - A waterproof paper or plastic, pressure-sensitive, gummed label placed on the sample container. Information regarding the sampling activity is recorded on the label and the label is attached to the appropriate sample container.
- 3.2.7 Sample Container Tag - A tag of cardboard, plastic, or other rigid material that is an exact representation of the sample label. It is firmly attached with string, waterproof tape, or rubber bands to the sample container and provides evidence and a permanent record of samples received by the analytical laboratory.
- 3.2.8 Sample Identification (ID) Number - A unique number assigned to a sample that will be used to trace the sample from its origin to final reporting of data. Features of the ID may be used to identify the sampling location, installation type, sequential sample number, the media (i.e., air, water, or soil/sediment) sampled, or other pertinent descriptive information.
- 3.2.9 Sample Seal - Waterproof or plastic tape with gummed back used to make it possible to determine whether samples have been tampered with following sample collection and prior to the time of analysis. The seal is attached in such a way that it is necessary to "break" the seal in order to open the sample container, either an individual sample container or a shipping container, such as an ice chest. Seals are affixed to the containers before they leave the custody of the sampling team personnel.

#### 4.0 RESPONSIBILITIES

4.1 See common responsibilities at the front of the Data Management Manual.

#### 4.2 TASK LEADER

The Task Leader is responsible for ensuring that personnel in his or her area of responsibility receive appropriate training in Handling and Control of Sampling Documentation.

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**4.3 FIELD SAMPLING TEAM LEADER**

The Field Sampling Team Leader is responsible for assisting in the preparation of the Sampling and Analysis Plan (SAP) and its implementation; coordinates the actual content of the field logbooks (i.e., the number and types of samples per logbook, types of forms to include within the logbook, the need for blank forms, etc.); assigns sampling team members to teams; coordinates and prepares for field sampling activities; and oversees all field data collection, recording, and documentation activities.

**4.4 FIELD SAMPLING TEAM MEMBERS**

The Field Sampling Team Members are responsible for assisting the Field Sampling Team Leader by collecting required field samples, recording information about the sampling event, tagging and labeling sample containers, and handling sampling documentation. A Field Sampling Team Member other than the recorder performs a QA review to verify the accuracy, completeness, legibility, consistency, and clarity of documentation entries.

**4.5 DATA COORDINATOR**

The Data Coordinator is responsible for preparing documentation for the sampling team and over the course of the project receives documentation from project staff and the laboratory and submits it to the project file. The Data Coordinator is also responsible for coordinating the copying of logbooks and the data entry and verification of field data, as required.

**4.6 ANALYTICAL LABORATORY**

The Analytical Laboratory is responsible for receiving samples and documentation, completes documentation as appropriate, and returns it to the Data Coordinator. The laboratory documents handling of the samples at the laboratory as required by the QAPjP or LQAP.

**5.0 GENERAL**

5.1 Compliance with procedures is mandatory. Compliance will be evaluated by periodic audits, surveillances, reviews, or inspections.

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5.2 All personnel involved in field sampling activities and the completion of sampling documentation will be appropriately trained. Successful completion of training must be documented and the documentation must be submitted to the Central Records Facility

## 6.0 PROCEDURE

### 6.1 FIELD LOGBOOKS

- 6.1.1 The Data Coordinator prepares draft logbooks for requested samples.
- 6.1.2 The Field Sampling Team Leader performs a QA review of the draft logbooks.
- 6.1.3 The Data Coordinator makes any needed revisions; has the logbooks bound; records titles and numbers of logbooks; and submits the listing of logbook titles and numbers to the project file.
- 6.1.4 The Data Coordinator delivers the logbooks to the Field Sampling Team Leader.
- 6.1.5 The Field Sampling Team Leader stores the logbooks in a secure location until sampling.
- 6.1.6 The Field Sampling Team Leader transfers logbooks to the Field Sampling Team Members.
- 6.1.7 During sampling, the designated Field Sampling Team Member records all required information about the sampling event in the logbook.
- 6.1.8 When the Field Sampling Team Leader assures the recorder that no additional information will be recorded, the recorder gives the logbook to the Field Sampling Team Member designated to perform a QA review of the entries.
- 6.1.9 The designated Field Sampling Team Member performs a QA review to verify the accuracy, completeness, legibility, consistency, and clarity of the field logbook entries and signs the logbook.
- 6.1.10 The recorder makes any corrections and initials and dates the corrections.

- 6.1.11 The Data Coordinator or designee makes a backup copy of the logbook at specified intervals until the logbook is completed as follows:
- a) a logbook page with entries is copied and a peel off label is placed on the bottom of the logbook page;
  - b) a Logbook Copying Transmittal Form is completed;
  - c) two sets of copies are made - one for the CRF and the other retained in a ring binder by the Data Coordinator;
  - d) the Field Team Member removes the peel off label from the logbook page if any additions or corrections are made; and
  - e) the Data coordinator updates the ring binder as copies are made, replacing any updated or modified pages.

6.1.12 The Field Sampling Team Member or Field Sampling Team Leader locks the logbook in the fire-proof safe.

6.1.13 If no additional samples are to be collected, a backup copy of the logbook is made and submitted to the CRF.

6.1.14 The Data Coordinator or designee enters field data into the data base. Any questions are resolved.

6.1.15 At the end of the project, the Data Coordinator submits the logbooks to the project file and to CRF.

## **6.2 SAMPLE CONTAINER LABELS**

6.2.1 The Data Coordinator generates the sample container label from the data base and delivers it with the bound field logbook to the Field Sampling Team Leader for secure storage until sampling.

6.2.2 The Field Sampling Team Leader transfers the sample label to the Field Sampling Team Member, who completes the label during sampling and affixes it to the sample container.

6.2.3 The Field Sampling Team Member who performs the QA review verifies information on the label, and any corrections are initialed and dated.

6.2.4 The sample container is shipped to the laboratory. At receipt, the information on the sample label is verified. At the laboratory, the sample container and sample label affixed to the container are discarded after completion of the analyses.

**6.3 SAMPLE CONTAINER TAGS**

- 6.3.1 The Data Coordinator generates the sample container tag from the data base and delivers it with the bound field logbook to the Field Sampling Team Leader for secure storage until sampling.
- 6.3.2 The Field Sampling Team Leader transfers the sample tag to the Field Sampling Team Member, who completes the tag during sampling and affixes it to the sample container with string, rubber band, or tape.
- 6.3.3 The Field Sampling Team Member who performs the QA review verifies information on the tag, and any corrections are dated and initialed.
- 6.3.4 The sample is shipped to the laboratory. At receipt, the information on the sample container tag is verified. The laboratory staff remove the tag and store it until the end of the project.
- 6.3.5 At the end of the project, the laboratory returns all the tags to the Data Coordinator.
- 6.3.6 The Data Coordinator submits the tags to the project file.

**6.4 CUSTODY SEALS**

- 6.4.1 The Field Sampling Team Leader ensures that custody seals for individual sample containers are brought to the field.
- 6.4.2 During sampling, the Field Sampling Team Member who is designated as the recorder completes information on the custody seal and attaches the seal to the container in such a way that the seal must be broken if the sample container is opened.
- 6.4.3 The Field Sampling Team Member who packs the shipping container completes the custody seal and attaches it to the shipping container in such a way that the seal must be broken if the shipping container is opened or tampered with.
- 6.4.4 When the samples are received at the laboratory, the Analytical Laboratory staff document the condition of the samples, including whether or not the custody seals on the shipping container and sample containers were intact when the samples were received.

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## 6.5 CHAIN-OF-CUSTODY (COC) FORMS

- 6.5.1 The Data Coordinator delivers the numbered COC forms to the Field Sampling Team Leader with the bound field logbooks, sample container labels, and sample container tags.
- 6.5.2 The Field Sampling Team Leader transfers the COC forms to the Field Sampling Team Member who is designated as the recorder.
- 6.5.3 As samples are collected, the recorder completes the form, and the COC number is entered in the field logbook. In addition, the airbill number is recorded on the COC if the samples will be shipped using a courier company.
- 6.5.4 The Field Sampling Team Member who performs the QA review verifies the information on the COC, and any corrections are initialed and dated.
- 6.5.5 At the end of the day's sampling, the Field Sampling Team Leader (or designee) separates the copies of the COC. The original COC is sealed in a zippered plastic bag, which is taped to the inside of the cover of the shipping container and shipped to the laboratory.
- 6.5.6 As soon as practical (but no later than 72 hours), the Field Sampling Team Leader delivers a copy of the COC to the Data Coordinator.
- 6.5.7 The Data Coordinator stores the copy of the COC in a notebook kept in a secure location. At the end of the project, the notebook is submitted to the project file.
- 6.5.8 The Field Sampling Team Leader retains a copy of the COC and files it in a notebook in secure storage. At the end of the project, the notebook is submitted to the project file.
- 6.5.9 The Analytical Laboratory receives the original of the COC with the samples, and notes the condition of samples at receipt on the COC. The date and time of receipt are also recorded. Information on the COC is used to verify the number of samples received, sample IDs, and analyses requested. The airbill number recorded on the COC is also checked. When information is verified, a member of the laboratory sample receiving staff signs and dates the COC.



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6.5.10 The Analytical Laboratory returns the original or a copy of the completed, signed, and dated COC to the Data Coordinator with the letter of receipt (LOR). A copy of the COC is returned as part of the data package.

6.5.11 The Data Coordinator submits the original or a copy of the COC to the CRF with the LOR.

## 6.6 AIRBILLS

6.6.1 If samples will be shipped to the laboratory using a courier company, the Field Sampling Team Leader is responsible for ensuring that an airbill is included with other sampling documentation taken to the field.

6.6.2 The Field Sampling Team Member who packs the samples for shipment records the airbill number on the COC.

6.6.3 The Field Sampling Team Member who packs the samples for shipment, photocopies the airbill and follows standard company procedures for submitting the customer copy of the airbill to the billing department. A photocopy of the airbill is submitted to the project file.

6.6.4 When the samples arrive at the laboratory, the Analytical Laboratory staff member signs the airbill and files it.

6.6.5 The original or a copy of the airbill is returned to the Data Coordinator in the data package.

6.6.6 The Data Coordinator copies the data package and submits the original data package, including the airbill, to the project file.

## 6.7 NONCONFORMANCE REPORT

6.7.1 A nonconformance could be identified at any step in the process of handling and control of sampling documentation. The person finding a nonconformance completes a nonconformance report (NCR) form and follows standard procedures.

6.7.2 A copy of the closed NCR is placed with the data and submitted to the project file with the data package. The original NCR is submitted to the CRF.

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7.0 RECORDS

All records generated as a result of the implementation of this procedure are collected and maintained in a project file in accordance with the requirements specified in QAAP 17.1, Records Management. These records include but are not limited to training records, field logbooks, sample container tags, COCs, airbills, NCRs, etc.

8.0 ATTACHMENTS

None.

**APPENDIX D**

**USACE Environmental Sampling Instructions  
(Appendix C, EM 200-1-3)**

## Appendix C Environmental Sampling Instructions

### C-1. Sampling Strategies

*a. Scope of application.* This section discusses various sampling strategies that can be employed when sampling various media, including but not limited to soils, sediments, or water. Several different types of sampling strategies exist that can be categorized as either a statistical or non-statistical method. Applications and limitations of each sampling strategy will be briefly described.

*b. Sampling strategies.* One of the main goals of any investigation is to collect samples that are representative of the site conditions so that an accurate assessment of contamination can be made with a minimum number of samples. To ensure that samples are as representative as possible, statistics are often used to select the appropriate sampling strategy. Typically, more than one approach is used and most sampling plans employ a combination of sampling strategies. Table C-1, "Comparison of Sampling Strategies," summarizes basic descriptions, applications, and limitations for frequently used sampling strategies. The various sampling strategies available can be grouped into two basic categories: classical statistical and non-statistical methods. Because of the spatial variability limitations of soil, discussions on sampling strategies using classical statistical techniques are frequently used with the sampling of solid media. However, classical statistical methods are also applicable to sampling of other media, including groundwater and surface water. For a more detailed presentation of the implementation of each of these sampling strategies, refer to other USACE guidance on the planning of hazardous, toxic, and radioactive waste sites.

(1) Classical statistical sampling. A discussion of statistical sampling is presented below. For a detailed discussion of classical statistical methods see Environmental Protection Agency (EPA) 1530-SW-89-026.

(a) Simple random sampling. Simple random sampling is the most basic statistical approach and is usually applied when minimal site background information (e.g., past practices, uses of hazardous materials, etc.) is available and visible signs of contamination are not evident during the initial site survey. This strategy uses the theory of random chance probabilities to choose representative sampling locations. Each sample location

is chosen independently of any previously chosen sample location. It is most effective when the number of available sampling points is large enough to lend statistical validity to the random selection process. The simple random sampling approach may be more costly than other statistical methods since a larger number of samples may be required to characterize the site.

(b) Stratified random sampling. Investigations of large sites that encompass a number of soil types, topographic features, or land uses may benefit by using a modified random sampling approach, called "stratified random sampling." In this strategy, the site is divided into different sampling areas (strata) that are internally homogeneous based on existing data and background information. The division of the site into strata is based on the assumption that each stratum is more internally homogeneous than the site as a whole. Each stratum is sampled at locations based on a simple random sampling approach. By grouping similar sampling points together and treating each group separately, each with its own individual random sampling scheme, the precision of the study is increased. In addition, this approach controls the variability due to contaminant concentration, location, terrain type, etc., and it often results in more efficient allocation of resources than would be possible with a simple random sampling method. Sampling analyses from each stratum may be used to determine the mean or total contaminant concentration within the stratum. However, data from each stratum may be used to make comparisons between the different strata or combined to provide information about the entire site.

(c) Systematic grid. Systematic grid sampling, sometimes referred to as systematic random sampling, is the most common statistical sampling strategy. It involves collecting samples at predetermined, regular intervals (i.e., within a grid pattern). The location of the first sampling point is selected at random and all subsequent sample locations are determined using a systematic pattern from that point. This approach is typically used when a large site (e.g., measured in acres) must be sampled to characterize the presence and distribution of contaminants. The grid-based option is probably the best classical statistical sampling strategy for minimizing bias and providing complete site coverage. The most basic grid system is a straight line between two points on which regularly spaced sampling locations are designated. This one-dimensional sampling grid may be used for sampling along a straight drainage ditch or other man-made feature. However, most soil sampling schemes require a two-dimensional grid system for locating sampling points.

**Table C-1**  
**Comparison of Sampling Strategies**

Sampling strategy	Description	Application	Limitatons
<b>Classical statistical sampling strategies:</b>			
Simple random sampling	Representative sampling locations are chosen using the theory of random chance probabilities	Sites where background information is not available and no visible signs of contamination are present.	May not be cost-effective because samples may be located too close together. Does not take into account spatial variability of media.
Stratified random sampling	Site is divided into several sampling areas (strata) based on background or site survey information; each stratum is evaluated using a separate random sampling strategy	Large sites characterized by a number of soil types, topographic features, past/present uses, or manufacturing/storage areas.	Often more cost-effective than random sampling. More difficult to implement in the field and analyze results. Does not take into account spatial variability of media.
Systematic grid sampling	Most common statistical strategy; involves collecting samples at pre-determined, regular intervals within a grid pattern	Best strategy for minimizing bias and providing complete site coverage. Can be used effectively at sites where no background information exists. Ensures that samples will not be taken too close together.	Does not take into account spatial variability of media.
Hot-spot sampling	Systematic grid sampling strategy tailored to search for hot spots	Sites where background information or site survey data indicate that hot spots may exist.	Does not take into account spatial variability of media. Tradeoffs between number of samples, chance of missing a hot spot, and hot spot size/shape must be weighed carefully.
Geostatistical approach	Representative sampling locations are chosen based on spatial variability of media. Resulting data are analyzed using kriging, which creates contour maps of the contaminant concentrations and the precision of concentration estimates.	More appropriate than other statistical sampling strategies because it takes into account spatial variability of media. Especially applicable to sites where presence of contamination is unknown.	Previous investigation data must be available and such data must be shown to have a spatial relationship.
<b>Non-statistical sampling strategies:</b>			
Biased sampling	Sampling locations are chosen based on available information.	Sites with specific known contamination sources.	Contaminated areas can be overlooked if they are not indicated by background information or visual signs of contamination. Best used if combined with a statistical approach, depending on the project objectives.
Judgmental sampling	An individual subjectively selects sampling locations that appear to be representative of average conditions.	Homogeneous, well-defined sites.	Not usually recommended due to bias imposed by individual, especially for final investigations.

Two types of grids are generally used: square grids and triangular grids. Sampling is usually performed at each grid-line intersection (i.e., each place where the grid lines cross). However, sampling in the center of each grid square/triangle or obtaining a composite of samples within a grid square/triangle is also acceptable.

(d) Hot-spot sampling. "Hot spots" are usually defined as small, localized areas of a media that are characterized by high contaminant concentrations. In

order to detect hot spots, a special systematic grid sampling approach is necessary. However, because all of the media cannot be sampled, there is still a possibility that hot spots exist even if none are discovered during the sampling process. Statistical approaches for detection of hot spots are discussed in Gilbert (1987). A hot-spot sampling plan should consider the following factors:

(1) Grid spacing and geometry. A triangular grid pattern increases the efficiency of the hot spot search. In

addition, the probability of finding hot spots increases as the spacing between grid points decreases.

(2) Hot-spot shape/size. The larger a hot spot is, the more likely it is to be discovered. The shape of the hot spot also affects the probability of it being detected. Narrow or small-circular patterns may escape detection because they are located between grid sampling locations. Large-circular and wide-elliptical hot spots are the easiest to find.

(3) False negative rate. This measures the probability that a hot spot will be missed even if one is present.

(e) Geostatistical approach. Classical statistical methods for the design of sampling projects are well-known and have been the standard approach in the past. However, these strategies have one major drawback—they do not take the natural variability of the media into account. As such, they may not adequately characterize contamination at sites, especially those sites that are fairly heterogeneous and/or where the presence of contamination is unknown. Consequently, classical statistical methods are most appropriately applied to sites where the source of contamination is known (e.g., a landfill, waste pile, etc.) or small sites where the entire area is to be remediated as a unit (e.g., in the case of soils, the entire site will be solidified). To more accurately characterize sites where the presence of contamination is unknown, statisticians now believe that geostatistical methods are more appropriate than classical statistical methods because they take into account the spatial variability of the media when estimating contaminant concentrations. Geostatistical methods may be used for sampling naturally occurring materials such as soils or groundwater and man-made units such as landfills or waste piles. Characterization of any media is difficult because contaminant levels are spatially correlated. This means that contaminant concentrations from samples taken close together are more likely to be similar than contaminant concentrations from samples taken farther apart (regional variability). Geostatistics describes how to sample and analyze regional variability by defining the representativeness of a sample in terms of its range of correlation or zone of influence. For example, a sample location selected through geostatistics will represent a circular area with a radius less than or equal to the zone of influence. In other words, the sample would be representative of the media within the circular area. A two-stage sampling approach is typically used in geostatistical sampling strategies. Initially, a sampling survey is performed to collect basic data. These data are used to create a graph that defines the distance over which samples are representative. This graph is then

used to dictate the shape, size, and orientation of another systematic grid that is used in the second, final sampling event. Geostatistical sampling strategies are relatively complex, and further discussions of this approach are found in Borgman and Quimby (1988), Gilbert (1987), and "The Hazardous Waste Consultant" (1992).

(2) Non-statistical sampling. A discussion of non-statistical sampling is presented below.

(a) Biased sampling. Biased sampling is used to evaluate sites with specific, known sources of contamination (e.g., the site-survey-discovered visible signs of contamination or records indicate that certain locations are suspect based on past/present practices). As such, sampling locations are chosen based solely on available information.

(b) Judgmental sampling. In judgmental sampling schemes, an individual subjectively selects the sampling locations that appear to be representative of average conditions. If the individual is knowledgeable, judgmental sampling can result in accurate estimates of site conditions. Although a certain amount of judgment is necessary in any sampling approach, total reliance on judgment decisions is not recommended because an individual's bias often leads to poor quality data and improper conclusions. However, if judgmental sampling is necessary, multiple samples should be collected to add some measure of precision.

*c. Potential problems.* Table C-1 shows the limitations associated with the above sampling strategies.

## C-2. Groundwater Sampling

*a. Scope of application.* Instructions presented in this section are for collecting representative groundwater samples from temporary and permanent groundwater monitoring wells and, where applicable, other push-in well screen samplers. Typical groundwater monitoring wells are 2 or 4 in. in diameter and are constructed of PVC or stainless steel. Instructions presented here are intended to include sample collection from wells that have not been completed as production or extraction wells. The instructions can be used to identify an appropriate sampling protocol for the acquisition of a representative sample. Instruction C-4, "Potable Water Sampling," includes procedures for sampling permanent production wells or any other well constructed with a discharge tap. Instructions for purging and sampling wells by the following techniques are included in this section: bailer,

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portable submersible pump, bladder pump, hand pump, centrifugal pump, peristaltic pump, and air lift pump.

*b. Sampling strategies.* Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including, but not limited to, sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross contamination. A more detailed discussion of the issues to consider when developing sampling strategies is presented in other USACE guidance documents. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme for purposes of characterizing a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, and mobility in various media.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to identify contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Instruction C-1 discusses random, systematic, and biased sampling in detail. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some wells may be biased to potentially contaminated areas (e.g., former wastewater lagoons, former process or disposal areas) or potentially impacted areas (e.g., down-gradient locations). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Groundwater monitoring wells are positioned at locations and depths to satisfy groundwater monitoring objectives. Groundwater samples collected from monitoring wells are evaluated as discrete samples collected from the same location. Groundwater samples collected from the same well are distinguished from each other because they are distributed through time. Unless each groundwater

monitoring well has a sampler dedicated to the well, the order of sampling monitoring wells should be from the least contaminated wells to the most contaminated wells.

(2) Sample type. Groundwater samples are typically discrete samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at once and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, since contamination in groundwater disperses over time and distance, it will take more grab samples to characterize the extent of contamination as the time from a release increases.

(3) Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, well diameter, depth to groundwater, limitations of lift capacity of the sampling device, specified analytical parameters, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Contaminant concentrations in groundwater vary across both time and space. Therefore, it is important to consider the potential temporal variability of the data collected. Determination of the number of samples needed to characterize a site is dependent upon the objectives and the site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and the objective is to establish the boundaries of the groundwater contamination or trends in the data over time, a greater number of samples may be needed. In many cases statistical considerations can be helpful in determining sampling strategy.

*c. Sample preservation and handling.* Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in groundwater monitoring programs are not chemically stable, and therefore sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical*

*Methods (SW-846).* Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2 of Appendix F, "Packaging and Shipping Procedures." Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. Samples should be transferred in the field from the sampling equipment directly into the container that is required for that analysis or set of compatible parameters. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. The samples for volatile analysis should be carefully transferred directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container. Samples should be collected in the order of the parameter shown in Section C-2c(1). If more than one container is required per parameter, the sample should be split equally among all containers until filled. Containers used to collect samples for organic analyses should not be pre-rinsed with water because of the possibility that additional contaminants could adhere to the sample container and taint the analytical results.

(1) Sample containers. When metals are the analytes of interest, high density polyethylene containers with polytetrafluoroethylene-lined polypropylene caps should be used. (Polytetrafluoroethylene is commonly referred to using the registered name of Teflon. Polytetrafluoroethylene will be referred to as PTFE.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, Analytical Techniques/Procedures, contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of pre-cleaned bottles should be verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common groundwater parameters follows.

- (a) Volatile organics (VOA).
- (b) Purgeable organic carbon (POC).

- (c) Purgeable organic halogens (POX).
- (d) Total organic halogens (TOX).
- (e) Total organic carbon (TOC).
- (f) Extractable organics.
- (g) Total metals.
- (h) Dissolved metals.
- (i) Phenols.
- (j) Cyanide.
- (k) Sulfate and chloride.
- (l) Turbidity.
- (m) Nitrate and ammonia.
- (n) Radionuclides.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, retard hydrolysis, and reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. Pre-preserved sample containers should not be used. Because different amounts of preservative may be necessary to bring the sample to the required pH, USACE policy is to add the preservative to the container in the field. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special handling for VOA samples. Water samples to be analyzed for purgeable organic compounds should be stored in 40-ml septum vials with screw caps and like all other samples, a PTFE-silicone disk should be placed in the cap to prevent contamination of the sample by the cap. Disks should be placed in the caps (PTFE side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. The 40-mL vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a



"convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After the bottle is capped, it should be turned over and tapped to check for bubbles. If any bubbles are present, the procedure must be repeated. Care should be taken to ensure that no loss of preservative occurs, if applicable.

(4) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) All work should be conducted on a clean surface, such as a stainless steel table.

(c) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(d) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(e) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(f) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(g) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(h) Collection of adequate field control samples.

*d. Sampling methods.* Sampling instructions for the most common techniques for collecting groundwater samples from groundwater monitoring wells are presented in this section. A summary of the methods is presented in Table C-2. Additional information is presented in EPA/625/R-93/003. After completion of the well installation, the well should be developed to remove any fine material adjacent to the well casing. ~~Because the well casing was developed more than 48 hr prior to purging and sampling the well,~~ well development is not addressed in this sampling and analysis guidance document. Refer to other USACE guidance for further information on well development. Once a well has been located and properly identified, field measurements should be noted in a bound field logbook. A cross reference should be made between the previously recorded physical location/identification locating the well to be sampled, to ensure the proper well has been selected. Misidentification of a sampling point in the field will result in erroneous data that may affect management decisions. Also included in field measurements are the physical measurements of the well, and its physiochemical parameters. Physical measurements that may also be recorded in the field logbook include the presence and diameter of protective casing, diameter and construction material of the well casing, total depth of well from the top of casing, surveyor's mark, depth from top of casing to water, and the volume of water in the well and filter pack. The volume of water can be calculated by calculating the submerged length of the well and calculating the volume of water in the submerged casing and filter pack. Volumes of water in various well casing diameters are as follows:

Water Volume in Casing	
Nominal Casing Diameter Inches (centimeters)	Gallons/Linear Ft. (Liters/Linear Meter)
2 (5.1)	0.16 (2.03)
4 (10.2)	0.65 (8.11)
6 (15.2)	1.47 (18.24)
8 (20.3)	2.61 (32.43)
10 (25.4)	4.08 (50.67)
12 (30.5)	5.88 (72.96)

**Table C-2  
Summary of Groundwater Sampling Techniques**

	Compatible Construction Material	Ease of Use	Economical	External Power Source Needed	VOC Degassing	Ease of Decontamination	Large Water Volumes	Restrictive Groundwater Depth
Bailer	.	.	.					
Submersible Pump	.			.	.		.	
Bladder Pump	.			.				
Hand Pump	.	.	.		.			
Centrifugal Pump			.	.	.		.	.
Peristaltic Pump	.			.	.	.		.
Air-Lift Pump		.		.	.		.	.

The volume of water in the filter pack should be calculated assuming a porosity of 30 percent within the filter pack. The volume of water present in the well casing and filter pack may be calculated as shown in the example below.

**Example:**

Assumptions: 2-in. well casing; well depth is 100 ft below ground surface, groundwater depth is 20 ft below the ground surface, and the boring diameter is 8 in.

$$\begin{aligned}
 \text{Volume of water in well} &= (\text{well depth} - \text{depth to water}) \\
 &\quad \times (\text{water volume in casing}) \\
 &= (100 - 20) \text{ ft } (0.1632 \text{ gal/ft}) \\
 &= 13.0 \text{ gal}
 \end{aligned}$$

$$\begin{aligned}
 \text{Volume of water in filter pack} &= (\text{volume of filter pack}) \times \\
 &\quad 30\% / 231 \text{ in.}^3/\text{gal} \\
 &= ((\pi (8 \text{ in.})^2 / 2) \times 80 \text{ ft} \\
 &\quad (12 \text{ in./ft})) \times \\
 &\quad 0.3 / 231 \text{ in.}^3/\text{gal} \\
 &= 58.7 \text{ gal}
 \end{aligned}$$

$$\begin{aligned}
 \text{Total volume in well casing and filter pack} &= 13 \text{ gal} + 58.7 \text{ gal} \\
 &= 71.7 \text{ gal}
 \end{aligned}$$

The volume of water in any size casing can be determined using the following formula.

$$\text{No. of gallons} = 5.8752 \times C^2 \times H$$

Where C = Casing diameter, feet

H = Height of water column, feet

In addition to the physical measurements taken above and other information that may identify the well, physiochemical information such as specific conductance, pH, temperature, turbidity, and dissolved oxygen should be recorded initially (and in that order), during purging and prior to sampling (see following section).

(1) Well purging. To obtain a representative sample of groundwater from a groundwater monitoring well, the water that has stagnated and/or thermally stratified in the well casing must be purged or evacuated. The purging procedure allows fresh or representative groundwater to enter the well. The optimum or preferred method to ensure that fresh water representative of the aquifer in contact with the well screen is being sampled is to perform a controlled sampling experiment. When indicator parameters such as specific conductance, pH, temperature, turbidity, and dissolved oxygen are stabilized, the well is presumed to be adequately flushed for the representative sample. In some instances, purging rates must be kept below 5 gal/min to avoid overpumping or pumping the well to dryness. Ideally, wells should never be pumped to dryness. To accomplish this, pump rates may be adjusted, sometimes to less than 1 gal/min, and pumping times extended. Pumping with low flow rates may also reduce the need for filtering water samples. Purging or

evacuation of the well can be accomplished in several ways. In any instance it is paramount to ensure that the purging procedure does not cause cross-contamination from one well to the next. Therefore, the preferred method employs dedicated equipment and pumps. Because in many cases it may not be practicable to dedicate a pump to a specific well, it is permissible to decontaminate this equipment, using approved methods. Tubing should always be dedicated and never used for more than one well. The selection of an evacuation method most often relies on the depth to water (DTW) in the well. If the static DTW is less than 25 ft, a hand pump or bailer may be the best method for evacuation. If the static DTW is greater than 25 ft, a submersible pump should be used. As mentioned earlier, care must be used to ensure that this does not act as a route of cross-contamination. Pumps should be decontaminated between well locations. During evacuation, pump intake must not be set greater than 6 ft below the dynamic water level. This requires that the evacuation device be lowered as purging continues and the water level drops. Hand bailing may be utilized with a static water level greater than 25 ft if a submersible pump is not available or with a static water level less than 25 ft if other conventional pumps are not available. However, this is not recommended for reasons such as the potential to aerate the well water, inadequate removal of fines, a concentration of floating product on the bailer that may introduce contamination, potential to introduce contaminants from inside of the well casing, and non-steady removal of water, which may result in dilution instead of evacuation of the well. In general, the mechanics of the hand-bailing method for well purging may introduce contamination potential and variability. There are many pumps that may be used for well purging. Not all pumps are acceptable under all conditions. The preferred and most commonly used pumps are centrifugal and peristaltic pumps (when depth to water is less than 25 ft) and submersible pumps (when depth to water is greater than 25 ft). Information on various pumps and methods of purging is provided later in this instruction. Recent studies have found that some in situ groundwater sampling devices minimize or eliminate the need for purging EPA/600/54-90/028. Occasionally, a non-aqueous phase layer (NAPL) (floating product) may be present in a monitoring well designated for sampling. If it is suspected that the well contains an NAPL, an interface probe should be used to verify its presence. If an NAPL is present, the thickness should be measured and an appropriate inert bailer should be used to collect a sample of the product. Collection of a groundwater sample may not be appropriate if an NAPL is known to be in the well.

(2) Bailers. Bailers are one of the simplest and most commonly used sampling methods for sampling groundwater monitoring wells (Figure C-1).

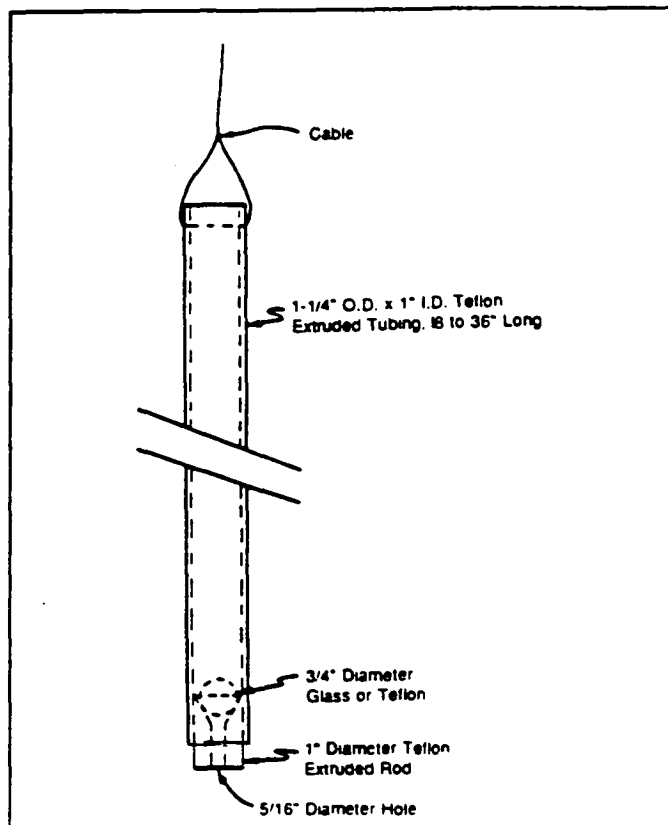


Figure C-1. Bailer

(a) Applicability. Bailers are constructed of a wide variety of materials compatible with the parameter of interest. They are economical and convenient enough that a separate bailer may be dedicated to each well to minimize cross-contamination. An external power source is not required. Bailers provide a low surface-to-volume ratio, which reduces degassing of volatile organic compounds (VOCs). Cross-contamination can be a problem if the bailer is not adequately decontaminated. Bailers offer a relatively limited sample volume and may not be desirable for purging a well if large amounts of water need to be removed from the well for purging purposes. Bailers may also cause a surging action on the well, which may increase the turbidity of the well sample.

(b) Method summary and equipment. Bailers are one of the simplest and most commonly used sampling methods for groundwater wells. Bailers are manufactured in

numerous types, sizes, and construction materials. Bailers are typically weighted lengths of pipe attached to a cord with a check valve at the lower end. They are typically constructed of PVC, PTFE, or stainless steel. The PTFE bailer is recommended for collecting groundwater samples for VOC analysis. Bailers can be dedicated to a specific well, i.e., used only for purging and sampling that well. Dedicated bailers are typically stored to prevent cross-contamination or, less preferably, left hanging in the well itself. The bailer should be decontaminated after each use, regardless of whether the bailer is dedicated to one well or used to sample other wells. Disposable bailers are also available and are cost-effective for certain investigations. Haul-lines for bailers may consist of PTFE-coated stainless steel cable, polyethylene rope, or nylon rope. Of these three, nylon rope is the least desirable because it may introduce contaminants. The use of braided rope is discouraged, because it cannot be decontaminated. For each sampling event, the rope for dedicated bailers should be changed following purging and prior to sampling. For nondedicated bailers, rope should be changed between wells. After removal, the rope should be properly discarded.

(c) Sampling procedure.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging purposes.
- Attach decontaminated bailer to cable or line for lowering or use dedicated bailer already in well.
- Lower bailer slowly until it contacts water surface.
- Allow bailer to sink and fill with a minimum of surface disturbance.
- Slowly raise bailer to surface. Do not allow bailer line or bailer to contact ground.
- Purge well until the pH, temperature, and specific conductance are each at equilibrium, and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance.

Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.

- Tip bailer to allow slow discharge from top to flow gently down the side of the sample bottle with minimum entry turbulence. If a bottom drain is present on the bailer, it is recommended that a slow steady flow be achieved through the bottom drain.
- Repeat steps 4-8 as needed to acquire sufficient volume to fill all sample containers.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to include all necessary information.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook, field sheet, and complete all chain-of-custody documents (see Instruction F-1, "Documentation," in Appendix F).
- Thoroughly decontaminate the bailer after each use, regardless of whether the bailer is dedicated to one well or used to sample other wells.
- Close well.

(3) Portable submersible pump. Portable submersible pumps are an effective technique for pumping large volumes of water at a steady rate but require an external electrical power source.

(a) Applicability. Advantages of submersible pumps include their ability to pump variable amounts from various depths. This advantage makes these pumps applicable not only for purging and sampling but also for aquifer characterization tests. Pumping rates for various units range from as little as 100 ml per minute to 1,000 gpm. The pumping rate for most units can also be individually adjusted. Disadvantages of submersible pumps are that they require an external electrical power source and may be difficult to decontaminate between wells. The

propeller construction of the pump assembly may cause degassing of volatile organic compounds; therefore, some states or EPA regions may restrict the use of submersible pumps when sampling for VOCs.

(b) Method summary and equipment. For submersible pumps, the pump assembly, the electric drive motor, and associated hoses and electrical cables are suspended from a steel cable or discharge pipe and submerged in the well. Intake is typically located between the motor and the pump assembly. Horsepower, head, and lift capacity range widely. Submersible pumps are available for 2-in. and larger wells. Some pumps are constructed of stainless steel and PTFE to maintain sample integrity. Submersible pumps far exceed the pumping limitations of other sampling equipment.

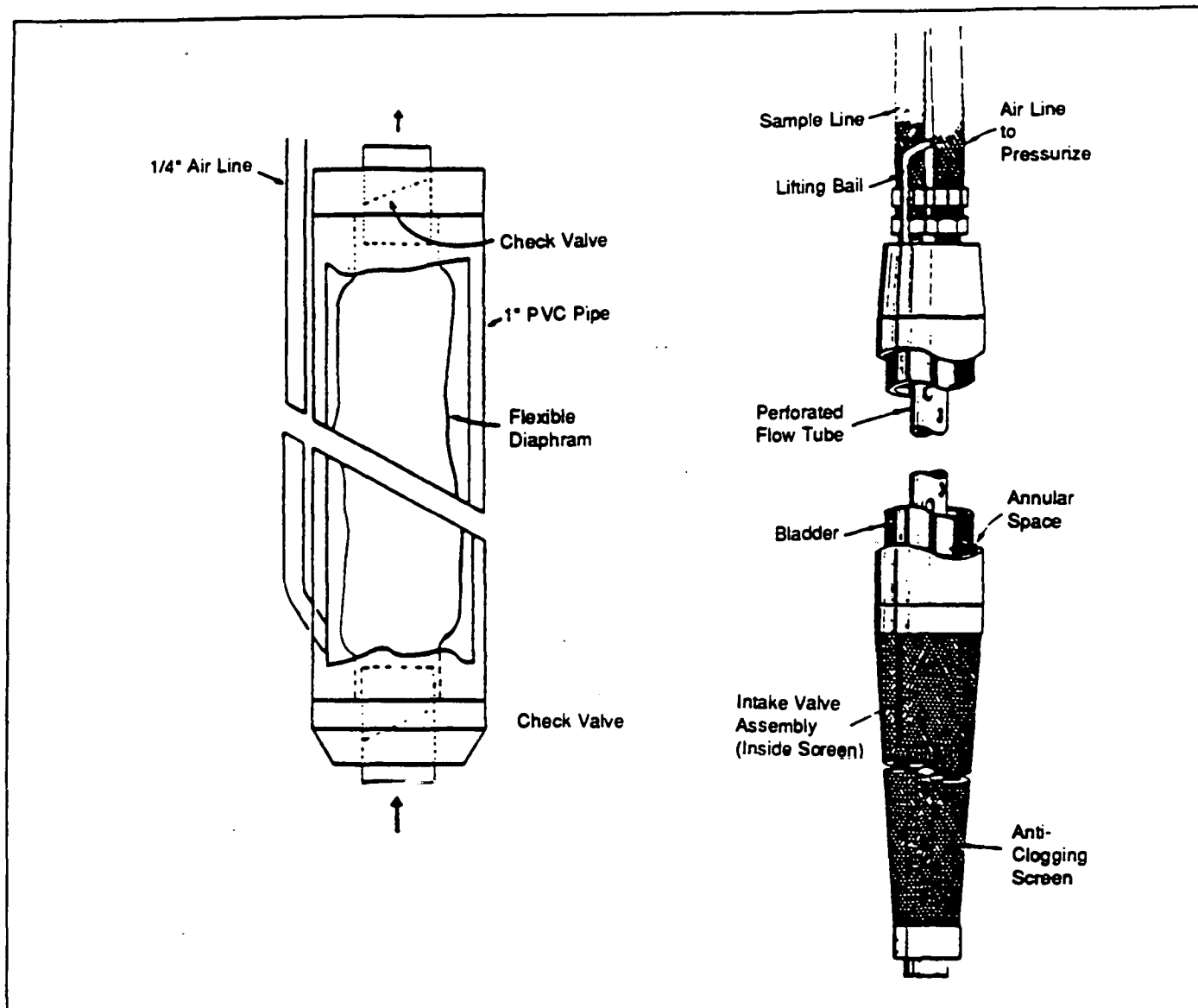
(c) Sampling procedure. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
  - Determine the saturated water column in the well using an electronic water level indicator. Calculate fluid volume in the casing and determine the amount of water to be removed for purging purposes.
  - Lower the decontaminated pump to below the water level and begin pumping. Collect or dispose of purged water in an acceptable manner. Lower the pump as required to maintain submergence.
  - Measure rate of discharge frequently. A bucket and stopwatch are commonly used.
  - Purge well until the pH, temperature, and specific conductance are each at equilibrium, and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between readings.
  - Reduce the pump discharge rate to less than 500 mL/min. Fill sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
  - Ensure that the PTFE-liner is present in cap. Secure the cap tightly.
  - Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
  - Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
  - Complete chain-of-custody documents, field log-book, and field sheet (see Instruction F-1, "Documentation," in Appendix F).
  - Pull pump and allow system to drain and decontaminate.
  - Close well.

(4) Bladder pump. Bladder pumps employ a closed collection system that eliminates agitation and air or gas contact with the sample (Figure C-2).

(a) Applicability. Advantages of the bladder pump include its ideal design for sampling wells for VOC analysis from wells as small as 2 in. in diameter. The pump can pump water from various depths and at adjustable rates. It can operate in low-yielding wells without the possibility of burning out the pump if the well is pumped dry. The inlet for the pump body is typically at the lower end, thus requiring minimum submergence. Top-ended inlet pumps are also available for floating product recovery. Disadvantages of the bladder pump include its relatively low pumping rate. It also requires an outside power source of compressed air or gas and may be difficult to decontaminate between wells.

(b) Method summary and equipment. The closed system provides the best method available for sampling wells for VOCs. The pump fills through a lower check valve under hydrostatic pressure, collapsing the bladder in the pump body. The bladder is then pressurized with gas or air causing it to expand, thus applying pressure in the pump body. The bladder is pressurized using a control box and air compressor assembly. This in turn closes the lower check valve and forces the contents of the pump body up through the sample line check valve. Venting the bladder will allow the pump to refill and begin



**Figure C-2. Bladder pump**

another cycle. An inflatable packer is often used in conjunction with bladder pumps to reduce the amount of water to be purged for sampling. The packer is often positioned immediately above the well screen so that only water in the screened area of the well will require purging once the bladder is properly inflated.

(c) Sampling procedure. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.

- Determine the amount of water to be removed for purging purposes. Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing if an inflatable packer is not present in the well. If an inflatable packer is present in the well, refer to construction diagrams of the well to determine the saturated water column below the packer. Make sure that the packer is not within the screened interval.

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- Attach a pressurized air hose to the packer connection (if present) and inflate packer to proper pressurization level, typically 60 to 80 psi. After the packer is inflated, re-attach pressurized air hose to the bladder pump connection and purge the well as discussed above.
- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.
- Purge the well until the pH, temperature, and specific conductance are at equilibrium and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.
- Fill the necessary sample bottles by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in cap. Secure the cap tightly.
- Label the sample with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field log-book, and appropriate field sheet (see Instruction F-1, "Documentation," in Appendix F).
- De-pressurize packer (if present), remove the pump, and close well.

(5) Hand pumps. Hand pumps are positive displacement pumping systems designed for developing, purging, and sampling (for some analyses) 2-in. or larger groundwater monitoring wells.

(a) Applicability. Hand pumps do not require an external power source. Units are easily transported. A sustained pumping rate can be achieved. The hand pump could cause cross-contamination if the unit is not thoroughly decontaminated. The hand pump may not be suitable for collecting samples for VOCs because the pump creates a vacuum pressure on the water during operation which may result in degassing of volatile compounds.

(b) Method summary and equipment. Hand pumps are readily transportable and can be used to provide sampling in remote areas. Hand operation enables the user to vary the pumping rate to more than 4 gpm at depths exceeding 100 ft. Hand pumps are typically constructed of offset sizes of PVC piping and check valves. Typically, a small diameter pipe resides within a larger diameter pipe. The small diameter pipe is forced up and down and the resulting movement creates a positive displacement.

(c) Sampling procedure. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to prevent cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging purposes.
- Lower the decontaminated hand pump assembly into the well and begin operating the pump in a steady motion.
- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.
- Purge the well until the pH, temperature, and specific conductance are each at equilibrium and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.

- Fill the necessary sample bottles by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field log-book, and appropriate field sheet (see Instruction F-1, "Documentation," in Appendix F).
- Remove the pump assembly and decontaminate.
- Close the well.

(6) Centrifugal pump. A centrifugal pump is a type of suction pump that is used to purge wells. The centrifugal pump is not suitable for collecting samples for VOC analysis because the pump creates a vacuum pressure on the water during operation, which results in degassing of volatile compounds.

(a) Applicability. Advantages of centrifugal pumps include their ability to provide substantial pumping rates, and their ready availability. Disadvantages are that they require an external power source and may be difficult to decontaminate between wells. The materials with which these pumps are constructed may frequently be incompatible with certain sample analytes. The centrifugal pump is not suitable for collecting samples for VOC analysis because the pump creates a vacuum pressure on the water during operation, which results in degassing of volatile compounds. These pumps cannot pull water more than 20 vertical ft.

(b) Method summary and equipment. Centrifugal pumps are a type of suction pump. An impeller rotating inside the pump chamber discharges water by centrifugal force. The resulting pressure drop in the chamber creates a suction that causes water to enter the intake pipe in the

well. Since entrance of water into the intake depends on atmospheric pressure, the height of the intake lift is limited to about 20 ft at sea level and less at higher altitudes. Discharge rates from 5 to 40 gpm can be attained and water can be pushed as high as 150 ft above the pump. Pumps are typically motorized by a small gasoline engine attached to the pump.

(c) Sampling procedure. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging purposes.
- Lower decontaminated intake hose into well.
- Prime pump with distilled water and start pump.
- Containerize or discharge purge water accordingly.
- Measure the rate of discharge frequently. A bucket of known volume and a stopwatch are commonly used.
- Purge the well until the pH, temperature, and specific conductance are each at equilibrium and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.
- Collect volatile organic analysis samples, if required, with a bailer.
- Fill sample bottles by allowing pump discharge to flow gently down the side of the bottle with minimal entry turbulence. The pump discharge rate should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the samples as necessary and verify that the pH is sufficient for the criteria.



- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field sheet, and field logbook. (See Instruction F-1, "Documentation," in Appendix F).
- Close the well.

(7) Peristaltic pump. Peristaltic pumps operate in a manner similar to centrifugal pumps but displace the fluid by mechanical peristalsis (Figure C-3).

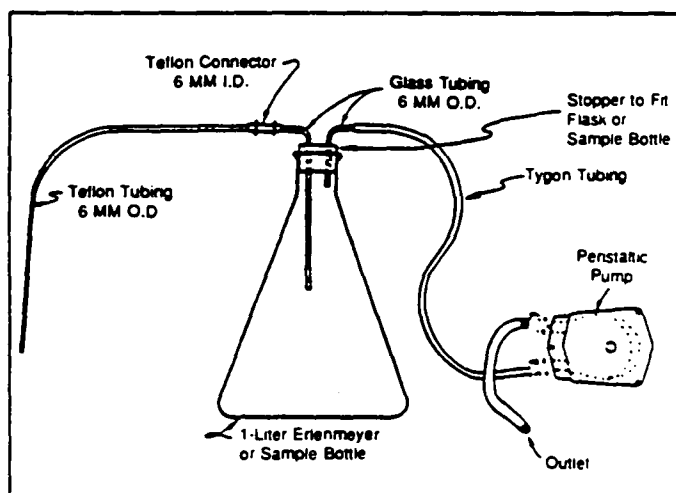


Figure C-3. Peristaltic pump

(a) Applicability. An advantage of the peristaltic pump is its design, which isolates the sample from the moving part of the pump and allows for easy decontamination by removal or replacement of the flexible tubing. Tubing can be dedicated to wells to reduce decontamination time. Disadvantages of these pumps include their low pumping rates and their limited height of intake lift (less than 20 ft). These pumps also require an outside power source and, like other suction pumps, are not suitable for collecting samples for VOC analysis because of potential degassing effects.

(b) Method summary and equipment. A flexible sampling tube is mounted around the pump chamber, and

rotating rollers compress the tubing, forcing fluid movement ahead (the peristaltic effect) and inducing suction behind each roller (Figure C-3). Peristaltic pumps generally have very low pumping rates suitable only for sampling shallow water tables in small-diameter wells.

(c) Sampling procedures. Recommended sampling procedures are discussed below.

- Prepare the work area outside the well by placing plastic sheeting on the ground to avoid cross-contamination.
- Determine the saturated water column in the well using an electronic water level indicator. Calculate the fluid volume in the casing and determine the amount of water to be removed for purging purposes.
- Install clean medical grade silicon tubing in the peristaltic pump head and attach the silicon tubing to the glass tubing outlet from the sample bottle.
- Attach the inlet glass tubing from the sample bottle to the required length of new PTFE suction line and lower to the midpoint of the well screen, if known, or slightly below the existing water level.
- Purge the well until the pH, temperature, and specific conductance are each at equilibrium and begin sampling. Equilibrium is established as follows: pH variation less than 0.2 pH units, temperature variation less than 0.5 deg Celsius, and less than 10 percent variation in specific conductance. Equilibrium will be established by three consecutive readings, where one casing volume is pumped between each reading.
- Collect volatile organic analysis samples, if required, with a bailer.
- Fill sample bottles by allowing the discharge to flow gently into the bottle with minimal entry turbulence. Pump discharge should be less than 500 mL/min. Cap each bottle as filled.
- Preserve the samples as necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.
- Complete chain-of-custody documents, field sheet, and field logbook (see Instruction F-1, "Documentation," in Appendix F).
- Allow system to drain, then disassemble. Decontaminate or replace tubing for next sampling.
- Close the well.

(8) Air lift pump. Air lift pumps are usually used for developing or purging recovery or extraction wells.

(a) Applicability. Air lift pumps are not recommended for sampling monitoring wells. Because of the contact with well water and the source gas, the sample could be chemically altered. Depending on the source gas, the pH could be altered, oxidation could occur, degassing of VOCs could occur, and lubricating oils from the air compressor could be introduced. Air lift pumps are usually used for developing or purging recovery wells rather than monitoring wells because of their ease of use and their ability to maintain moderate flow rates.

*e. Decontamination procedures.* All equipment that will enter the well must be decontaminated prior to its entry. The inside surface of pumps and tubing apparatus must be decontaminated by drawing the decontamination solution through the equipment. Field measurement equipment such as water level indicators should be cleaned as described in Instruction E-5 in Appendix E. If the sampling equipment is being prepared for later use, it should be wrapped in cleaned foil. The sampling equipment should remain wrapped in this manner until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time. The requirement for dedicated equipment should apply to all bailers used for collecting samples. Bailers, other sampling equipment, and sample bottles must be physically separated from generators during transport and storage. Decontamination procedures for field equipment are discussed in Instruction E-5 (Appendix E).

*f. Field control sample requirements.* Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include

blanks, replicates, and/or background (upgradient) samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

*g. Documentation requirements.* Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and the time of entry recorded. At the end of each day's activity, or entry of a particular event, if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and initial indicating the conclusion of the entry or the day's activity. All aspects of sample collection and handling as well as visual observations, shall be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

- (1) Project name.
- (2) Sampling locations.
- (3) Date and times.
- (4) Sampling personnel present (identify responsibilities, if applicable).
- (5) Level of personal protection equipment worn.
- (6) Weather or any environmental condition which may affect the samples.
- (7) Equipment utilized.
- (8) Calibration data for field screening instruments.
- (9) Water quality parameters (i.e., pH, temperature, specific conductance, and dissolved oxygen) taken during development, purging, or sampling.
- (10) Deviations to the approved workplans/SAP.
- (11) A sketch of the sampled area (denoting sample numbers to locations).

(12) Notating of the system for identifying and tracking all samples taken to their associated QC samples.

(13) Visitors to the site.

(14) Investigation, initials, and date on each page.

(15) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sampling form containing the information previously discussed can be developed and used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should also be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

### C-3. Surface Water Sampling

*a. Scope of application.* Instructions presented in this section are for collecting representative surface water samples from surface water bodies. Surface water bodies can be classified into two primary types: flowing and standing. Flowing bodies include industrial effluent, municipal wastewater, rivers, sewers, leachate seeps, streams, or any other lotic water body. Standing bodies include lagoons, ponds, nonaqueous (e.g., surface impoundments), lakes, or any other lentic water body. Surface water samples can be collected from various depths of the water bodies using some of the techniques described in this chapter. Instructions for sampling surface water bodies using the following techniques are included in this section: hand-held bottle, dipper, pond sampler, peristaltic pump, Kemmerer sampler, weighted bottle, and Bacon bomb sampler.

*b. Sampling strategies.* Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including but not limited to sampling locations, types of

samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross-contamination. A more detailed discussion of the issues to consider when developing sampling strategies is presented in other USACE guidance. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme to characterize a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, and mobility in various media.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to identify contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. However, other factors such as accessibility, sampling equipment requirements, and demands on the sampling team need to be considered when selecting locations. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminant's fate. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially contaminated areas (e.g., visually contaminated surface water) or potentially impacted areas (e.g., downstream from discharge pipe). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Due to the nature of the media, locations for surface water samples are restricted to locations within the water body under evaluation. However, variations of location within the water body may include depth, horizontal location, and time.

(2) Types of samples. The type of sample should be designated when selecting a sampling method. Surface water samples may be discrete or composite samples. A

discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease. Composites are samples composed of two or more specific aliquots (discrete samples) collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix.

(3) Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, desired depth, tidal influences, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Determination of the number of samples needed to characterize a site depends upon sampling objectives and site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. In many cases, statistical considerations can be helpful in determining sampling strategy. It may also be necessary to strategically plan the timing of samples. For example, industrial discharges may be more likely during working hours.

c. *Sample preservation and handling.* Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in monitoring programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid*

*Waste-Physical/Chemical Methods (SW-846).* Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. Samples should be transferred in the field from the sampling equipment directly into the container that is required for that analysis or set of compatible parameters. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. The samples for volatile analysis should be carefully transferred directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container. Samples should be collected in the order of the parameters shown in C-3c(1). When more than one container is required per parameter, the sample should be split equally among all containers until filled. Containers used to collect samples for organic analyses should not be prerinsed with water because of the possibility that additional contaminants could adhere to the sample container and taint the analytical results.

(1) Sample containers. When metals are the analytes of interest, high-density or polyethylene containers with PTFE-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/Procedures," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

- (1) Volatile organics (VOA).
- (2) Purgeable organic carbon (POC).
- (3) Purgeable organic halogens (POX).

- (4) Total organic halogens (TOX).
- (5) Total organic carbon (TOC).
- (6) Extractable organics.
- (7) Total metals.
- (8) Dissolved metals.
- (9) Phenols.
- (10) Cyanide.
- (11) Sulfate and chloride.
- (12) Turbidity.
- (13) Nitrate and ammonia.
- (14) Radionuclides.

(2) **Sample preservation.** Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. Pre-preserved sample containers should not be used. Because different amounts of preservative may be necessary to bring the sample to the required pH, the USACE policy is to add the preservative to the container in the field. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) **Special handling for VOA samples.** Water samples to be analyzed for purgeable organic compounds should be stored in 40-mL septum vials with screw caps and like all other samples, a PTFE-silicone disk should be placed in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (PTFE side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. The 40-mL vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After the bottle is capped, it should be turned over and

tapped to check for bubbles. If any bubbles are present, the procedure must be repeated. Care should be taken to ensure no loss of preservative occurs, if applicable.

(4) **Special precautions for trace contaminant sampling.** Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves will be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(g) Collection of adequate field control samples.

*d. Sampling methods.* Sampling instructions for the most common techniques for collecting surface water samples are presented in this section. Prior to sample collection, water body characteristics (size, depth, flow) should be recorded in the field logbook. Sampling should

proceed from downstream locations to upstream locations so that disturbance related to sampling does not affect sampling quality. When wading in a stream always collect the samples on the upstream side. In addition, if sediment samples are to be collected at the same locations as water samples, the water samples must be collected first. If the project requirements make it necessary to distinguish the concentration of metals in solution from the concentration of metals associated with solids, filtration of the surface water will be required. Filtration techniques are discussed in Instruction E-1 (Appendix E) of this manual. The factors that will contribute to the selection of a sampler include the width, depth, and flow of the location being sampled, and whether the sample will be collected from the shore or a vessel. For flowing liquids an additional concern must be addressed. Tidal influence should be determined and its influence on sample collection should be detailed in the sampling plan. At a minimum, the stage of the tide at the time of sample collection should be recorded. Consideration should be given to sampling at varied tidal stages. Samplers may encounter situations where rate of flow affects their ability to collect a sample. For fast-flowing rivers and streams, it may be nearly impossible to collect a mid-channel sample at a specific point. Low-flowing streams and leachate seeps present the opposite problem. In these cases, the sampler should attempt to find a location where flow is obstructed and a pool is created. If this is not possible, the only way to obtain a sample may be to dig into the sediment with a decontaminated trowel to create a pooled area where the liquid will accumulate. However, this method is not recommended since the sample will probably be highly turbid. If the banks are not sloped, sampling personnel may be able to collect the liquid directly into the sample bottle from the edge of the water body. In some instances where the liquid to be sampled cannot be reached, a pond sampler, by virtue of its extension capabilities, may be necessary. In these cases, the pond sampler should be assembled to ensure that sampling personnel are not in danger of falling into the water body being sampled. For a stream, channel, or river, the sample should be collected at mid-depth. For standing liquid, the sample should be collected just below the surface or at mid-depth. Specific sampling strategies may be altered depending on the contaminants of concern. For instance, when sampling for hydrocarbons or other light nonaqueous phase liquids it may be better to sample at the surface. Once the sample is obtained it should be transferred directly into the sample bottle. The sampling device should be decontaminated before the next sample is taken. If sampling below the water surface is required, some of the samplers discussed below will allow collection of discrete representative liquid samples at various

depths. Proper use of the sampling device chosen includes slow lowering and retrieval of the sample, immediate transfer of the liquid into the sampling container, and notation in the logbook of the depth at which the sample was collected.

(1) Hand-held bottle.

(a) Applicability. Filling the sample containers directly is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container. This would affect samples being collected for VOC analysis. The hand-held bottle is not applicable for samples required at depth.

(b) Method summary and equipment. Samples from shallow depths can be readily collected by merely submerging the sample containers.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Submerge the sample container with the cap in place with minimal surface disturbance so that the open end is pointing upstream.
- Allow the device to fill slowly and continuously using the cap to regulate the speed of water entering the bottle.
- Retrieve the sample container from the surface water with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Verify that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately along with the required trip blank, if analyzing for VOCs.

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- Record the information in the field logbook and complete the chain-of-custody form and field sheets (See Instruction F-1, "Documentation," in Appendix F).

## (2) Dippers and pond samplers.

(a) **Applicability.** Dippers and pond samplers prevent unnecessary contamination of the outer surface of the sample bottle that would otherwise result from direct immersion in the source. Dippers and pond samplers can either be reused or discarded. Discarding the samplers would eliminate the need for decontamination. With the pond sampler, samples can be obtained at distances as far as 10 ft from the edge of the source, preventing the technician from having to physically contact the source. The tubular handle may bow when sampling very viscous liquids if sampling is not done slowly. Dippers and pond samplers perform similar functions, except that the length of the dipper is smaller.

(b) **Method summary and equipment.** The pond sampler consists of an adjustable clamp attached to the end of a two- or three-piece telescoping aluminum or fiberglass pole that serves as the handle. The clamp is used to secure a sampling beaker (Figure C-4).

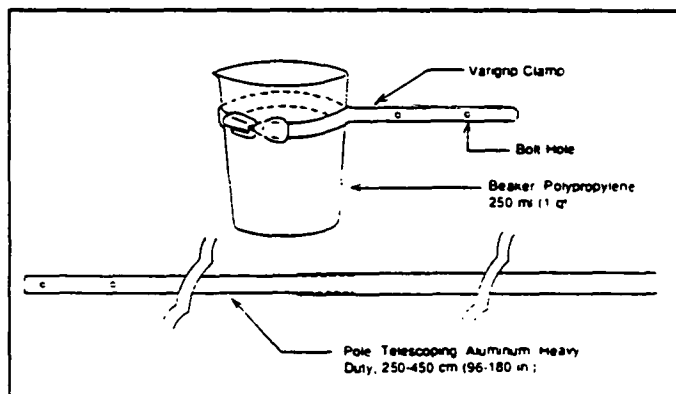


Figure C-4. Pond sampler

## (c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Assemble the dipper or pond sampler. If appropriate, make sure that the sample container and the bolts and nuts that secure the clamp to the pole are tightened properly.

- Collect samples by slowly submerging the pre-cleaned dipper or pond sampler with minimal surface disturbance. Make sure that the open end is pointed upstream.
- Retrieve the dipper or pond sampler from the surface water with minimal disturbance.
- Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper/sampler's edge.
- Empty the sampler slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence.
- Continue delivery of the sample until the bottle is filled.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete the chain-of-custody documents and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Properly clean and decontaminate the equipment prior to reuse or storage.

## (3) Peristaltic pump.

(a) **Applicability.** An advantage of the peristaltic pump is its design, which isolates the sample from the moving part of the pump and allows for easy decontamination by removal or replacement of the flexible tubing. This method can both extend the lateral reach of the sampler and allow sampling from depths below the water surface. Disadvantages of these pumps include their low pumping rates and their limited height of intake lift (less than 20 ft). These pumps also require an outside power

source and, like other suction pumps, are not suitable for collecting samples for VOC analysis because of potential degassing effects.

(b) Method summary and equipment. Peristaltic pumps displace fluid by mechanical peristalsis. A flexible sampling tube is mounted around the pump chamber, and rotating rollers compress the tubing, forcing fluid movement ahead (the peristaltic effect) and inducing suction behind each roller (Figure C-3 in Instruction C-2, "Ground Water Sampling," in this appendix.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Install clean, medical-grade silicone tubing in the pump head, as instructed by the manufacturer. Attach the silicon tubing to the glass tubing outlet from the sample bottle. (If the sampling device is not constructed as shown in Figure C-3 and the sample bottle is filled directly from the discharge line of the peristaltic pump, the sample will be in direct contact with the intake tubing, the pump head, and the discharge tubing prior to release to the sample container. In this situation, PTFE tubing must be used for the discharge line to avoid cross-contamination of the samples from contaminant leaching that would occur from other "less inert" tubing.)
- Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the intake side of the sample bottle. Heavy-wall PTFE, or a diameter equal to the required pump tubing, suits most applications. (A heavier wall will allow for a slightly greater lateral reach.)
- If possible, allow several liters of sample to pass through the system before actual sample collection. Collect this purge volume and return it to the source after the sample aliquot has been withdrawn.
- Fill the necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as filled.

- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete the chain-of-custody documents and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Allow system to drain, then disassemble. Decontaminate tubing if necessary, otherwise discard appropriately.

(4) Kemmerer sampler.

(a) Applicability. The Kemmerer sampler is a practical method for collecting discrete, at-depth samples where the collection depth exceeds the lift capacity of pumps. The use of the Kemmerer sampler is limited, however, because it is typically constructed of brass.

(b) Method summary and equipment. The Kemmerer sampler is a messenger-activated water sampling device that is used to sample water from a specific depth (Figure C-5). In the open position, water flows easily through the device. Once lowered to the desired depth, a messenger is dropped down the sample line tripping the release mechanism and closing the container. In the closed position, the bottle is sealed at the top and bottom, isolating the sample during retrieval.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Inspect Kemmerer sampler to ensure that sample drain valve is closed (if equipped).



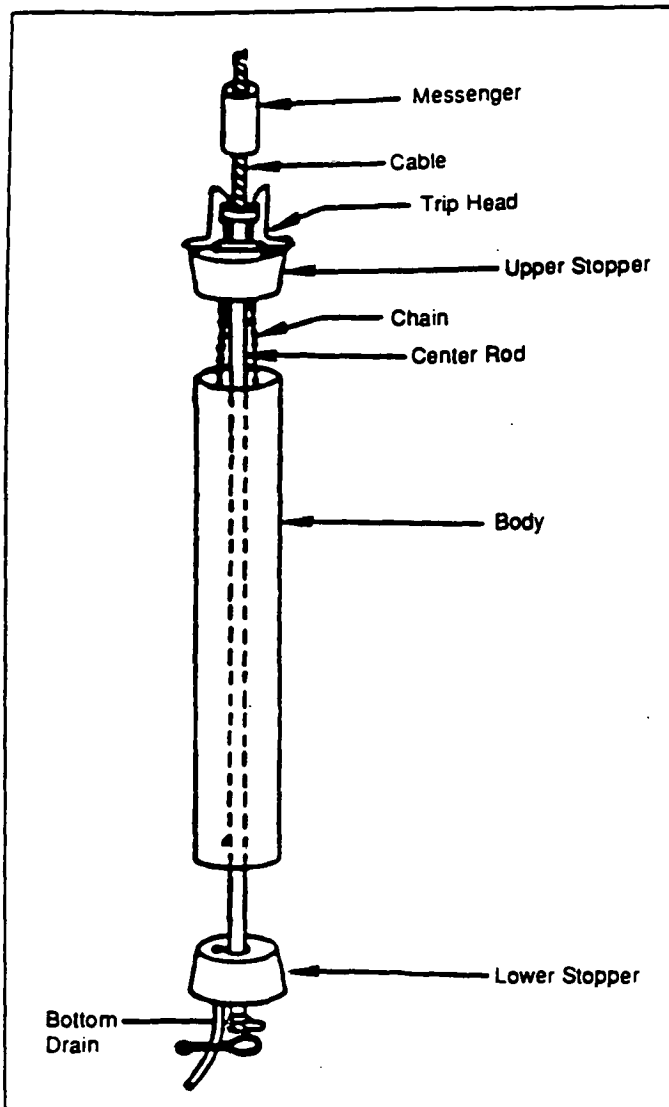


Figure C-5. Kemmerer sampler

- Measure and mark sampler line at desired sampling depth.
- Open bottle by lifting top stopper-trip head assembly.
- Gradually lower bottle until desired sample depth is reached (predesignated mark from Step c).
- Place messenger on sample line and release.
- Retrieve sampler; hold sampler by center stem to prevent accidental opening of bottom stopper.
- Rinse or wipe off exterior of sampler body.

- Recover sample by grasping lower stopper and sampler body with one hand (gloved), and transfer sample by either lifting top stopper with other hand and carefully pouring contents into sample bottles or holding drain valve (if present) over sample bottle and opening valve.
- Allow sample to flow slowly down the side of the sample bottle with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete all chain-of-custody records and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampler.

(5) Weighted bottle.

(a) Applicability. The weighted bottle can be used to obtain samples from a specific depth. The glass construction of the sampler can make the use of this sampler more desirable than the Kemmerer in some sampling situations.

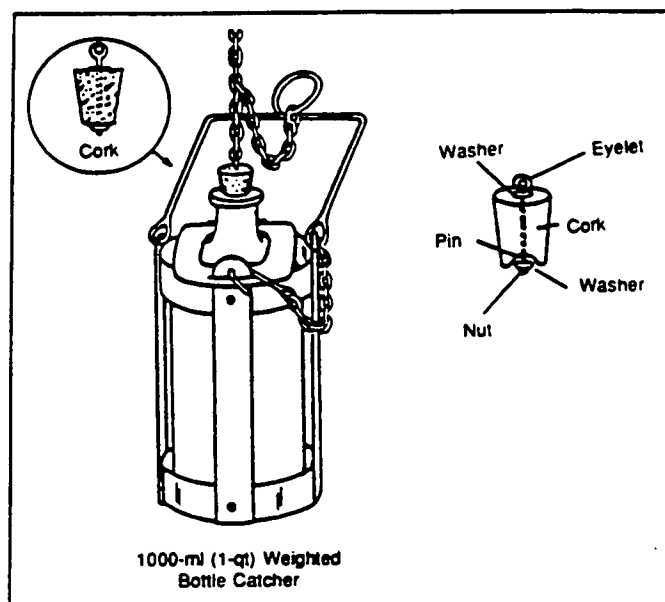
(b) Method summary and equipment. The weighted bottle can be used for collecting representative samples from a specific depth. The sampler consists of a glass bottle, a weighted sinker, a bottle stopper, and a line that is used to open the bottle and to lower and raise the sampler during sampling. Once the sampler is lowered to the desired sampling depth, the stopper is opened, and the bottle is filled and retrieved to the surface.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment

decontaminated and to prevent cross-contamination.

- Assemble the weighted bottle sampler as shown in Figure C-6.



**Figure C-6. Weighted bottle**

- Measure and mark the sampler line at the desired sampling depth.
- Lower the sampling device to the predetermined depth.
- When the sampler is at the required depth, pull out the bottle stopper with a sharp jerk of the sampler line and allow the bottle to fill completely. (This is usually evidenced by the cessation of air bubbles.)
- Retrieve the sampler.
- Rinse or wipe off the exterior of the sampler body.
- Allow sample to flow slowly down side of sample bottle with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.

- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete all chain-of-custody records and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampler.

(6) Bacon bomb sampler.

(a) Applicability. The Bacon bomb sampler is a widely used, commercially available sampler, designed for sampling petroleum products and viscous liquids (Figure C-7). It is very useful for sampling larger storage tanks because the internal collection chamber is not exposed to a product until the sampler is triggered. It is useful in collecting samples at various vertical locations. Like the weighted bottle sampler, the Bacon sampler remains unopened until it reaches the desired sampling depth. The Bacon sampler is difficult to decontaminate and it is difficult to transfer the sample into the sample bottles. The possibility of aerating the sample exists if the sampler does not completely fill with water and air is entrapped in the sampler during retrieval.

(b) Method summary and equipment. The Bacon bomb sampler is constructed of brass or stainless steel and is available in two sizes: 1.5 in. or 3.5 in. in diameter. Samplers range in volume from 4 oz to 32 oz. The Bacon bomb sampler is equipped with a trigger that is spring loaded. When opened, the trigger allows liquid to enter the collection chamber. When the trigger is released, liquid is prevented from flowing into the collection chamber or out of the collection chamber.

(c) Sampling procedure.

- Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
- Measure and mark the sampler line at the desired sampling depth.

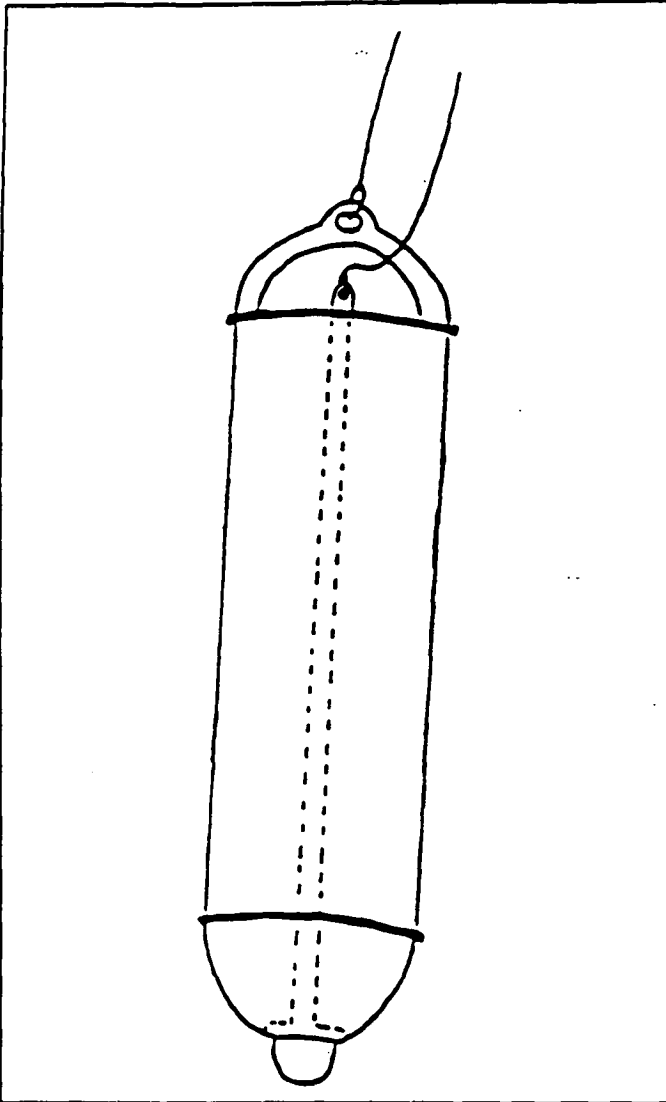


Figure C-7. Bacon bomb sampler

- Lower the Bacon bomb sampler carefully to the desired sampling depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.
- Release the trigger line and retrieve the sampler.
- Transfer the sample to the sample bottles by pulling on the trigger. Allow the sample to flow down the side of the sample bottle with minimal disturbance.
- Preserve the sample as necessary and verify that the pH is sufficient for the criteria.

- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
- Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
- Record the information in the field logbook and complete all chain-of-custody records and field sheets (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate the sampler.

*e. Decontamination procedures:* All equipment that will enter the water must be decontaminated prior to its entry. The inside surface of pumps and tubing apparatus must be decontaminated by drawing the decontamination solution through the equipment. Sampling equipment should be decontaminated, as described in Instruction E-5 (Appendix E). The sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time. During transport and storage, sampling equipment and sample bottles must be physically separated from engines/generators that are used to power some sampling equipment.

*f. Field control sample requirements.* Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background (upgradient) samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

*g. Documentation requirements.* Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry should be recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and use his initials to indicate the

conclusion of the entry or the day's activity. All aspects of sample collection and handling, as well as visual observations, should be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

- (1) Project name.
- (2) Sampling locations.
- (3) Date and times.
- (4) Sampling personnel present (identify responsibilities, if applicable).
- (5) Level of PPE worn.
- (6) Weather or any environmental condition which may affect the samples.
- (7) Equipment utilized.
- (8) Calibration data for field screening instruments.
- (9) Deviations to the approved workplans/SAP implemented.
- (10) A sketch of the sampled area (denoting sample numbers to locations).
- (11) Notation of the system for identifying and tracking all samples taken to their associated QC samples.
- (12) Notation of any visitors to the site.
- (13) Initials and date on each page.
- (14) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks shall be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sampling form containing the information previously discussed can be developed and used in lieu of a field logbook. Proper field sheet, sample labeling,

chain-of-custody, and sample tracking documentation should also be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initiating the sampling program.

#### C-4. Potable Water Sampling

*a. Scope of application.* Instructions presented in this section are for collecting representative potable water (tap water) samples. Discussions are based on the assumption that a supply tap is available for sampling the selected location, for example, a residence. Under this assumption the only applicable sampling method would be the hand-held bottle. The sampling methods discussed in Instruction C-2, "Groundwater Sampling," or C-3, "Surface Water Sampling," should be reviewed if other sampling methods are required for collecting a sample. Discussions presented in this section are a review of the protocols and procedures that should be used when collecting water samples from a tap.

*b. Sampling strategies.* Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed at a particular site will influence several project decisions, including, but not limited to, sampling locations, type of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross-contamination. A more detailed discussion of the issues to consider when developing sampling strategies is presented in other USACE guidance. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme for purposes of characterizing a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, mobility, and contaminant degradation in various media.

(1) Sampling locations. Potable water is usually sampled in an attempt to discover contamination and to define its extent and variability. With such an objective,

it is most logical to choose sample locations that will yield the most information about the water supply system. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminant's fate. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Potable water samples may also be collected for evaluating contamination in a particular well or identifying the need for alternate water supply systems. When sampling residential wells, the sample tap should not be located after a household purification system (i.e. water softening or filtration). In these cases an outdoor tap may have to be sampled. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially contaminated areas or potentially impacted areas. In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Water taps are stationary and are typically sampled for purposes of evaluating drinking water regulations or contaminant impact on local drinking water supplies. Selection of a sampling location is an investigation objective.

(2) Type of sample. The type of sample should be designated when selecting a sampling method. Potable water samples are typically discrete samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at once and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease.

(3) Suggested samplers. The sample container is normally used to collect a potable water sample. Use of additional sampling equipment is not recommended. Sample disturbance, sample volume, and chemical/physical reactivity between potential contaminants and the sampling container should be considered when collecting the potable water sample.

(4) Sample frequency. Determination of the number of samples needed to characterize a site is also dependent upon the objectives and site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful

information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. Timing for collecting samples may also be crucial. In many cases statistical considerations can be helpful in determining sampling strategy.

c. *Sample preservation and handling.* Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in potable water monitoring programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods (SW-846)*. Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. Samples should be collected in the container that is required for that analysis or set of compatible parameters. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. Samples for volatile analysis should be taken in a manner that minimizes contaminant loss through agitation/volatilization. Samples should be collected in the order of the parameters shown in Section C-4c(1). When more than one container is required per parameter, the sample should be equally split among all containers until filled. Containers used to collect samples for organic analyses should not be prerinsed with water because of the possibility that additional contaminants could adhere to the sample container and taint the analytical results.

(1) Sample containers. When metals are the analytes of interest, high density polyethylene containers with PTFE-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/Procedures Instructions," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be

verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

- (a) Volatile organics (VOA).
- (b) Purgeable organic carbon (POC).
- (c) Purgeable organic halogens (POX).
- (d) Total organic halogens (TOX).
- (e) Total organic carbon (TOC).
- (f) Extractable organics.
- (g) Total metals.
- (h) Dissolved metals.
- (i) Phenols.
- (j) Cyanide.
- (k) Sulfate and chloride.
- (l) Turbidity.
- (m) Nitrate and ammonia.
- (n) Radionuclides.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, retard hydrolysis, and reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. Pre-preserved sample containers should not be used. Because different amounts of preservative may be necessary to bring the sample to the required pH, the policy of the USACE is to add the preservative to the container in the field. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special handling for VOA samples. Water samples to be analyzed for purgeable organic compounds

should be stored in 40-mL septum vials with screw caps, and like all other samples, a PTFE-silicone disk should be placed in the cap to prevent contamination of the sample by the cap. Disks should be placed in the caps (PTFE side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. The 40-mL vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After the bottle is capped, it should be turned over and tapped to check for bubbles. If any bubbles are present, the procedure must be repeated. Care should be taken to ensure that no loss of preservative occurs, if applicable.

(4) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(g) Adequate field control samples should be collected.

*d. Sampling methods.* When sampling potable water, utmost care must be taken to ensure that samples are representative of the water being sampled. This is important not only from a technical and public health perspective, but also from a public relations standpoint. Poor sampling techniques may result in incorrect results (either not detecting a compound that is present or by contaminating the sample and falsely indicating a compound that is not present). If incorrect results are disclosed to the public, it may be impossible to change public opinion when correct results are reported. As discussed in Appendix C-2, "Groundwater Sampling," potable water wells must be purged before the sample is collected. This procedure ensures that water representative of the formation is sampled. The tap should be opened and allowed to flow until the pH, conductivity, and temperature have reached equilibrium. This procedure ensures that any contaminants that might have entered the area of the tap from external sources have been avoided. If the project requirements make it necessary to distinguish the concentration of metals in solution from the concentration of metals associated with solids, filtration of the potable water sample will be required. Filtration techniques are discussed in Instruction E-1 in Appendix E of this manual. Potable water samples should be representative of the water quality within the household or office under investigation. The sampling tap must be protected from exterior contamination associated with being too close to the sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the bottle during the collecting procedure since it is difficult to place a bottle under a low tap without grazing the neck interior against the outside faucet surface. Leaking taps that allow water to flow from around the stem of the valve handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations. Aerator, strainer, and hose attachments on the tap must be removed before sampling. These devices can harbor a bacterial population if they are not cleaned routinely or replaced when worn or cracked.

Whenever a steady stream of water cannot be obtained from taps, after such devices are removed, a more suitable tap should be sought. Taps where the water flow is not steady should be avoided because temporary fluctuation in line pressure may cause sheets of microbial growth that are lodged in some pipe section or faucet connection to break loose. A smooth-flowing water stream at moderate pressure without splashing should be obtained. Then, without changing the water flow, which could dislodge some particles in the faucet, the samples can be collected. Occasionally, samples are collected to determine the contribution of transmission pipes, water coolers, water heaters, etc., to the quality of water in private residences, offices, etc. The purpose of these investigations may be to determine if metals, e.g., lead, are being dissolved into the water supply. In these cases, it may be necessary to ensure that the water source has not been used for a specific time interval, e.g., over a weekend or a three- or four-day holiday period. Sample collection may consist of collecting a sample of the initial flush and collecting a sample after the indicator parameters have reached equilibrium. Regardless of the type of sample bottle being used, the bottle cap should not be placed on the ground or in a pocket. Instead, the bottle should be held in one hand and the cap in the other, using care not to touch the inside of the cap. Exercise care not to lose the PTFE liner in certain bottle caps. Contaminating the sample bottle with fingers or permitting the faucet to touch the inside of the bottle should be avoided. Sample bottles should not be rinsed before use. When filling any container, care should be taken not to splash drops of water from the ground or sink into either the bottle or cap. To avoid dislodging particles in the pipe or valve, the stream flow should not be adjusted while sampling. Name(s) of the resident or water supply owner/operator and the resident's exact mailing address, as well as his/her home and work telephone numbers, should always be obtained. This information is required in order that the residents or water supply owner/operators can be informed of the results of the sampling program.

(1) Hand-held bottle.

(a) Applicability. Filling the sample containers directly is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container. This would affect samples collected for VOC analysis.

(b) Method summary and equipment. Samples can be readily collected by directly filling the sample containers.

(c) Sampling procedure. The sampling procedures previously discussed in this paragraph should be addressed, if appropriate. Additional sampling procedures are discussed below.

- Place plastic sheeting on the ground surface to prevent cross-contamination of samples.
- Purge the tap or well until the pH, temperature, and specific conductance are at equilibrium.
- Fill the container slowly and continuously.
- Preserve the sample if necessary and verify that the pH is sufficient for the criteria.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle with an appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately, along with the required trip blanks if analyzing for VOCs.
- Record the information in the field logbook and complete the chain-of-custody form and field sheets. (See Instruction F-1, "Documentation," in Appendix F).

*e. Field control sample requirements.* Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background (upgradient) samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 in Appendix H.

*f. Documentation requirements.* Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event, if appropriate, the investigator should draw a diagonal line at the conclusion

of the entry and enter his initials, indicating the conclusion of the entry or the day's activity. All aspects of sample collection and handling, as well as visual observations, shall be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

- (1) Project name.
- (2) Sampling locations.
- (3) Date and times.
- (4) Sampling personnel present (identify responsibilities, if applicable).
- (5) Level of PPE worn.
- (6) Weather or any environmental condition which may affect the samples.
- (7) Equipment utilized.
- (8) Calibration data for field screening instruments.
- (9) Deviations to the approved workplans/SAP implemented.
- (10) A sketch of the sampled area (denoting sample numbers to locations).
- (11) Notation of the system for identifying and tracking all samples taken to their associated QC samples.
- (12) Notation of any visitors to the site.
- (13) Initials and date on each page.
- (14) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sampling form containing the information previously discussed can be developed and used in lieu of a



field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

### C-5. Sediment Sampling

*a. Scope of application.* Instructions presented in this section are for collecting representative sediment and sludge samples from surface water bodies. Sediment can be considered as any material that is submerged/saturated (at least temporarily) or suspended in any surface water body. This includes sludges, lake bottom sediments, perennial and intermittent stream sediments, and marine sediments. For discussion purposes, sampling devices are classified into the following categories according to applicability: (1) surface sediments/shallow water (scoop), (2) subsurface sediments/shallow water (hand auger/tube sampler, and hand driven split spoon sampler), (3) surface sediments/deep water (Ponar, Ekman, and Smith-McIntyre samplers), and (4) subsurface sediments/deep water (gravity corer and soil coring device/silver bullet sampler).

*b. Sampling strategies.* Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including, but not limited to, sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels, and the problems associated with trace level cross-contamination. A more detailed discussion of the issues to consider when developing sampling strategies is presented in other USACE guidance. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme for purposes of characterizing a hazardous waste site should follow the fundamentals of the scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, and mobility in various media.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to discover

contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminants' fate. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Often biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially contaminated areas (e.g., lagoons, former process or disposal areas) or potentially impacted areas (e.g., areas of stressed vegetation, sediment downstream from discharge pipe). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Due to the nature of the media, locations for collecting sediment samples are restricted to locations within the water body under evaluation. Variations of locations for collecting sediment samples include depth, horizontal location, and time. Depositional patterns should be considered against the sample objectives when deciding the sediment sample locations. These patterns differ between standing or flowing bodies of water. Generally, for flowing water (e.g., stream or river beds), the depositional areas are normally found inside bends, and downstream of islands or obstructions. Areas directly downstream of the joining of two streams should be avoided because the flows may not immediately mix. For standing water bodies, the center of the mass or a discharge point should be sampled for sediments. As discussed above, selection of sample locations should satisfy investigation objectives.

(2) Types of samples. The type of sample should be designated when selecting a sampling method. Sediment samples can be discrete (grab) or composite. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected at once and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease. Composites are samples composed of more than one specific aliquot (discrete samples) collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can in certain instances be used as an alternative

analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix.

(3) Suggested samplers. Samplers for this medium are dictated significantly by project objectives of surficial versus subsurface samples and site constraints of the water depth. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Determination of the number of samples needed to characterize a site is also dependent upon sampling objectives and site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. In many cases statistical considerations can be helpful in determining sampling strategy.

c. *Sample preservation and handling.* Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in investigation programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods (SW-846)*. Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. When subsequent analysis allows, sediment samples should be collected using a clean stainless steel scoop, spoon, or trowel and placed into a clean stainless steel or other appropriate homogenization container. The sample should be mixed thoroughly to obtain a homogeneous, representative sample prior to placement into the sample container. Refer to Instruction E-2 of Appendix E for a discussion of

homogenization procedures. When compositing of samples collected from different locations or at different times is desired, all components of the composite sample are mixed in the homogenization container before the composite sample is placed in the sample container. Refer to Instruction E-3 of Appendix E for a discussion of compositing procedures. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. For example, the samples packaged for volatile analysis should not be homogenized or composited. They should be carefully transferred directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container.

(1) Sample containers. When metals are the analytes of interest, wide mouth glass containers with PTFE-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/Procedures," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of precleaned bottles should be verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

- (1) Volatile organics (VOA).
- (2) Purgeable organic carbon (POC).
- (3) Purgeable organic halogens (POX).
- (4) Total organic halogens (TOX).
- (5) Total organic carbon (TOC).
- (6) Extractable organics.
- (7) Total metals.

- (8) Phenols.
- (9) Cyanide.
- (10) Radionuclides.
- (11) Total solids.

(2) **Sample preservation.** Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods for sediment samples are generally limited to no headspace in sample container, refrigeration, and/or protection from light. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) **Special handling for VOA samples.** Samples to be analyzed for purgeable organic compounds should be stored in the containers identified in Appendix I. A PTFE-silicone disk should be in the cap to prevent contamination of the sample by the cap. Disks should be placed in the caps (PTFE side in contact with the sample) in the laboratory prior to the beginning of the sampling program. The sample container should be completely filled to prevent volatilization. There should be no headspace left in the sample jar after filling. The sample jar should be closed as soon as possible after filling.

(4) **Special precautions for trace contaminant sampling.** Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose

waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(g) Collection of adequate field control samples.

*d. Sampling methods.* Presented below are sampling instructions for the most common techniques for collecting sediment and sludge samples. For additional information see EM 1110-2-5027, Plumb (1981), and Spigolon (1993). Prior to sample collection, water body characteristics (size, depth, flow) should be recorded in the field logbook. Sampling should proceed from downstream locations to upstream locations so that disturbance from sampling does not affect sampling quality. Additionally, if the surface water samples will be collected at the same locations as sediment samples, the water samples must be collected first. The factors that contribute to the selection of a sampler include the width, depth, flow, and the bed characteristics of the surface water body to be sampled, the volume of sample required, and whether the sample will be collected from the shore or a vessel. In collecting sediment samples from any source, care must be taken to minimize disturbance and sample washing as it is retrieved through the liquid column. Sediment fines may be carried out of the sample during collection if the liquid above is flowing or deep. This may result in collection of a non-representative sample due to the loss of contaminants associated with these fines. While a sediment sample is usually expected to be a solid matrix, the sampler should not place the sample in the bottle and decant the excess liquid. If the sample is collected properly, any liquid in the bottle is representative of sediment conditions. As with liquid sampling, a determination of tidal influence on the surface water body being sampled should be made and the effect of the tide on the sample collection should be detailed in the sampling plan. At a minimum, the stage of the tide at the time of sample

collection should be recorded. Consideration should be given to sampling at varied tidal stages. If liquid flow and depth are minimal and sediment is easy to reach, a trowel or scoop may be used to collect the sediment sample. However, when the liquid above the sediment collection point is either flowing or greater than 6 in. in depth, a corer or other device that eliminates sample washing must be used to collect the sample to minimize washing the sediment as it is retrieved. One of the coring devices listed will allow the collection of an undisturbed core of sediment. It may be necessary to decant standing water from the top of the core. This should be done carefully and prior to transfer to the sample bottle. A decontaminated trowel should be utilized to transfer the sample from the corer directly into the bottle. After collection, the sampling device should be decontaminated before collecting the next sample. In some instances, the dimensions of the surface water dictate that a barge or boat must be used. The device used for sample collection in this case will, again, depend upon the depth and flow of the liquid above the sample location and the bed characteristics of the surface water. Generally trowels or scoops cannot be used in an offshore situation. Instead, cores or dredges are a more efficient means for sample collection. The barge or boat should be positioned upstream (if there is flowing water) of the desired sample location. As the corer or dredge is lowered it may be carried slightly downstream, depending upon the force of the flow. Upon retrieval, the contents of the corer or dredge should be transferred directly into the sample bottle using a decontaminated trowel. Both the corer or dredge and the trowel should be decontaminated before collecting the next sample.

(1) Surface sediments/shallow water: Scoop or trowel.

(a) Applicability. The scoop or trowel method is a very accurate procedure for collecting representative samples. This method can be used in many sampling situations but is limited to sampling exposed sediments or sediments in surface waters less than 6 in. deep. The scoop or trowel sampler is not effective for sampling in waters more than 6 in. deep.

(b) Method summary and equipment. The simplest, most direct method of collecting sediment samples is with the use of a stainless steel scoop or trowel (Figure C-8). A stainless steel scoop or trowel can be used to collect the sample and a stainless steel bowl can be used to homogenize the sample when applicable to the subsequent analysis. The scoop or trowel should not be chrome-plated if metals are contaminants of concern.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Sketch the sample area or note recognizable features for future reference.
- Insert scoop or trowel into material and remove sample. In the case of sludges exposed to air, it may be desirable to remove the first 1-2 cm of material prior to collecting the sample.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Check that a PTFE liner is present in cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(2) Surface sediments/shallow water: Tube sampler.

(a) Applicability. Equipment for the tube sampler is portable and easy to use. Discrete sediment samples can be collected efficiently. Disadvantages of the tube sampler include its limited sampling depth and inability to collect sediment samples in water bodies greater than a few feet in depth. The tube sampler may not penetrate gravelly or rocky sediments.

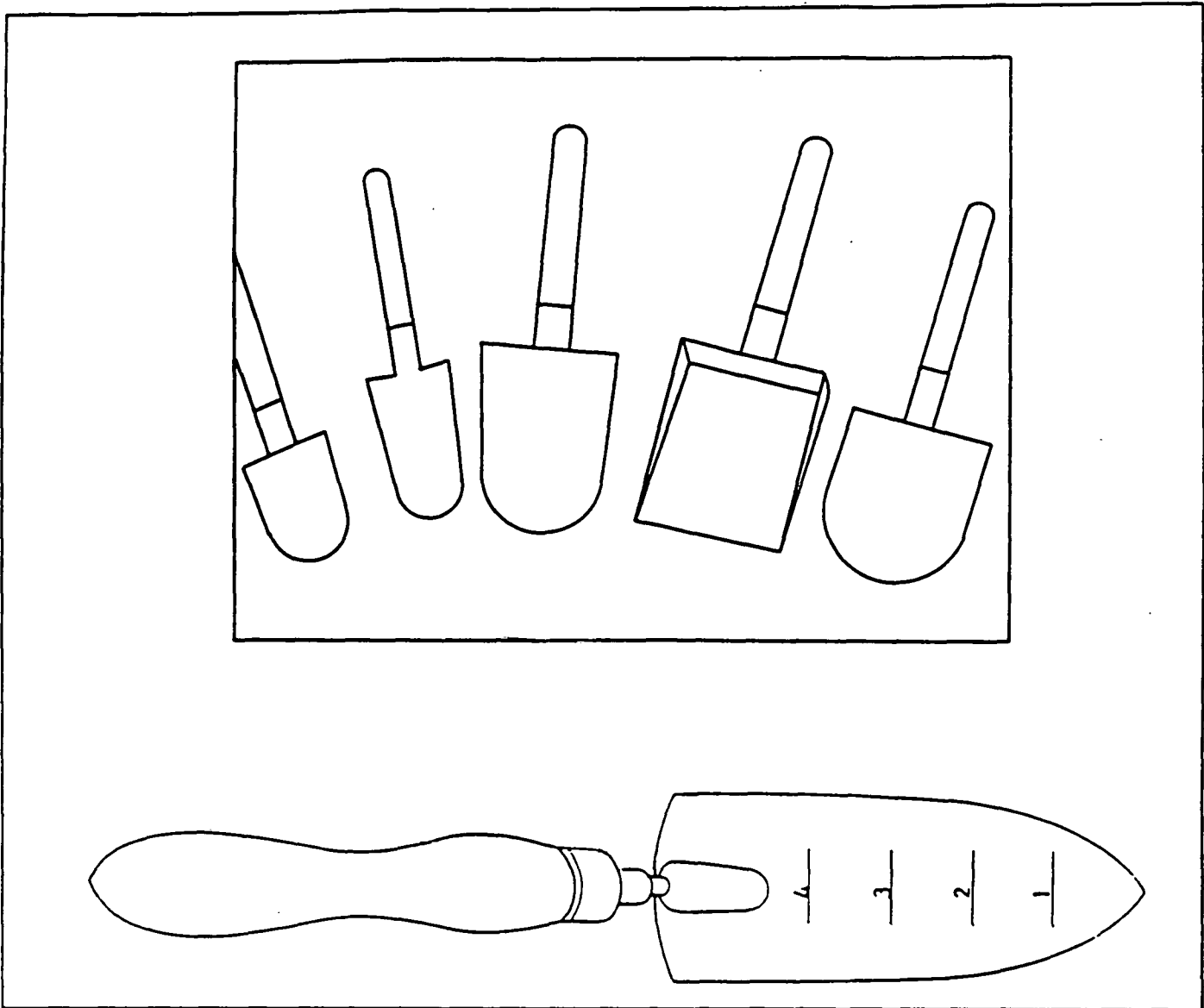


Figure C-8. Scoop trowel

(b) Method summary and equipment. Tube samplers are a simple and direct method for obtaining sediment samples. The corer is forced into the sediment. The corer is then withdrawn and the sample is collected. In non-cohesive soils, sample retention may be a problem. In this case a piston-type sampler is recommended.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Clear the area to be sampled of any surface debris (twigs, rocks, litter).
- Gradually force corer into sediment.
- Remove corer.
- Remove sediment core from corer and place core on a clean working surface.
- Discard top of core if any organic material is present.

- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Repeat steps (3) through (8) as necessary to obtain sufficient sample volume.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents, and field sheets and record in the field logbook (See Instruction F-1, Documentation).
- Decontaminate sampling equipment after use and between sample locations.

(3) Subsurface sediments/shallow water: Hand auger and tube sampler.

(a) Applicability. Equipment for the hand auger is portable and easy to use. Discrete sediment samples can be collected efficiently. Disadvantages of the hand auger include its limited sampling depth and inability to collect sediment samples in water bodies greater than a few feet in depth. The tube sampler may not penetrate gravelly or rocky sediments.

(b) Method summary and equipment. Hand augers are a simple and direct method for obtaining sediment samples. Although the maximum sampling depth for the hand auger is typically 5 ft, greater depths can be sampled depending on the sediment type. Hand augers come in various dimensions and various types. The bucket auger bit is used to bore a hole to the desired sampling depth and then withdrawn. The auger tip is then replaced with the tube corer, lowered into the borehole, and forced into the sediment at the desired depth. The corer is then

withdrawn and the sample is collected. Potential problems encountered with this method include the collapsing or sloughing of the borehole after removal of the bucket auger. Relocating of the borehole with the tube sampler may also be difficult if the water is turbid.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Attach the auger bit to a drill rod extension and further attach the "T" handle to the drill rod.
- Clear the area to be sampled of any surface debris (twigs, rocks, litter).
- Begin drilling and periodically remove accumulated sediment. This prevents accidentally brushing loose material into the borehole when removing the auger or adding drill rods.
- After reaching the desired depth, slowly and carefully remove the auger from boring.
- Remove auger tip from drill rods and replace with a precleaned or decontaminated thin-wall tube sampler. Install proper cutting tip.
- Carefully lower corer down borehole. Gradually force corer into sediment. Take care to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring because the vibrations may cause the boring wall to collapse.
- Remove corer and unscrew drill rods.
- Remove cutting tip and remove core from device.
- Discard top of core (approximately 2.5 cm), which represents any material collected by the corer before penetration of the layer in question.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.

- Repeat steps (7) through (12) as necessary to obtain sufficient sample volume.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets, and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(4) Subsurface sediments/shallow water: Hand-driven split spoon sampler.

(a) Applicability. The split spoon sampler is used for obtaining sediment samples in cohesive and non-cohesive type soils. Similarly to the hand auger, the split spoon sampler can only be used in shallow water. However, because it is hammered into place, it can sometimes penetrate sediments that are too hard to sample with a hand auger.

(b) Method summary and equipment. The split spoon sampler is a 2-in.-diam, thick-walled, steel tube that is split lengthwise (Figure C-9). A cutting shoe is attached to the lower end; the upper end contains a check valve and is connected to the drill rods. For sediment sampling, the split spoon sampler is usually attached to a short driving rod and driven into the sediment with a sledge hammer or slide hammer to obtain a sample.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the heavier head piece on top.

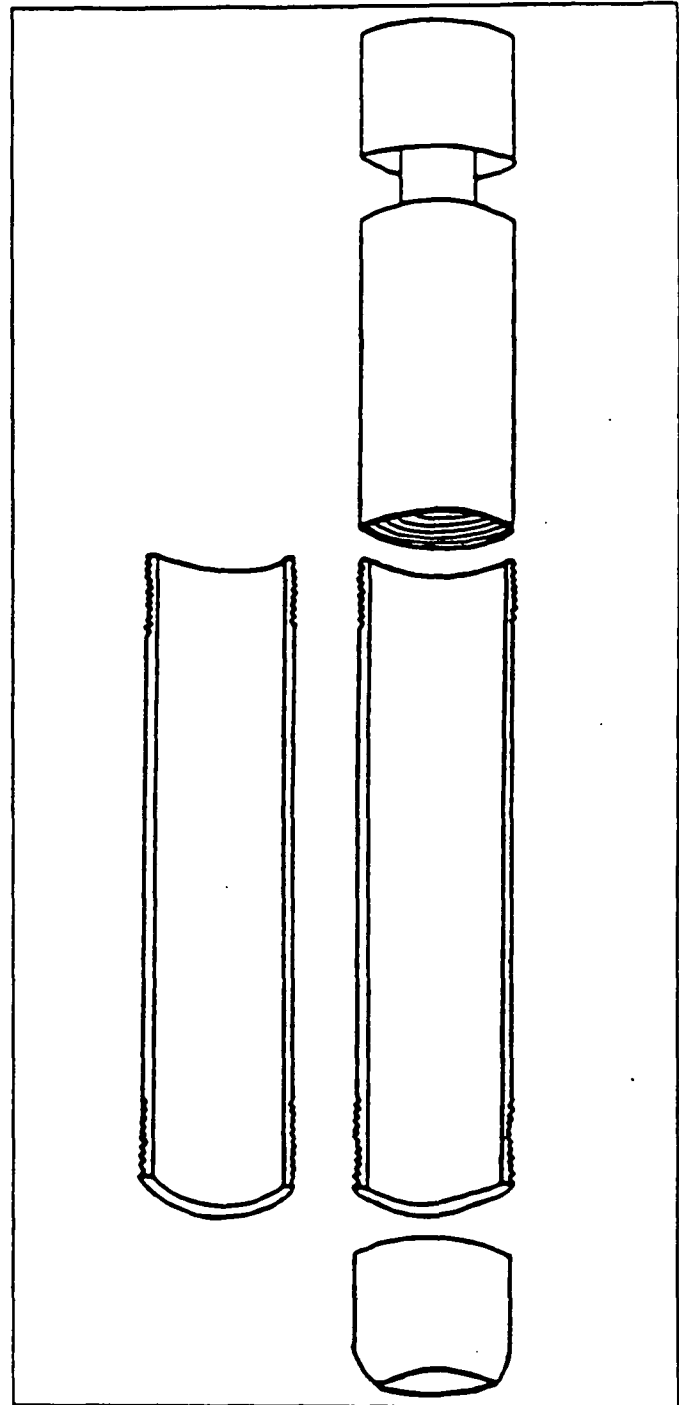


Figure C-9. Standard split spoon sampler

- Place the sampler in a perpendicular position on the material to be sampled.

- Drive the tube utilizing a sledge hammer. Do not drive past the bottom of the head piece as this will result in compression of the sample.
- Record the length of the tube that penetrated the material being sampled and the number of blows required to obtain this depth.
- Withdraw the sampler and open by unscrewing drive shoe and head and splitting barrel. If split samples are desired, a decontaminated stainless steel knife should be utilized to split the tube contents in half longitudinally.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Repeat Steps (2) through (8) until sufficient soil volume has been collected.
- Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets, and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(5) Surface sediments/deep water: Ponar sampler.

(a) Applicability. Ponar samplers are capable of sampling most types of sludges and sediments from silts to granular materials. They are available in hand-operated sizes to winch-operated sizes. Ponars are relatively safe,

easy to use, prevent escape of material with end plates, reduce shock waves, and have a combination of the advantages of other sampling devices. Ponar grab samplers are more applicable for a wide range of sediments and sludges because they penetrate deeper and seal better than spring-activated types (e.g., Ekman samplers). Penetration depths will usually not exceed several centimeters. Grab samplers are not capable of collecting undisturbed samples. As a result, material in the first centimeter of sediment cannot be separated from the rest of the sample. Ponars can become buried in soft sediment. The Ponar sampler is not recommended for the acquisition of VOA samples.

(b) Method summary and equipment. The Ponar grab sampler is a clamshell-type scoop activated by a counter-lever system (Figure C-10). The shell is opened, latched in place, and slowly lowered to the bottom. When tension is released on the lowering cable, the latch releases and the lifting action of the cable on the lever system closes the clamshell.

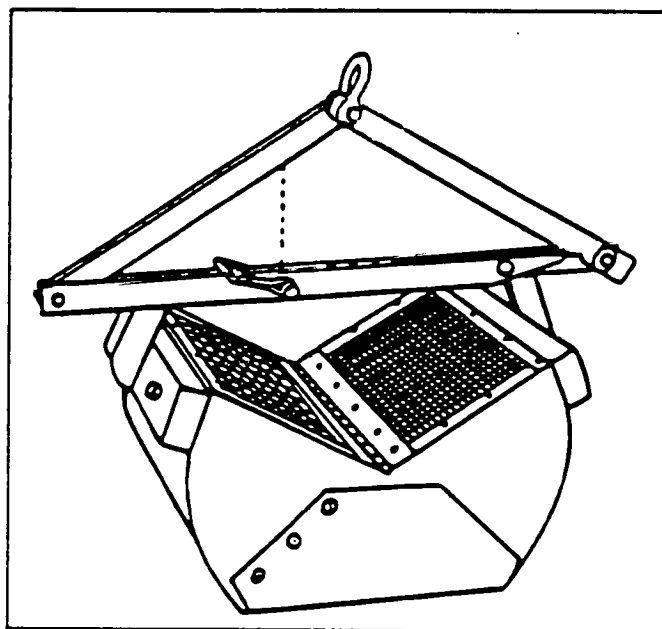


Figure C-10. Ponar sampler

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach a decontaminated Ponar to the necessary length of sample line. Solid braided 5-mm (3/16-in.) nylon line is usually of sufficient



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strength; however, 20-mm (3/4-in.) or greater nylon line allows for easier hand hoisting.

- Measure the depth to the top of the sediment with a weighted object.
- Mark the distance to the top of the sediment on the sample line with a proximity mark 1 m above the sediment. Record depth to top of sediment and depth of sediment penetration.
- Open sampler jaws until latched. From this point, support the sampler by its lift line, or the sampler will be tripped and the jaws will close.
- Tie free end of sample line to fixed support to prevent accidental loss of sampler.
- Begin lowering the sampler until the proximity mark is reached.
- Lower the sampler at a slow rate of descent through last meter until contact is felt.
- Allow sample line to slack several centimeters. In strong currents, more slack may be necessary to release mechanism.
- Slowly raise dredge to clear surface.
- Drain free liquids through the screen of the sampler, being careful not to lose fine sediments.
- Place Ponar into a stainless steel or PTFE tray and open. Lift Ponar clear of the tray, and decontaminate.
- Repeat Steps (5) through (12) until sufficient sample volume has been collected.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Collect a suitable aliquot with a stainless steel laboratory spoon or equivalent, and place sample

into appropriate sample bottle. Secure the cap tightly.

- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(6) Surface sediments/deep water: Ekman sampler.

(a) Applicability. The Ekman sampler collects a standard size sample. The Ekman sampler is not useful in rough waters or if vegetation is on the bottom.

(b) Method summary and equipment. The Ekman sampler (Figure C-11) is another type of clamshell-type grab sampler and works similarly to the Ponar sampler described previously. However, because the Ekman sampler is much lighter than the Ponar sampler, it is easier to handle and can even be attached to a pole for shallow applications. The Ekman sampler is unsuitable for sampling, rocky, or hard bottom surfaces.

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach a decontaminated Ekman sampler to the necessary length of sample line or in shallow waters to the end of a pole. Because the Ekman sampler is lightweight, solid braided 5-mm (3/16-in.) mylar line is sufficient.
- Measure the depth to the top of the sediment with a weighted object.
- Mark the distance to top of sediment on the sample line with a proximity mark 1 m above the sediment. Record depth to top of sediment and depth of sediment penetration.

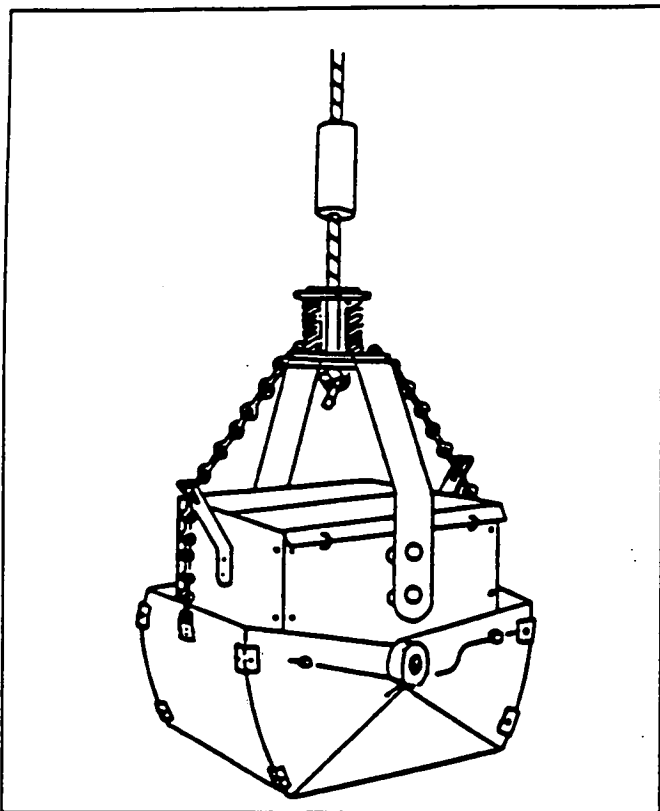


Figure C-11. Ekman sampler

- Open sampler jaws until latched. From this point, support the sampler by its lift line, or the sampler will be tripped and the jaws will close.
- If using a sample line, tie the free end of the sample line to fixed support to prevent accidental loss of sampler.
- Begin lowering the sampler until the proximity mark is reached.
- Lower the sampler at a slow rate of descent through the last meter until contact is felt.
- If using a sample line, place a messenger on the sample line and release, allowing the messenger to slide down to the sample line and activate the spring.
- Slowly raise dredge to clear surface.
- Drain free liquids through the screen of the sampler, being careful not to lose fine sediments.

- Place Ekman sampler into a stainless steel or PTFE tray and open. Lift Ekman sampler clear of the tray and decontaminate.
- Repeat Steps (5) through (12) until sufficient sample volume has been collected.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Collect a suitable aliquot with a stainless steel laboratory spoon or equivalent, and place sample into appropriate sample bottle.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(7) Surface sediment/deep water. Smith-McIntyre sampler.

(a) Applicability. The Smith-McIntyre sampler can be used in rough water because of its large and heavy construction. It reduces premature tripping and can be used in depths up to 3,500 ft. The flange on the jaws reduces material loss. It is good for sampling all sediment types. However, because of its large and heavy construction, the Smith-McIntyre sampler is cumbersome to operate.

(b) Method summary and equipment. The Smith-McIntyre sampler (Figure C-12) is also a type of clam-shell-style grab sampler and works similarly to the Ponar sampler described previously.

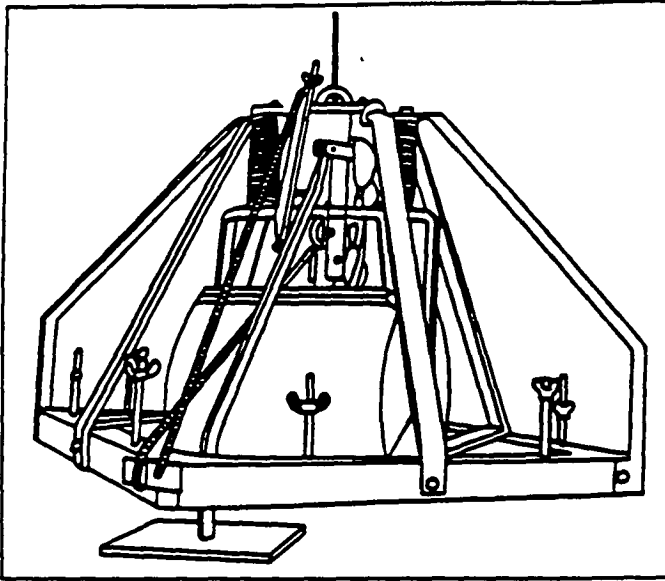


Figure C-12. Smith-McIntyre sampler

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach a decontaminated Smith-McIntyre sampler to the necessary length of sample line or in shallow waters to the end of a pole. Because the Smith-McIntyre sampler is large and heavy, a winch may be necessary for hoisting and lowering the sampler.
- Measure the depth to the top of the sediment with a weighted object.
- Mark the distance to top of sediment on the sample line with a proximity mark 1 m above the sediment. Record depth to top of sediment and depth of sediment penetration.
- Open sampler jaws until latched. From this point, support the sampler by its lift line, or the sampler will be tripped and the jaws will close.
- If using a sample line, tie the free end of sample line to fixed support to prevent accidental loss of sampler.
- Begin lowering the sampler until the proximity mark is reached.
- Lower the sampler at a slow rate of descent through the last meter until contact is felt.
- If using a sample line, place messenger on sample line and release, allowing messenger to slide down the sample line and activate the spring.
- Slowly raise dredge clear to surface.
- Drain free liquids through the screen of the sampler, being careful not to lose fine sediments.
- Place Smith-McIntyre sampler into a stainless steel or PTFE tray and open. Lift Smith-McIntyre sampler clear of the tray and decontaminate.
- Repeat Steps (5) through (12) until sufficient sample volume has been collected.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Collect a suitable aliquot with a stainless steel laboratory spoon or equivalent, and place sample into appropriate sample bottle. Secure cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Decontaminate sampling equipment after use and between sample locations.

(8) Subsurface sediments/deep water: Gravity corer.

- (a) Applicability. Gravity corers are capable of collecting samples of most sludges and sediments. They

collect essentially undisturbed samples that represent the profile of strata which may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the corer, penetration to depths of 30 in. can be attained.

(b) Method summary and equipment. The gravity corer is a metal tube with a replacement tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. Most corers are constructed of brass or steel and many can accept plastic liners and additional weights.

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach a decontaminated corer to the required length of sample line. Solid braided 3/16-in. nylon line is typically sufficient; 3/4-in. nylon, however, is easier to grab during hand hoisting.
- Secure the free end of the line to a fixed support to prevent accidental loss of the corer.
- Allow corer to free fall through liquid to bottom.
- Retrieve corer with a smooth, continuous lifting motion. Do not bump corer as this may result in some sample loss.
- Remove nosepiece from corer and slide sample out of corer into stainless steel or PTFE pan.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Transfer sample into appropriate sample bottle with a stainless steel lab spoon or equivalent.

- Check that a liner is present in cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Thoroughly decontaminate the gravity corer after each use.

(9) Subsurface sediments/deep water: Soil coring device/silver bullet sampler.

(a) Applicability. The soil coring device and the silver bullet sampler are used when a core sample is desired.

(b) Method summary and equipment. The soil coring device consists of a brass cylinder with a handle for turning. The bit of the corer is sharp plastic. A plastic collection tube that will hold a sample is placed on the inside of the brass cylinder. This device may be substituted for the soil auger if core analysis of depth profiles needs to be done. A serious limitation of this instrument is that the depth of the core is only 1.6 ft long. Also, the cutting edge of the coring device is plastic and is unable to pass through very rocky or tightly packed soil. The silver bullet sampler consists of a cylinder into which the sampler is fitted with a T-handle, which is used to manipulate the sampler. The bit is changeable. The silver bullet sampler is designed to take core samples in peat substrates. Due to its design, the sampler lends itself well to uses in hazardous waste sampling. It is versatile and can be used as a soil coring device because the body is adjustable to reach greater depths. Also, the silver bullet sampler has a serrated bit, which allows the sampler to move through rocky or tightly packed substrate more easily.

(c) Sampling procedure.

- Place plastic sheeting around the sampling location to prevent cross-contamination.

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- Insert borosilicate collection tube into the sampler.
- Place the sampler in position with the bit touching the ground.
- Press down on the T-handle while rotating the sampler clockwise.
- After reaching the required depth, turn the sampler 360° counterclockwise and remove from the ground taking care not to lose any of the sample.
- Remove the borosilicate glass collection tube and collect sample, or cap at both ends for sample shipment.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Check that a PTFE liner is present in cap. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).

(10) Subsurface sediments/deep water: Vibratory coring device.

(a) Applicability. Vibratory corers are capable of collecting samples of most soils, sediments, and sludges.

(b) Method summary and equipment. The vibratory system consists of a tripod that supports a core tube. An external power source is necessary to drive a top head and cause vibrations. The vibratory motion causes the soil sediments to become fluidized and the core tube to slip through the soil or sediment. For additional information,

see U.S. Army Engineer Waterways Experiment Station (1981a, 1981b, 1982, 1993).

(c) Sampling procedure.

- Assemble decontaminated vibratory corer and connect external power source (i.e., air compressor).
- Attach decontaminated corer to the required length or top of the soil or sediment. Begin vibratory coring until the core tube has fully penetrated.
- Carefully remove the core tube and remove the core liner.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place the sample in an appropriate container and put the container on ice.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F).
- Thoroughly decontaminate the vibratory corer after each use.

*e. Decontamination procedures.* All equipment that will enter the sediment must be decontaminated. Sampling equipment should be decontaminated as described in Instruction E-5 (Appendix E). Sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time.

*f. Field control sample requirements.* Field control samples are collected by the sampling team to determine whether data are of suitable quality. They include blanks.

replicates, and/or background samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

*g. Documentation requirements.* Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and enter his initials indicating the conclusion of the entry or the day's activity. All aspects of sample collection and handling as well as visual observations should be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back, once reviewed. Documentation should include:

- (1) Project name.
- (2) Sampling locations.
- (3) Date and times.
- (4) Sampling personnel present (identify responsibilities, if applicable).
- (5) Level of PPE worn.
- (6) Weather or any environmental condition that may affect the samples.
- (7) Equipment utilized.
- (8) Calibration data for field screening instruments.
- (9) Deviations to the approved workplans/SAP implemented.
- (10) A sketch of the sampled area (denoting sample numbers to locations).
- (11) Notation of the system for identifying and tracking all samples taken to their associated QC samples.
- (12) Notation of any visitors to the site.

(13) Initials and date on each page.

(14) Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sample form containing the previously described information can be developed and used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

## C-6. Soil Sampling

*a. Scope of application.* Instructions presented in this section are for collecting representative soil samples. Soil sampling can be classified into two primary types: surficial and subsurface. Bedrock has also been included under this category because most of the equipment used for subsurface soil sampling is also used for rock core sampling. Instructions for sampling surficial and subsurface soils by the following techniques are included in this section: spade and scoop, hand auger and tube sampler, split spoon sampler, ring-lined barrel sampler, thin-walled (Shelby) tube, continuous barrel sampler, and core barrel sampler. EM 1110-2-1907, "Soil Sampling," also addresses these and other types of geotechnical soil sampling which may be adapted for environmental purposes.

*b. Sampling strategies.* Sampling strategies are developed by the project team to satisfy project-specific data needs that are identified in the HTRW technical planning process. The sampling strategy developed for a particular site will influence several project decisions, including, but not limited to, sampling locations, types of samples, sampling frequency, and sampling and analytical protocols. Sampling strategies may be significantly influenced by such factors as physical site constraints, safety, and cost, to name a few. The technical planning process that results in the development of the sampling strategy is critical because of the difficulty in acquiring representative samples, the reduction of contaminant action levels,

and the problems associated with trace level cross-contamination. Successful investigations of hazardous waste sites are highly dependent on an effective sampling scheme. Development of a sampling scheme to characterize a hazardous waste site should follow the fundamentals of scientific approach. A successful sampling scheme requires a logical design to allow an evaluation of potential contaminants in relation to ambient conditions, vertical extent, horizontal extent, and mobility in various media.

(1) **Sampling locations.** Sampling at hazardous waste sites is usually conducted in an attempt to discover contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. When evaluating a site, sampling can be conducted by random, systematic, or biased sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminant's fate. Random sampling depends on the theory of random chance probabilities to choose the most representative sample. Often, biased and random sampling techniques can be used together to thoroughly address an entire site. Some samples may be biased to potentially contaminated areas (e.g., stained soil, former process or disposal areas) or potentially impacted areas (e.g., areas of stressed vegetation). In areas less likely to be contaminated or areas with little available background information, random samples may be used to allow adequate assessment of the entire site. Because of the nature of the media, soil samples can vary considerably across a site. Physical properties of the soil, including grain size and cohesiveness, may limit the depth from which samples can be collected and the method required to collect them. In most soils, hand-powered equipment can only be used to a depth of approximately 4 to 5 ft. At greater depths, soil sampling is normally performed with a drill rig or other mechanically driven device.

(2) **Types of samples.** The type of sample should be designated when selecting a sampling method. Application techniques for sample methods include discrete (grab) or composite samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected immediately and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the

representativeness of grab samples will decrease. Composites are samples composed of two or more specific aliquots (discrete samples) collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix. Samples can be collected manually if soil conditions are favorable and the desired depth of sampling is not too great. Manual sampling involves minimal initial cost, and the method is well-suited to a relatively small or specific number of samples. At depths greater than 4 to 5 ft, manual sampling will probably not be possible, and a mechanically driven drilling device will be required. Depending on the sampling requirements of the site, the use of a mechanical drilling device can substantially increase the cost of a sampling investigation. However, it is usually the only method available to obtain soil samples at depths greater than a few feet. There are a great variety of mechanical drilling devices available for soil sampling. Discussions concerning the use of mechanical drilling devices will be limited to the actual tools used to collect the soil samples.

(3) **Suggested samplers.** Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Sub-surface soil conditions themselves will restrict the application of certain samplers. For example, the thin-walled tube sampler is not applicable for sampling sands. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) **Sample frequency.** Determination of the number of samples needed to characterize a site also depends on the objectives and the site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples, from properly chosen locations, will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. In many cases statistical considerations can be helpful in determining sampling strategy. Additional guidance concerning sample frequency can be found in other USACE guidance.

c. *Sample preservation and handling.* Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in soil investigation programs are not chemically stable, and therefore sample preservation is required. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods (SW-846)*. Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F. Improper sample handling may alter the analytical results of the sample, causing the results to be invalid. When subsequent analysis allows, soil samples should be collected using a clean stainless steel scoop, spoon, or trowel and placed into clean stainless steel or other appropriate homogenization containers. Homogenization procedures are discussed in Instruction E-2 of Appendix E. The sample should be mixed thoroughly to obtain a homogeneous, representative sample prior to placement into the sample container. When compositing samples from different locations or at different times is desired, all components of the composite sample are mixed in the homogenization container before the composite is placed in the sample container. Compositing procedures are discussed in Instruction E-3 in Appendix E. The sample should then be preserved in the field as specified in Appendix I. Because of the low analytical detection limits that are required for certain data uses, care must be taken when collecting the sample to avoid the loss of any contaminants. For example, the samples packaged for volatile analysis should not be homogenized or composited. They should be transferred carefully directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container.

(1) *Sample containers.* When metals are the analytes of interest, wide mouth glass jar containers with PTFE-lined polypropylene caps should be used. (PTFE is commonly referred to using the registered name of Teflon.) When organics are the analytes of interest, glass bottles with PTFE-lined caps should be used. Refer to Appendix I or the specific analytical method to designate an acceptable container. Containers should be cleaned based on the analyte of interest. Appendix G, "Analytical Techniques/Procedures Instructions," contains additional information on appropriate glassware cleaning protocols. The cleanliness of a batch of pre-cleaned bottles should be

verified by the container supplier or in the laboratory. Residue analysis should be available prior to sampling in the field. Refer to Appendix I or the specific analytical method in Appendix G for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

- (a) Volatile organics (VOA).
- (b) Purgeable organic carbon (POC).
- (c) Purgeable organic halogens (POX).
- (d) Total organic halogens (TOX).
- (e) Total organic carbon (TOC).
- (f) Extractable organics.
- (g) Total metals.
- (h) Phenols.
- (i) Cyanide.
- (j) Radionuclides.
- (k) Total solids.

(2) *Sample preservation.* Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods for soil samples are generally limited to no headspace in the sample container, refrigeration, and/or protection from light. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) *Special handling for VOA samples.* Samples to be analyzed for purgeable organic compounds should be stored in containers identified in Appendix I. A PTFE-silicone disk should be in the cap to prevent contamination of the sample by the cap. Disks should be placed in the caps (PTFE side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. The sample container should be completely filled to prevent volatilization. There should be no headspace left in the sample jar after filling. The sample jar should be closed as soon as possible after filling.



(4) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(c) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(d) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc., while the other members collect all of the samples.

(e) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(f) Field personnel should use equipment constructed of PTFE, stainless steel, or glass that has been properly precleaned. PTFE or glass is preferred for collecting samples where trace metals are of concern.

(g) Collection of adequate field control samples.

*d. Sampling methods.* Presented below are sampling instructions for the most common techniques of collecting soil samples. Prior to sample collection, the soil sampling location and characteristics (soil type, depth) should be recorded in the field logbook. Selection of soil sampling equipment is usually based on the depth of the samples. Manual techniques are usually selected for surface or shallow, subsurface soil sampling. At greater depths, mechanically driven equipment is usually required to

overcome torque induced by soil resistance and depth. Additional information on collecting soil samples is presented in EPA/625/R-93/003.

(1) Spade and scoop.

(a) Applicability. The spade and scoop method is a very accurate, representative method for collecting surface and shallow subsurface soil samples. This method is usually limited to soil depths less than 1 ft.

(b) Method summary and equipment. The simplest, most direct method of collecting surface soil samples is to use a spade and stainless steel scoop (Figure C-13). A typical garden spade can be used to remove the top cover of soil to the required depth, and the smaller stainless steel scoop can be used to collect the sample. Typical "garden type" scoops are many times plated with chrome or other metals and would therefore be inappropriate for sampling when analyzing for metals.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Carefully remove the top layer of soil to the desired sample depth with a precleaned or decontaminated spade.
- Using a precleaned or decontaminated stainless steel scoop or trowel, collect the sample aliquot for VOC analysis first, then homogenize enough soil in a stainless steel bowl for the remaining sample containers (see Instructions E-2 and E-3 in Appendix E).
- Transfer sample into the appropriate sample bottle with a stainless steel lab spoon or equivalent.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and record in the field logbook (See Instruction F-1, "Documentation," in Appendix F). Prepare

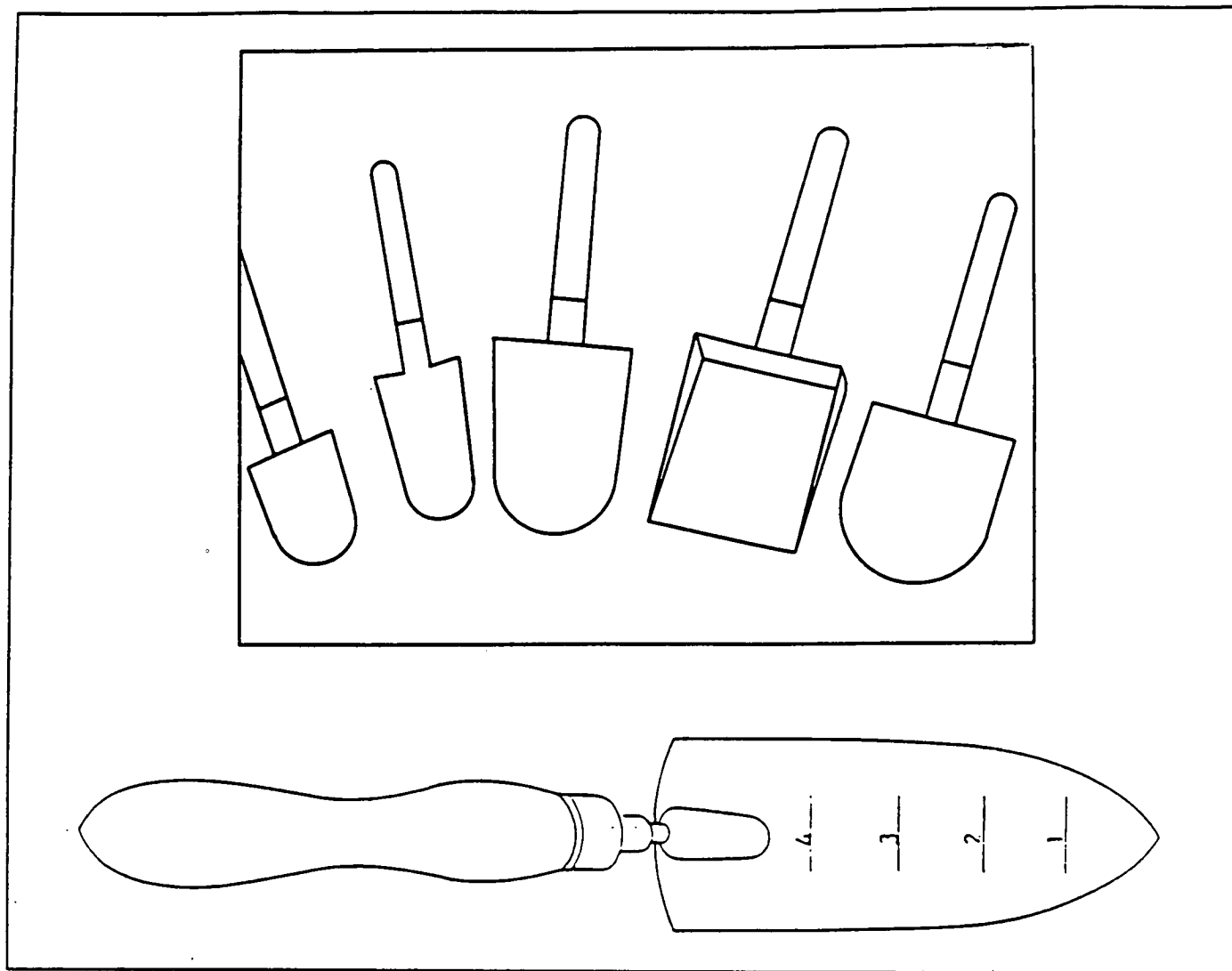


Figure C-13. Spade and scoop

samples for shipment (See Instruction F-2, "Sample Packaging and Shipping," in Appendix F).

- Decontaminate sampling equipment after use and between sample locations.

(2) Hand auger and tube sampler.

(a) Applicability. Equipment for the hand auger is portable and easy to use. Discrete subsurface soil samples can be collected efficiently without the use of a drill rig. Disadvantages of the hand auger include its limited sampling depth. The tube sampler may not penetrate gravelly or rocky soils.

(b) Method summary and equipment. Hand augers are the simplest and most direct method for sampling subsurface soil samples (Figure C-14). Although the maximum sampling depth for the hand auger is typically 5 ft, greater depths can be sampled depending on the soil type. Hand augers come in various diameters and various types. The auger bit is used to bore a hole to the desired sampling depth and then withdrawn. The auger tip is then replaced with the tube corer, lowered into the borehole, and forced into the soil at the completion depth. The corer is then withdrawn and the sample is collected.

(c) Sampling procedure.

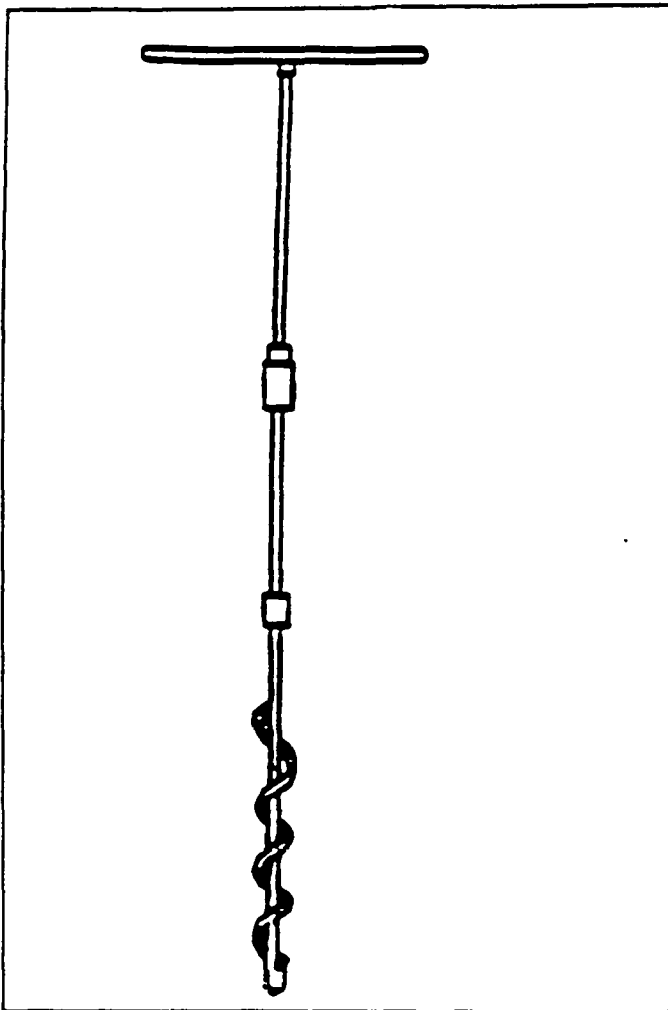


Figure C-14. Hand auger and tube sampler

- After reaching desired depth, slowly and carefully remove auger from boring.
  - Remove auger tip from drill rods and replace with a precleaned or decontaminated thin-wall tube sampler. Install proper cutting tip. If non-cohesive materials, (i.e., sands) are being sampled, then it may be necessary to use a bucket hand auger.
  - Carefully lower corer down borehole. Gradually force corer into soil. Take care to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring because the vibrations may cause the boring wall to collapse.
  - Remove corer by twisting to prevent losing core, and unscrew drill rods.
  - Remove cutting tip and remove core from device.
  - Discard top of core (approximately 2.5 cm), which represents any material collected by the corer before penetration of the layer in question. Place remaining core into VOA sample container or stainless steel bowl for homogenizing (See Instructions E-2 and E-3 in Appendix E).
  - Secure the cap tightly.
  - Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
  - Place filled sample containers on ice immediately.
  - Complete all chain-of-custody documents and record information in the field logbook (See Instruction F-1, "Documentation," in Appendix F). Prepare sample for shipment (See Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
  - Decontaminate sampling equipment after use and between sampling locations.
- (3) Split spoon sampler.
- (a) Applicability. The split spoon sampler is used for sampling subsurface soil in cohesive and non-cohesive
- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
  - Attach the auger bit to a drill rod extension and further attach the "T" handle to the drill rod.
  - Clear the area to be sampled of any surface debris (twigs, rocks, litter). It may be advisable to remove the first 8 to 15 cm of surface soil for an area approximately 15 cm in radius around the drilling location.
  - Begin drilling, periodically removing accumulated soils. This prevents accidentally brushing loose material into the borehole when removing the auger or adding drill rods.

type soils. It is used extensively for collecting subsurface soil samples for chemical analysis. The split spoon sampler will require a drill rig and crew for collecting samples greater than 5 ft.

(b) Method summary and equipment. The split spoon sampler is typically a 2- or 3-in.-diam, thick-walled, steel tube that is split lengthwise (Figure C-15). If a 2-in. diam split spoon sampler is used, then standard penetration tests can be taken to determine the density of the soil (ASTM 1967). A cutting shoe is attached to the lower end; the upper end contains a check valve and is connected to the drill rods. When a boring is advanced to the point that a sample is to be taken, drill tools are removed and the sampler is lowered into the hole on the bottom of the drill rods. The sampler is driven into the ground in accordance with the standard penetration test.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe on the bottom and the heavier headpiece on top.
- Place the sampler in a perpendicular position on the material to be sampled.
- Drive the tube utilizing a sledge hammer or drill rig if available. Do not drive past the bottom of the headpiece because this will result in compression of the sample.
- Record the length of the tube that penetrated the material being sampled and the number of blows required to obtain this depth. Typically, the number of blows per 6 in. of depth is recorded.
- Withdraw the sampler and open it by unscrewing the drive shoe and head and splitting the barrel. If split samples are desired, a decontaminated stainless steel knife should be utilized to split the tube contents in half longitudinally.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the

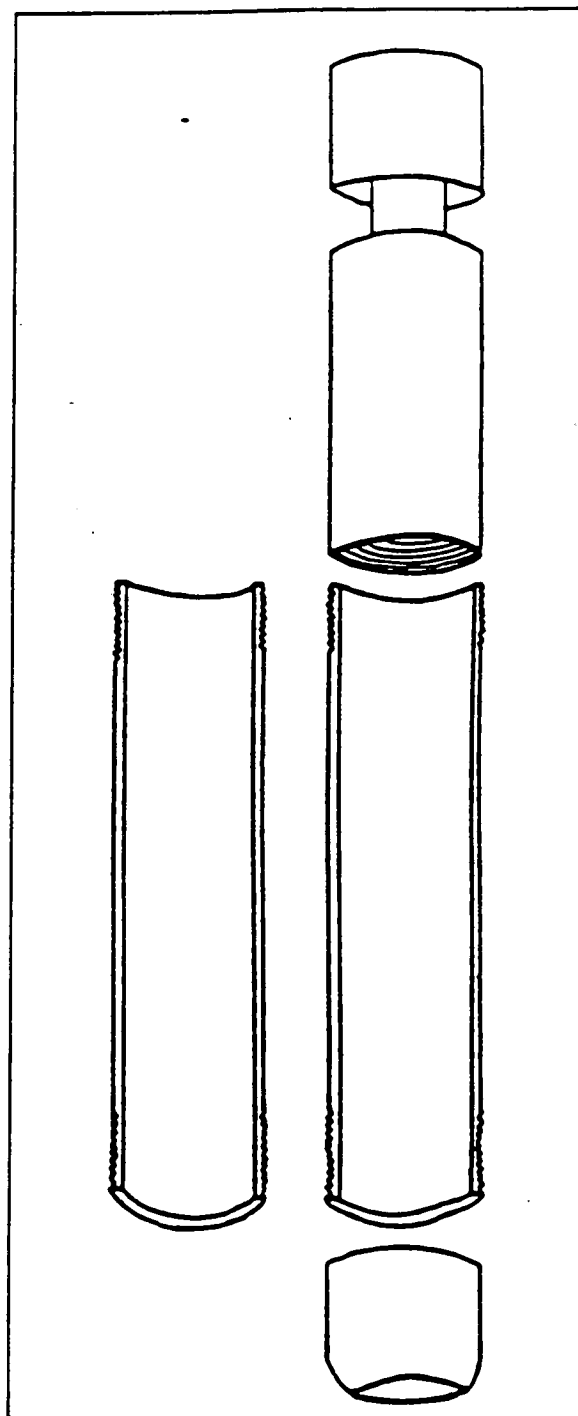


Figure C-15. Standard split spoon sampler

sample is transferred to the stainless steel bowl for mixing. Refer to Instructions E-2 and E-3, in Appendix E, respectively.

- Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to label the bottle carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and record information in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

#### (4) Ring-lined barrel sampler.

(a) Applicability. The ring-lined barrel sampler provides the ability to collect samples without losing volatiles or moisture. Soil is contained in the rings and it can be easily and quickly capped after it is removed. The relatively small size of the rings allows easy sample shipping and handling. However, the opportunity for describing the soil is diminished because most of the soil is concealed in the ring apparatus. Since rings are not always accepted by the laboratory, prior arrangements should be made with the laboratory.

(b) Method summary and equipment. Ring-lined barrel samplers are typically 3 in. in diameter and are used to obtain representative subsurface soil samples with a split sampling barrel that has removable rings. The rings are typically constructed of plastic, stainless steel, or brass and fit inside the barrel assembly. Rings are commonly used within the California Modified sampler and are typically 3 in. long.

#### (c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by placing eight 3-in.-long rings in the 2-ft-long sampler. Align both sides of the barrel and screw the drive shoe on the bottom and the heavier headpiece on top.
- Place the sampler in a perpendicular position on the material to be sampled.

- Drive the tube utilizing a sledge hammer or drill rig if available. Do not drive past the bottom of the headpiece because this will result in compression of the sample.
- Record the length of the tube that penetrated the material being sampled and the number of blows during each 6-in. increment.
- Withdraw the sampler and open it by unscrewing the drive shoe and head and the splitting barrel. Remove the sampling rings. Trim the soil at the end of the rings so that it is flush with the endings. For chemical samples, cap the end of the rings with a PTFE-lined plastic cap. For geotechnical samples, a plastic cap is suitable. Seal each end cap with plastic electrical tape.
- Label the sample ring with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.

- Place sealed sample rings on ice immediately.

- Complete all chain-of-custody documents and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

#### (5) Thin-walled (Shelby) tube sampler.

(a) Applicability. Thin-walled tube samplers allow collection of undisturbed samples in cohesive type soils (i.e., clays). They are primarily used for collecting soil samples for certain geotechnical tests. Thin-walled tube samplers are not the ideal container for transporting samples to the laboratory for chemical analysis. The opportunity for describing the soil is diminished because most of the soil is concealed in the tube.

(b) Method summary and equipment. The thin-walled tube sampler is designed to take undisturbed samples in cohesive type soils (Figure C-16). The thin-walled tube sampler is available in either brass, galvanized steel, plain steel, or stainless steel and is manufactured in either 30- or 36-in. lengths. It is available in 2-, 3-, and 5-in. diameters; however, the 3-in. diameter is the most commonly used. Thin-walled tube samplers are usually used

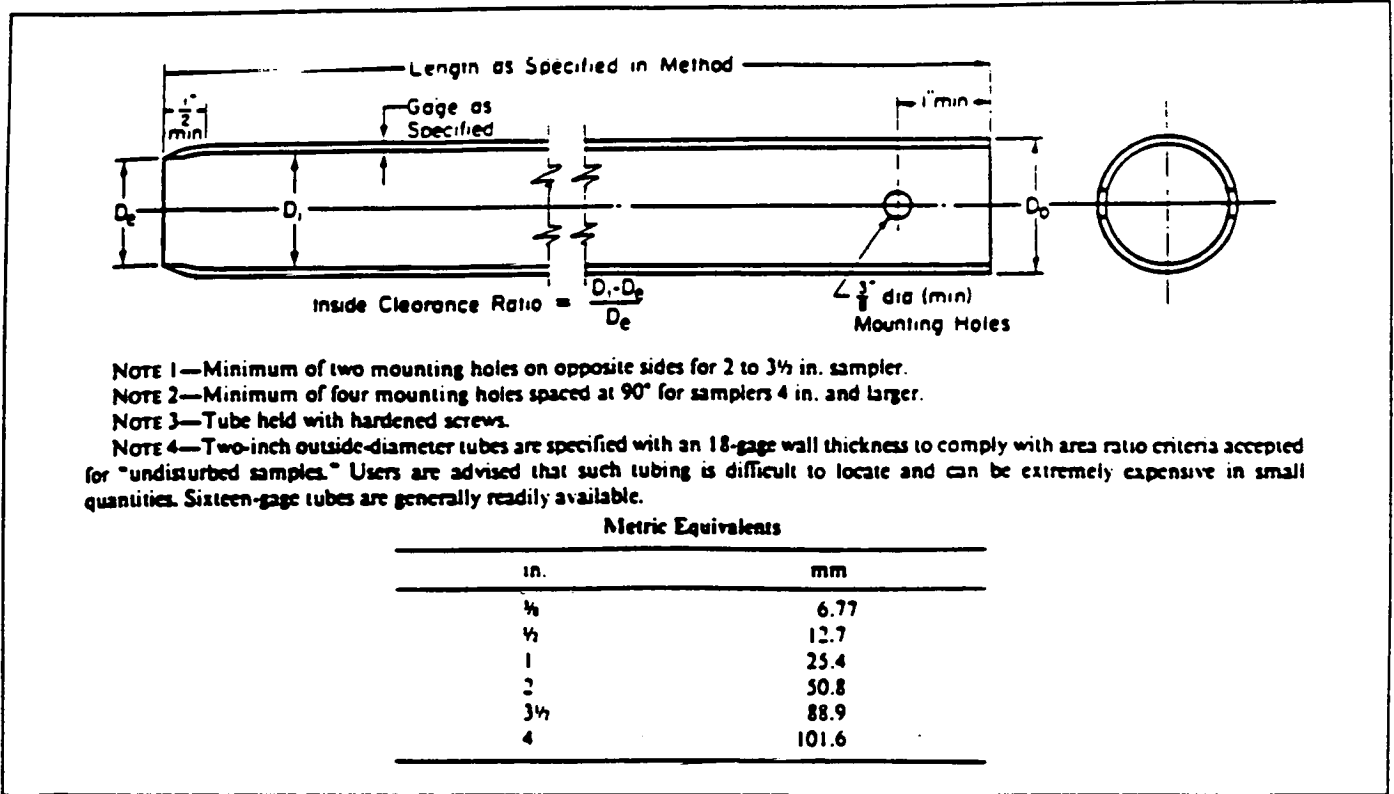


Figure C-16. Standard thin-walled (Shelby) tube sampler

for sampling cohesive soils for geotechnical evaluation, rather than chemical analysis.

(c) Sampling procedure.

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Place the sampler in a perpendicular position on the material to be sampled.
- Push the tube into the soil by a continuous and rapid motion, without impact or twisting. In no instance should the tube be pushed further than the length provided for the soil sample.
- When the soil is so hard that a pushing motion will not penetrate the sample sufficiently for recovery, it may be necessary to collect a disturbed sample with the split-spoon sampler. Extremely dense and hard soils may result in damage to the thin-walled tube sampler.
- Before pulling out the tube, rotate the tube at least two revolutions to shear off the sample at the

bottom. For geotechnical analysis, seal the ends of the tube with wax or rubber packers to preserve the moisture content. In such instances, the procedures and preparation for shipment should be in accordance with ASTM Method D1587-83 (ASTM 1983b). For chemical samples, seal the ends of the tube with PTFE-lined plastic caps. Seal each end cap with plastic electrical tape.

- Label the sample tube with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(6) CME (Central Mine Equipment) sampler.

(a) **Applicability.** The CME sampler provides good samples for describing soil profiles because of the long length of the samples. Discrete samples for chemical analysis can only be collected within a 5-ft increment. This sampler may not be effective in non-cohesive soil types and requires the use of a drilling rig.

(b) **Method summary and equipment.** The CME sampler is a split barrel sampler that is used in conjunction with the hollow stem auger drilling technique. The sampler is typically 5 ft long and is 4 in. in diameter. The sampler fits inside the lead hollow stem auger and collects soil as the auger is advanced into the soil.

(c) **Sampling procedure.**

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe on the bottom and the heavier headpiece on top.
- Attach the sampler to the drill rod extension and place the sampler inside the lead auger bit.
- Drive the sampler and the lead auger bit utilizing a well rig.
- Withdraw the sampler and open it by unscrewing the drive shoe and head and the splitting barrel. If chemical samples are desired, a decontaminated stainless steel knife should be utilized to divide the tube contents in half longitudinally.
- Transfer the sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.
- Secure the cap tightly.
- Place filled sample containers on ice immediately.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).

- Decontaminate sampling equipment after use and between sampling locations.

(7) **Core barrel.**

(a) **Applicability.** Core barrel sampling is used primarily for collecting samples for rock profiling purposes. Rock samples are not typically submitted for chemical analysis.

(b) **Method summary and equipment.** Core barrel drilling is used to obtain samples of rock or soils that are too hard to sample by soil sampling methods. Double tube core barrels work the best. Core bits used for this type of sampling are impregnated with diamonds that cut through the formation allowing a continuous rock sample to be collected.

(c) **Sampling procedure.**

- Place the core barrel into position with the bit touching the ground or the surface to be cored.
- Continue core drilling until core blockage occurs or until the net length of the core barrel has been drilled.
- Remove the core barrel from the hole and disassemble it as necessary to remove the core.
- Place the recovered core in a core box in accordance with ER 1110-1-1802, and ER 1110-1-1803. The core is placed in the core box with the upper end of the core at the upper left corner of the core box. Cores should be placed in the core box as a book would read, from left to right and top to bottom, within the longitudinal separators. Space blocks or plugs should be placed at the beginning of each core run. Core boxes should be marked on the outside to indicate the top and bottom, and the inside upper left corner of the box should be permanently marked with the letters UL to indicate the upper left corner. Soft or friable cores should be wrapped in plastic film or sealed in wax.

(8) **Cone penetrometer rigs.**

(a) **Applicability.** Cone penetrometer rigs have traditionally been used to collect geotechnical data for design of foundations and earth structures. Recent developments have expanded the use of this equipment to the area of

soil and groundwater sampling. Cone penetrometer rigs may also be used to delineate contaminant plumes. EPA/625/R-93/003 discusses the use of a cone penetrometer.

(b) Method summary and equipment. The cone penetrometer rig typically consists of a truck with a fully enclosed work area on the back. Within the work area is a hydraulic ram and computers to record data. The penetrometer collects data by pushing 1.5-in.-diam instrumented probes into the ground. As the probes are pushed they collect data and transmit the data to the onboard computer. This data can be viewed on the computer screen as the probe is advanced, allowing evaluation of the data immediately. The soil sampler used with the cone penetrometer consists of a lined steel cylinder with a retractable tip. The liner (typically a plastic type material) is placed in the sampler and the retractable tip is set at the bottom end of the sampler. The sampler is then advanced to the top of the interval where the soil sample is to be collected. The tip is remotely released and the sampler is pushed ahead into the interval to be sampled. Using this procedure, the soil sampler is pushed to the desired depth and the sample is collected without producing soil cuttings typically generated during soil boring activities. This type of soil sampler can be used with equipment other than cone penetrometers.

(c) Sampling procedure.

- Assemble decontaminated cone penetrometer device that will be pushed into the ground to collect data or samples.
- Push the data collection tip to the desired depth and record the data on the onboard computer. For the soil sampler, advance the sampler to the top of the interval to be sampled, release the tip, and advance the sampler to collect the soil sample.
- While removing the data collection tip, backfill the hole with grout by pumping grout through the tip as it is retracted. Following removal of the soil sample, backfill the hole with grout using the tremie method or by pouring the grout into the hole from the ground surface.
- Remove the liner from the soil sampler and begin sampling with the acquisition of any VOC samples, conducting the sampling with as little disturbance as possible to the media.

- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of a different location is desired, the sample is transferred to the stainless steel bowl for mixing. Refer to Instructions E-2 and E-3, in Appendix E, respectively.
- Transfer sample into an appropriate sample bottle using a stainless steel spoon or equivalent.
- Check that a PTFE liner is present in the cap. Secure the cap tightly.
- Label the sample bottle. Complete the label completely and clearly, addressing all the categories and parameters.
- Place filled sample containers on ice immediately.
- Complete chain-of-custody documents and field sheets and record in the logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate the equipment following each probe or sample.

(9) Piston sampler.

(a) Applicability. Piston samplers are used to collect soft subsurface soils that cannot be collected using other techniques.

(b) Method summary and equipment. The piston sampler (Figure C-17) consists of a sampling barrel with a piston that is retracted during sampling. Retraction of the piston creates a vacuum within the sample barrel that aids in retaining the sample in the barrel. Various piston type samplers are available, and each should be operated per the manufacturer's recommendations. EPA/625/R-93/003 and EPA/540/8-91/012 discuss the use of a piston sampler.

(c) Sampling procedure.

- Assemble decontaminated piston sampler and attach to rods that will lower the sampler down the borehole.



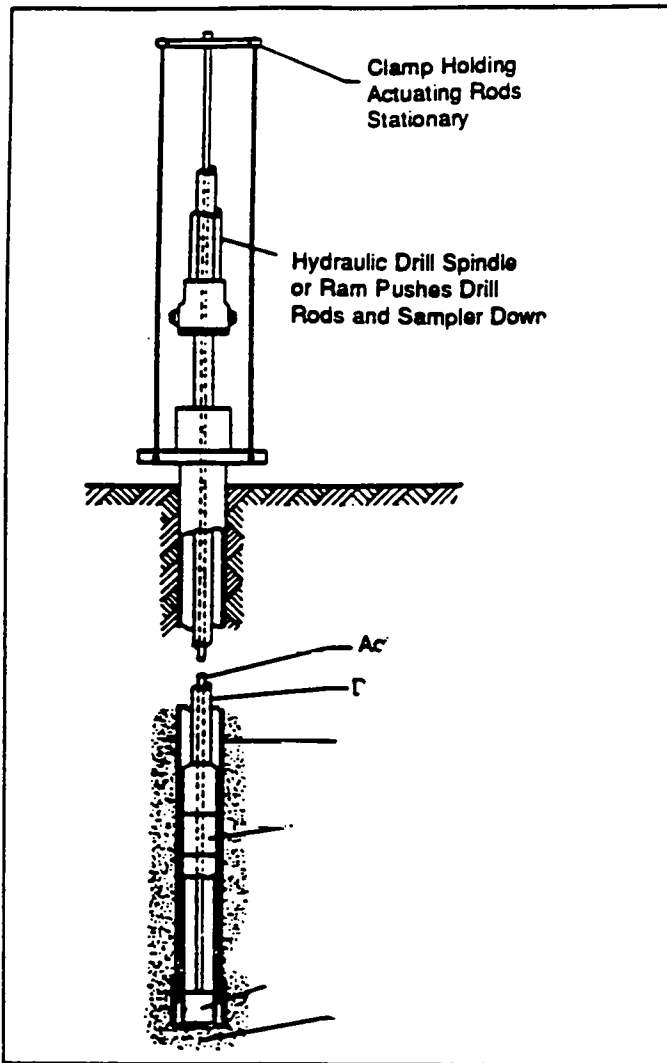


Figure C-17. Piston sampler

- Lower sampler to the desired depth. Advance the sampler into the soil while actuating the piston to create a vacuum within the sample barrel.
- Carefully remove the piston sampler from the bore hole.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to a stainless steel bowl for

mixing. Refer to Instructions E-2 and E-3, in Appendix E, respectively.

- Label the sample bottle with the appropriate sample label. Complete the label carefully and clearly, addressing all the categories or parameters.
- Place the sample in an appropriate container and put the container on ice.
- Complete all chain-of-custody documents and field sheets and record in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Thoroughly decontaminate the sampler after each use.

*e. Decontamination procedures.* All sampling equipment must be decontaminated prior to its use. Sampling equipment should be decontaminated as described in Instruction E-5 (Appendix E). The sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time.

*f. Field control sample requirements.* Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates, and/or background samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the sampling team for use by the primary laboratory. A detailed discussion of field control samples is contained in Instruction H-2 (Appendix H).

*g. Documentation requirements.* Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event, if appropriate, the investigator should draw a diagonal line at the conclusion of the entry and use his initials to indicate the conclusion of the entry or of the day's activity. All aspects of sample collection and handling as well as visual observations

should be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

- (1) Project name.
- (2) Sampling locations.
- (3) Date and times.
- (4) Sampling personnel present (identify responsibilities, if applicable).
- (5) Level of PPE worn.
- (6) Weather or any environmental condition which may affect the samples.
- (7) Equipment utilized.
- (8) Calibration data for field screening instruments.
- (9) Deviations to the approved workplans/SAP implemented.
- (10) A sketch of the sampled area (denoting sample numbers to locations).
- (11) Notation of the system for identifying and tracking all samples taken to their associated QC samples.
- (12) Notation of any visitors to the site.
- (13) Initials and date on each page.
- (14) Line out any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology that might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project files. A sample form can be developed and used in lieu of a field/logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details concerning

sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

## C-7. Surficial Sampling

*a. Scope of application.* Instructions presented in this section are for collecting representative samples from various surfaces. Surficial sampling is used to assess the existence and/or extent of contamination on various surfaces rather than in a soil, water, or air matrix. For example, the contamination of the interior of a building may be assessed by collecting wipe samples of the process vessels and ventilation ducts. Surface samples are not typically analyzed for VOCs. Typical sample parameters include polychlorinated biphenyls (PCBs), dioxans/furans, pesticides, semivolatiles, metals, and explosives. Surface samples are typically divided into three media. The media include non-porous surfaces, porous surfaces, and dust/soot. Non-porous surfaces can be sampled by wipe sampling; porous surfaces can be sampled by chipping or coring the surface; and dust/soot can be sampled by sweep sampling. Instructions for these techniques are included in this section. If these methods are difficult to implement due to irregular surface shapes or other limitations, a rinsate sample can be collected.

*b. Sampling strategies.* The data from surficial sampling is typically required for risk assessments or compliance issues. Therefore, the sampling strategy is either based on a biased approach to locate and/or identify contamination or a systematic approach for decontamination verification.

(1) Sampling locations. Sampling at hazardous waste sites is usually conducted in an attempt to discover contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. Surficial sampling can be conducted by either biased or systematic sampling. Biased samples are those collected at locations that were chosen based on historical information, knowledge about the behavior of the contaminant(s), and/or knowledge about the effects of the physical system on the contaminant's fate. Specific requirements for selecting sampling locations may be applicable for risk assessments or verification of cleanup levels. For example, sampling locations for verification of PCB cleanup levels are established in 40 CFR 761. Additional guidance for selecting sampling locations can be found in EPA/600/2-85/028, EPA/560/5-85/026, and EPA/560/586/017.

(2) Types of samples. Surficial samples are discrete samples. Discrete (grab) samples are defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected immediately and at one particular point in the sample matrix. Representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease.

(3) Suggested samplers. Each sampling technique presents various disadvantages and advantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Discussions of the advantages and disadvantages of each sampling technique are presented below.

(4) Sample frequency. Determination of the number of samples needed to characterize a site also depends on the objectives and the site-specific conditions. For example, if the objective of the event is to determine whether the site is contaminated, a limited number of samples from properly chosen locations will yield useful information. If, however, the site is known to be contaminated and delineation of the contamination is the objective, a greater number of samples may be needed. Confirmatory sampling for decontamination or removal actions may warrant specific sample frequency requirements. In many cases statistical considerations can be helpful in determining sampling strategy.

c. *Sample preservation and handling.* Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in investigation programs are not chemically stable; therefore, sample preservation is required. Chip, core, and sweep samples should be handled in the same fashion as sediment/soil samples. Wipe samples do not designate a preservation technique, but may implement protection from light and/or cooling. Appropriate preservation techniques for various parameters are specified in Appendix I. In addition, sample containers that the sampler should use for each constituent or common set of parameters are specified in Appendix I. These preservation methods and sample containers are based on *Test Methods for Evaluating Solid Waste-Physical/Chemical Methods, SW-846*. Procedures and techniques for transporting the samples to the offsite laboratory are discussed in Instruction F-2, "Packaging and Shipping Procedures," in Appendix F.

(1) Sample containers. Wipe samples should be placed in amber jars. The cleanliness of a batch of pre-cleaned bottles should be verified by the container supplier or in the laboratory. The residue analysis should be available prior to sampling in the field.

(2) Sample preservation. Methods of sample preservation are relatively limited and are generally intended to retard biological action, and hydrolysis, and to reduce sorption effects. Preservation methods are generally limited to refrigeration and protection from light. The sampler should refer to Appendix I or the specific preservation method in SW-846 for the appropriate preservation technique.

(3) Special precautions for trace contaminant sampling. Contaminants can be detected in the parts per billion and/or parts per trillion range. Therefore, extreme care must be taken to prevent cross-contamination of these samples. The following general precautions should be taken when sampling:

(a) A clean pair of new, disposable gloves should be worn each time a different location is sampled and gloves should be donned immediately prior to sampling.

(b) The appropriate template size should be identified. The solvent (including the required grade) in which the contaminants are most soluble should be identified.

(c) Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

(d) If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. It is good practice to enclose waste or highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean, plastic bags.

(e) If possible, one member of the field team should take all the notes, fill out sample tags, field sheets, etc.,

while the other members collect all of the samples. The exact areas sampled should be recorded in the logbook.

(f) Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

(g) Collection of adequate field control samples. For wipe samples, a blank is mandatory to identify potential interferences from the gauze, solvent, or sample containers.

*d. Sampling methods.* Presented below are sampling instructions for the most common techniques for collecting surface samples.

(1) Surface wipe sample.

(a) Applicability. This method of monitoring surficial contamination is intended for non-volatile species (e.g., PCBs) on non-porous surfaces (e.g., metal, glass). Sample points should be carefully chosen and should be based on site history, manufacturing processes, personnel practices, obvious contamination, and available surface area.

(b) Method summary and equipment. Surface wipe sampling methods vary and are dependent on the data objectives. A generalized procedure is presented here for reference.

(c) Sampling procedure.

- Place an appropriately sized square template cutout over the area to be sampled (Toxic Substances and Control Act (TSCA) requires 100 cm<sup>2</sup>).
- Remove a gauze pad from the box of gauze using decontaminated tongs (filter paper may also be used). Be sure to use a new pair of surgical gloves.
- Soak the gauze or filter pad in appropriate solvent.
- Using a decontaminated pair of tongs, wipe the area framed by the template cutout with the moistened gauze in one direction.
- Without allowing the gauze to contact any other surface, fold the gauze with the exposed side in, and then fold it again to form a 90-degree angle in the center of the gauze.

- Place the gauze in an amber laboratory sample container angle first and replace the container cap.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label properly and clearly, addressing all categories or parameters.
- Place filled sample container on ice immediately, if desired.
- Complete all chain-of-custody documents and record information in the field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare the samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Mark the area of the cutout using a paint stick, if possible.
- Record the location data, station number, sample time, date, and names of the sampling crew in the field logbook or log sheet for each wipe sample. In addition, document the sampling locations by a dimensioned sketch in the field logbook or log sheet if the sampled area cannot be marked by a paint stick or if locating the area from the field notes would be difficult.
- Dispose of generated waste material properly.

(2) Chip/core sample.

(a) Applicability. This method of monitoring surficial contamination is intended for non-volatile analytes (e.g., PCBs) on porous surfaces (e.g., cement, brick, wood). Suggested sampling points include floors near process vessels, storage tanks, loading docks, etc.

(b) Method summary and equipment. Samples from porous surfaces can be obtained by breaking up a designated surface with a chisel, brushing up the chipped pieces, and transferring the sample into a bottle. A core sample can also be collected using appropriate power tools. However, most confirmatory sampling requires that only the upper quarter inch of the media be sampled. Core samples may dilute contaminants that may only be

present in the upper quarter inch and are therefore discouraged.

(c) Sampling procedure. Once the sample location has been determined, measured, and marked off, sample collection can begin as follows:

- Place an appropriately sized square template cut-out over the area to be sampled.
- Use a decontaminated chisel and hammer to break up the surface to be sampled (TSCA requires 100 cm<sup>2</sup>). Avoid scattering pieces. Chip the area to less than 1/4 in. in depth.
- Record the depth at which the chips were taken.
- Collect the chipped pieces using new clean gloves and a pair of decontaminated tongs.
- Transfer the sample directly into the sample bottle.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample container on ice immediately.
- Complete all chain-of-custody documents and record in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

(3) Sweep sample.

(a) Applicability. This method of monitoring surficial contamination is intended for non-volatile analytes (e.g., PCBs) in residue found in porous (e.g., asphalt) or non-porous (e.g., metal) surfaces. Sweep sampling allows collection of dust/residue that may help in the assessment of contaminant determination and delineations.

(b) Method summary and equipment. Dust and residue samples can be collected with a bristle brush and dustpan in places where solvents cannot be used or when

large amounts of dust/residue make wipe samples impractical.

(c) Sampling procedure. Once the sample location has been determined, measured, and marked off, sample collection can begin as follows:

- Put on clean, chemical-resistant gloves (separate pair for each location).
- Place an appropriately sized square template cut-out over the area to be sampled (TSCA requires 100 cm<sup>2</sup>).
- Sweep all residue from the area to be sampled into the dustpan.
- Transfer the sample directly into the sample bottle.
- Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample container on ice immediately.
- Complete all chain-of-custody documents and record in field logbook (see Instruction F-1, "Documentation," in Appendix F). Prepare samples for shipment (see Instruction F-2, "Sample Packaging and Shipping," in Appendix F).
- Decontaminate sampling equipment after use and between sampling locations.

*e. Decontamination procedures.* All sampling equipment must be decontaminated prior to its use. Field equipment should be cleaned as described in Instruction E-5 in Appendix E. The sampling equipment should be placed in a plastic bag until immediately prior to use. Additional sampling devices may be needed onsite to ensure an adequate drying time.

*f. Field control sample requirements.* Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, replicates and/or background samples. QA samples are replicates which are sent to USACE's QA laboratory and analyzed to evaluate the contractor's laboratory performance. QC samples are replicates collected by the

sampling team for use by the primary laboratory. A detailed discussion of field control samples follows:

(1) Duplicate/split samples. True duplicate/split samples cannot be collected in a wipe sampling program. The gauze used to collect the wipe sample cannot be divided to obtain a duplicate/split sample because the contaminants will not be spread evenly on the gauze. The same surface area cannot be wiped a second time to obtain a duplicate/split sample because the first wipe sample will remove the contaminants from the wiped area. Collecting a sample from an area adjacent to the first sampling area is a viable alternative for collecting a duplicate/split sample. However, the sample is not a true duplicate/split sample and the contaminant concentrations in the samples from the adjacent area may not be the same.

(2) Wipe blank samples. Wipe blanks are samples collected in the field to determine if any interference has been caused by the sample collection materials (i.e., gauze, solvent, or sampling equipment). Wipe blanks are obtained by preparing the gauze for sampling, placing the solvent on the gauze, and placing the gauze in the sample containers. The gauze does not contact any sampling surface.

(3) Background samples. Background samples are recommended to be taken in conjunction with chip/core samples. Background samples should be taken using the same procedures used to obtain the field samples. The samples should be obtained from an uncontaminated area of the same matrix used to collect the field samples. The rationale for collecting background samples is to determine if there are any interferences inherent to the porous matrix.

(4) Rinsate blank samples. Rinsate samples consist of reagent water collected from a final rinse of surfaces after decontamination procedures have been performed. The purpose of the rinsate samples is to determine the thoroughness of the decontamination procedures performed.

*g. Documentation requirements.* Bound field logbooks should be used for the maintenance of field records. Preferably, a logbook should be dedicated to an individual project. The investigator's name, project name, and project number should be entered on the inside of the front cover of the logbook. All entries should be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the investigator should draw a diagonal line at the conclusion

of the entry and use his initials to indicate the conclusion of the entry or of the day's activity. All aspects of sample collection and handling, as well as visual observations, shall be documented in the field logbooks. Documentation should be recorded in pre-numbered bound notebooks using indelible ink pens in sufficient detail so that decision logic may be traced back once reviewed. Documentation should include:

- Project name.
- Sampling locations.
- Date and times.
- Sampling personnel present (identify responsibilities, if applicable).
- Level of PPE worn.
- Weather or any environmental condition which may affect the samples.
- Equipment utilized.
- Calibration data for field screening instruments.
- Deviations from the approved workplans/SAP implemented.
- A sketch of the sampled area (denoting sample numbers to locations).
- A photograph log.
- Notation of the system for identifying and tracking all samples taken to their associated QC samples.
- Notation of any visitors to the site.
- Initials and date on each page.
- Lining out of any remaining blank portions or pages with a signature and date.

All entries in field logbooks should be legibly recorded and contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and are maintained as part of the permanent project

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files. Sample forms may be developed and used in lieu of a field logbook. Proper field sheet, sample labeling, chain-of-custody, and sample tracking documentation should be maintained as appropriate. Specific details

concerning sample documentation and sample management should be included in planning documents and reviewed by the sampling team prior to initializing the sampling program.

**APPENDIX D-2**

**Sample Documentation and  
Shipment Instructions  
(Appendix F of EM 200-1-3)**



## Appendix F Sample Documentation and Shipment Instructions

### F-1. Documentation

*a. Scope and application.* This section describes procedures for maintaining sample control through proper sample documentation. When samples are collected for chemical or physical characteristics analysis, documentation such as chain-of-custody and sample analysis request forms, custody seals, and logbooks needs to be completed. The information presented in this section enables maintenance of sample integrity from time of collection through transportation and storage. It is this documentation that will verify that the samples were properly handled.

*b. Documentation.* The following discussion outlines standard practices and procedures to be used when documenting a sampling episode. All project-specific documentation requirements must be presented in the sampling and analysis plan (SAP). This includes identification of procedures required for field documentation, sample labeling, and the maintenance of chain-of-custody. Applicable requirements are identified in the following paragraphs. In addition, the contractor is required to obtain a tracking number (e.g., Laboratory Information Management System (LIMS) number) from the U.S. Army Corps of Engineers (USACE) technical manager that is used in conjunction with the government quality assurance (QA) sample shipments. The tracking number should be specified in the SAP. Proper completion of the logbook and supporting paperwork with indelible ink is necessary to support potential enforcement actions that may result from the sample analysis. Therefore, maintaining sample integrity through proper documentation is essential.

(1) Field logbooks. Project field logbooks must be bound and should have numbered, water-resistant pages. All pertinent information regarding the site and sampling procedures must be documented in indelible ink. Notations should be made in logbook fashion, noting the time and date of all entries. Information recorded in this logbook should include, but not be limited to, the following:

(a) Name and exact location of site of investigation or interest.

(b) Date and time of arrival and departure.

(c) Affiliation of persons contacted.

(d) Name of person keeping log.

(e) Names of all persons on site.

(f) Purpose of visit.

(g) All available information on site processes or products, waste generation, nature of spilled material) and the composition and concentration of substance, if known.

(h) Field instrument equipment used and purpose of use (i.e., health & safety screening, sample selection for laboratory analysis), calibration methods used, field results, and quality control (QC) information.

(i) Location of sampling points (including justification) [Note: It is recommended that a sketch of the general surroundings of the sampling area (site) be provided. Sample identification numbers should correspond directly with sample locations].

(j) Identification number, volume, sampling method, and containers (size/type) for each sample collected. Any sample manipulations such as filtration, compositing, and executed preservation techniques should also be documented.

(k) Date and time of sample and data collection and any factors that may affect their quality.

(l) Name of collector.

(m) All sample identification numbers and a description of samples--especially any related QC samples.

(n) Weather conditions on the day of sampling, and any additional pertinent field observations.

(o) Description of the number of shipping coolers packaged (attach associated chain-of-custody forms) and the shipping method employed (note applicable tracking numbers).

(p) Name and address of all receiving laboratories. For sample shipment to the government QA laboratory, note the associated project LIMS number.

(2) Documenting sampling points. The exact locations of sampling points should be documented for purposes of generating an accurate representation of the site conditions using the data generated to date, defining data gaps, and identifying potential future data needs. This is

accomplished through the use of a monument and compass. A monument should be chosen at each site to act as a stationary reference point from which all sampling points can be measured using a compass and measuring tape. If a building or other stationary structure exists, its corner may act as this reference point. If no monument exists, it will be necessary to create one. A piece of wood, approximately 2 in. by 2 in., should be hammered into the ground to almost ground level, making it difficult to remove and thus assuring its permanence. The stake should then be marked with flagging tape or fluorescent paint. When establishing a sampling point, the following procedure should be used:

(a) Standing at the monument, facing the sampling point, use the compass hairlines to determine the degree of direction.

(b) Ensure that the line of sight runs from the monument, through both hairline needles on the compass, to the sampling point.

(c) When first establishing the sampling point, record the degree and direction reading from the compass in the field logbook, along with the distance measurement from the monument to the sampling point.

(3) Photographic documentation. All sampling points should be documented on film. A film record of a sampling event allows positive identification of the sampling point. In some cases, a photograph of the actual sample collected may be required. Photographs are the most accurate and convenient record of field personnel observations. Photographs taken to document sampling points should include two or more reference points to facilitate relocating the point at a later date. Keeping a record of photographs taken is crucial to their validity as a representation of an existing situation. Photograph documentation is invaluable if the sampling and subsequent analytical data end in litigation, enforcement, or cost recovery actions. In addition to photographs, video coverage of a sampling episode can be equally or even more valuable than photographs because it can be used to prove that samples were taken properly as well as the location at which they were taken. Video coverage can be used as a record of site conditions and can give those who have not been onsite an idea of the circumstances. For each photograph taken, the following items should be noted in the field logbook:

- (a) Date.
- (b) Time.
- (c) Photographer (signature).
- (d) Name of site.
- (e) General direction faced and description of the subject taken.
- (f) Sequential number of the photograph and the roll number.
- (g) Site photo map (see Figure F-1).

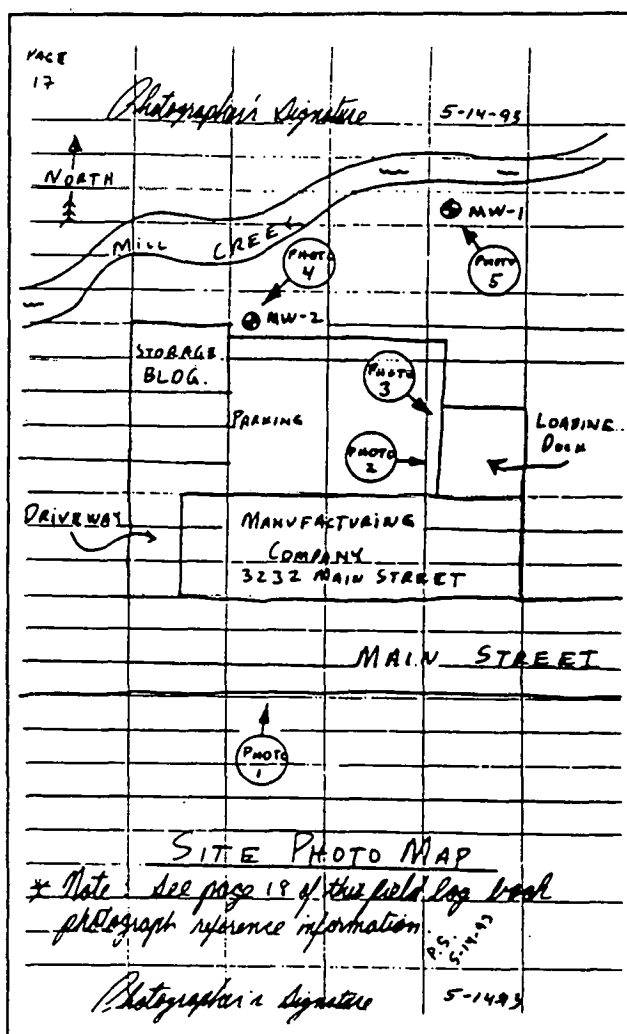


Figure F-1. Site photo map

(4) Sample collection paperwork.

(a) Sample labels. Sample labels are required for properly identifying samples and evidence. The data obtained from samples collected for a sampling or monitoring activity may be used for remedial measures. All samples must be properly labeled with the label affixed to the container prior to transportation to the laboratory. It is also recommended that samples be photographed so that labels are clearly readable for later identification. Information on sample labels should include, but not be limited to, the following:

- Project Code. An assigned contractor, project number, site name.
- Station Number. A unique identifier assigned to a sampling point by the sampling team.
- Sample Identification Number. Each sample, including field control samples, collected for a project should be assigned a unique number. This assigned number incorporates information on the sample type and date (see Section b(4)b in Instruction F-1).
- Samplers. Each sampler's name and signature or initials.
- Preservative. Whether a preservative is used and the type of preservative.
- Analysis. The type of analysis requested.
- Date/Time. Identify the date and time the sample was taken.
- Type of Sample. The type of sample should be identified as discrete or composite.

(b) Sample numbering. A sample numbering system should be used to identify each sample collected and submitted for analysis. The purpose of the numbering system is to assist in the tracking of samples and to facilitate retrieval of analytical results. The sample identification numbers for each sampling effort should be used on sample labels, sample tracking matrix forms, chain-of-custody forms, field logbooks, and all other applicable documentation. A listing of all sample identification numbers should be recorded in the field logbook. The sampling numbering system may vary depending upon the number and type of samples that will be collected at the site. An example of a sample numbering system is presented below. Location and sample identification

numbers should consist of the following designations to identify the location (AABBB-CC), sample sequence number, date (MMDDYY), and sample interval for soils (00-00):

For Soil and Bedrock: AABBB-CC/MMDDYY/00-00  
For Water: AABBB-CC/MMDDYY  
For QC Samples: AABBB-CC/MMDDYY

Example: SB001-01/081492/08-10=Soil Boring SB001, Sample Number 1, sampled on August 14, 1992, from a sample interval of 8 to 10 ft.

Duplicate samples should be numbered in sequential order. For example, a duplicate sample collected from the above soil boring example would have a designation as follows:

Example: SB001-02/08 1492/08-10

Each sample collected must be assigned a unique sample number. Sample numbers should change when the media or location changes. Sample numbers should not change because different analyses are requested. For example, water samples collected at the same location, date, and time for volatile organics, semivolatile organics, and metals analyses would all have the same sample number, although the various sample aliquots would be collected in different containers.

(c) Chain-of-custody. Chain-of-custody procedures provide documentation of the handling of each sample from the time it is collected until it is destroyed. Chain-of-custody procedures are implemented so that a record of sample collection, transfer of samples between personnel, sample shipping, and receipt by the laboratory that will analyze the sample is maintained. Records concerning the cleaning of empty sample containers, container shipment from the laboratory to the site, and security of empty containers at the site should also be maintained. The chain-of-custody (COC) record (Figure F-2) serves as a legal record of possession of the sample. The COC record is initiated with the acquisition of the sample. The COC record remains with the sample at all times and bears the name of the person (field investigator) assuming responsibility for the samples. The field investigator is tasked with ensuring secure and appropriate handling of the bottles and samples. To simplify the COC record and eliminate potential litigation problems, as few people as possible should handle the sample or physical evidence during the investigation. A sample is considered to be under custody if one or more of the following criteria are met:

CHAIN OF-CUSTODY RECORD

PROJ. NO		PROJECT NAME				NO. OF CONTAINERS	REMARKS						
SAMPLERS: (signature)													
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION								
Relinquished by: (signature)			Date/Time		Received by: (signature)			Relinquished by: (signature)		Date/Time		Received by: (signature)	
Relinquished by: (signature)			Date/Time		Received by: (signature)			Relinquished by: (signature)		Date/Time		Received by: (signature)	
Relinquished by: (signature)			Date/Time		Received for Laboratory by: (signature)			Date/Time		Remarks			

Figure F-2. Chain-of custody form

- The sample is in the sampler's possession.
- The sample is in the sampler's view after being in possession.
- The sample was in the sampler's possession and then was locked up to prevent tampering.
- The sample is in a designated secure area.

CUSTODY SEAL	CUSTODY SEAL
_____	_____
Date	Date
_____	_____
Signature	Signature

Figure F-3. Chain-of-custody seal

In addition to the COC record, there is also a COC seal. The COC seal (Figure F-3) is an adhesive seal placed in areas such that if a sealed container is opened, the seal would be broken. The COC seal ensures that no sample tampering occurred between the field and the laboratory analysis.

(d) Transfer of custody and shipment. All sample sets should be accompanied by a COC record. When transferring possession of samples, the individual receiving the samples should sign, date, and note the time that

he/she received the samples on the COC record. This COC record documents transfer of custody of samples from the field investigator to another person, other laboratories, or other organizational units. Samples must be properly packaged for shipment and delivered or shipped to the designated laboratory for analyses. Shipping containers must be secured by using nylon strapping tape and custody seals (Instruction F-2). The custody seals must be placed on the container so that it cannot be opened without breaking the seals. The seal must be signed and dated by the field investigator. When samples are split with a facility, state regulatory agency, or other government agency, the agency representative must sign the COC record, if present. All samples should be accompanied by the COC record. As previously discussed, the U.S. Army Corps of Engineers (USACE) tracking number (e.g., LIMS number) that is used in conjunction with the government QA sample shipment must be written on the QA sample's COC record. The original and one copy of the record will be placed in a plastic bag taped to the inside lid of the secured shipping container. One copy of the record will be retained by the field investigator or project leader. The original record will be transmitted to the field investigator or project leader after samples are accepted by the laboratory. This copy will become a part of the project file. If sent by mail, the package should be registered with return receipt requested. If sent by common carrier, an air bill should be used. Receipts from post offices and air bills should be retained as part of the documentation of the chain of custody. The air bill number or registered mail serial number should be recorded in the remarks section of the COC record.

(e) Sample analysis request. To ensure that proper analysis is performed on the samples, additional paperwork may need to be filled out, as required by the lab performing the analysis. This form identifies samples by number, location, and time collected and allows the collector to indicate the desired analysis. This form should act as a supplement/confirmation to the COC record and lab contacts made prior to the sample event initiation.

(5) EPA CLP variances. In addition to the previously discussed documents, if the site under investigation is an Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) site, the EPA will require the following documents:

(a) Field sheets. Field sheets are forms provided by the EPA that correspond to samples that are anticipated to be collected at the site. Figure F-4 is an example of an EPA field sheet. When working on an EPA activity, the field sheet will replace the sample analysis request form.

The field sheet contains information specific to that job site and sample, including, but not limited to the following:

- Activity number.
- Project number.
- EPA sample number.
- Analyses requested.
- Sample container.
- Preservatives.
- Sampler.
- Date and time.
- Sampler's signature.

(b) Sample identification tags. Sample identification tags are distributed as needed to field workers by the field sampling leader. Procedures for sample identification tags vary among EPA regions. Generally, the EPA serial numbers are recorded in the project files, the field logbook, and the document control officer's serialized document logbook. Individuals are accountable for each tag assigned to them. A tag is considered to be in an individual's possession until it has been filled out, attached to a sample, and transferred to another individual along with the corresponding COC record. Sample identification tags are not discarded. If tags are lost, voided, or damaged, the facts are noted in the appropriate field logbook, and the field team leader is notified. Figure F-5 is an example of a typical sample identification tag. Upon the completion of the field activities, unused sample identification tags are returned to the document control officer, who checks them against the list of assigned serial numbers. Tags attached to samples that are split with the owner, operator, agent-in-charge, or a government agency are accounted for by recording the serialized tag numbers on the receipt-for-samples form. Alternatively, tie split samples are not tagged but are accounted for on a COC record. Samples are transferred from the sample location to a laboratory or another location for analysis. Before transfer, however, a sample is often separated into fractions, depending on the analysis to be performed. Each portion is preserved in accordance with prescribed procedures and is identified with a separate sample identification tag, which should indicate in the "Remarks" section

DRAFT	FIELD SHEET			
U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION VII				
ENVIRONMENTAL SERVICES DIV. 25 FUNSTON RD. KANSAS CITY, KS 66115				
-----				
FY: 92 ACTNO: IS38P SAMNO: 012 QCC: F MEDIA: WATER PL: S P F D				
-----				
ACTIVITY DES: SHAW AVENUE DUMP SITE				REF LATITUDE: _____
LOCATION: CHARLES CITY	IA	PROJECT NUM: A41	PT: LONGITUDE: _____	_____
-----				
SAMPLE DES: ACID BLANK		DATE	TIME	FROM REF PT
LOCATION: CHARLES CITY	IA	BEG: ___/___/___	_____	EAST: _____
CASE/BATCH/SMO: ___/___/___	LAB: _____	END: ___/___/___	___:___	NORTH: _____
STORET/AIRS NO: _____				DOWN: _____
ANALYSIS REQUESTED:				
CONTAINER	PRESERVATIVE	MGP	NAME	
CUBI	5 ML HNO3	WM	METALS	
COMMENTS: FOR SUPERFUND ONLY: SUBSITE IDENTIFIER: _____ OPERABLE UNIT: _____				
SAMPLE COLLECTED BY : _____				

Figure F-4. EPA field sheet

that the sample is a split sample. The tag used for water, soil, sediment, and biotic samples contains an appropriate place for identifying the sample as a grab or a composite, the type of sample collected, and the preservative used, if any. The tag used for air samples requires the sampler to designate the sequence number and identify the sample type. Sample identification tags are attached to, or folded around, each sample and are taped in place. After collection, separation, identification and preservation, a sample traffic report is completed and the sample is handled using chain-of-custody procedures discussed in the following sections. If the sample is to be split, aliquots are placed into similar sample containers. Sample identification tags are completed and attached to each split and marked with the tag numbers of the other portions and the word "split." Blank or duplicate samples are labeled in the same manner as "normal" samples. Information on

blanks or duplicate samples is recorded in the field logbook.

(c) Sample traffic report. The sample documentation system for the CLP sample preparation program is based on the use of the sample traffic report (TR), a four-part carbonless form printed with a unique sample identification number. One TR and its printed identification number are assigned by the sampler to each sample collected. The three types of TRs currently in use include organic, inorganic dioxin, and high-concentration TRs. Figure F-6 is an example of an organics TR. To provide a permanent record for each sample collected, the sampler completes the appropriate TR, recording the case number, site name or code and location, analysis laboratory, sampling office, dates of sample collection and shipment, and sample concentration and matrix. The sampler enters the

★ GPO 776-312

Project Code	Station No. CS-MV-165	Month/Day/Year 01/15/85	Time 0830	Designate: Comp. <input type="checkbox"/> Grab <input checked="" type="checkbox"/>		
				Preservative: Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>		
Station Location MONITORING WELL #5		Samplers (Signatures) Sample 1, Sample 2				<b>ANALYSES</b>
						BOD
Remarks:						COD, TOC, Nutrients
						Phenolics
						Mercury
						Metals
						Cyanide
						Oil and Grease
						Organics GC/MS
						Priority Pollutants
						Volatile Organics <input checked="" type="checkbox"/>
						Pesticides
Mutagenicity						
Bacteriology						
Tag No. 418851		Lab Sample No.				

Figure F-5. EPA sample identification tag

numbers of sample containers and volumes beside the analytical parameter(s) requested for particular sample portions. The TR should be placed in the cooler with the COC record and sent to the laboratory.

(d) Receipt-for-samples form. Section 3007(a)(2) of the Resource Conservation and Recovery Act states "If the officer, employee, or representative obtains any samples, prior to leaving the premises, he shall give to the

owner, operator, or agent-in-charge, a receipt describing the samples obtained and, if requested, a portion of each such sample equal in volume or weight to the portion retained." Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act (SARA), contains identical requirements. Completing a receipt-for-samples form complies with these requirements; such forms should be used whenever splits are offered or provided to the site owner, operator, or agent-in-charge. Figure F-7 is an example of a typical receipt-for-samples form. This form is completed, and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is given to the field leader and is retained in the project files. In addition, the contractor must provide analytical results from the samples collected to the owner, operator, or agent in charge, as mandated in SARA.

c. QA/QC requirements.

(1) Corrections to documentation. All original data recorded in field logbooks and on sample labels, chain-of-custody records, and receipt-for-samples forms are written in waterproof ink. If an error is made on an accountable document, corrections should be made simply by crossing out the error and entering the correct information. The erroneous information should not be obliterated. Any error discovered on a document should be corrected by the person who made the entry. All corrections must be initialed and dated.

(2) Photographs. The photographer should review the photographs or slides when they return from developing and compare them with the photographic log to confirm that the log and photographs match.

d. Potential problems. Although most sample labels are made with water-resistant paper and are filled out using waterproof ink, inclement weather and general field conditions can affect the legibility of sample labels. It is recommended that after sample labels are filled out and affixed to the sample container, the label should be covered with wide clear tape. This will preserve the label and keep it from becoming illegible. In addition to label protection, chain-of-custody and analysis request forms should be protected when samples are shipped in iced coolers. Typically, these forms should be placed inside a ziplock bag or similar waterproof protection and taped to the inside lid of the secured shipping container with the samples.

<b>ORGANICS TRAFFIC REPORT</b>		Sample Number <b>AH 719</b>																																								
① Case Number: <u>9999</u>  Sample Site Name/Code: <u>C. KEMICAL SOUP/</u> <u>1750.75</u>	② SAMPLE CONCENTRATION (Check One) <input checked="" type="checkbox"/> Low Concentration <input type="checkbox"/> Medium Concentration  ③ SAMPLE MATRIX (Check One) <input checked="" type="checkbox"/> Water <input type="checkbox"/> Soil/Sediment	④ Ship To: <b>QER LAB</b> <b>321 ROAD STREET</b> <b>SOMERTOWN, STATE</b> <b>12345</b>  Attn: <u>SAMPLER COORDINATOR</u> Transfer _____ Ship To: _____																																								
⑤ Regional Office: <u>MS/AMC</u> Sampling Personnel: <u>SAMPLER</u> (Name) <u>412/788-1080</u> (Phone)  Sampling Date: <u>1/15/85</u> (Begin) (End)	⑥ For each sample collected specify number of containers used and mark volume level on each bottle. <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 30%;"></th> <th style="width: 15%;">Number of Containers</th> <th style="width: 15%;">Approximate Total Volume</th> <th style="width: 40%;"></th> </tr> </thead> <tbody> <tr> <td>Water (Extractable)</td> <td style="text-align: center;">2</td> <td style="text-align: center;">1 gal</td> <td>AH 719 - Water (Extractable)</td> </tr> <tr> <td>Water (VOA)</td> <td style="text-align: center;">2</td> <td style="text-align: center;">80 ml</td> <td>AH 719 - Water (Extractable)</td> </tr> <tr> <td>Soil/Sediment (Extractable)</td> <td></td> <td></td> <td>AH 719 - Water (Extractable)</td> </tr> <tr> <td>Soil/Sediment (VOA)</td> <td></td> <td></td> <td>AH 719 - Water (VOA)</td> </tr> <tr> <td>Other</td> <td></td> <td></td> <td>AH 719 - Water (VOA)</td> </tr> <tr> <td></td> <td></td> <td></td> <td>AH 719 - Soil/Sediment (Extractable)</td> </tr> <tr> <td></td> <td></td> <td></td> <td>AH 719 - Soil/Sediment (Extractable)</td> </tr> <tr> <td></td> <td></td> <td></td> <td>AH 719 - Soil/Sediment (VOA)</td> </tr> <tr> <td></td> <td></td> <td></td> <td>AH 719 - Soil/Sediment (VOA)</td> </tr> </tbody> </table>			Number of Containers	Approximate Total Volume		Water (Extractable)	2	1 gal	AH 719 - Water (Extractable)	Water (VOA)	2	80 ml	AH 719 - Water (Extractable)	Soil/Sediment (Extractable)			AH 719 - Water (Extractable)	Soil/Sediment (VOA)			AH 719 - Water (VOA)	Other			AH 719 - Water (VOA)				AH 719 - Soil/Sediment (Extractable)				AH 719 - Soil/Sediment (Extractable)				AH 719 - Soil/Sediment (VOA)				AH 719 - Soil/Sediment (VOA)
	Number of Containers	Approximate Total Volume																																								
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			AH 719 - Soil/Sediment (VOA)																																							
			AH 719 - Soil/Sediment (VOA)																																							
⑦ Shipping Information  <u>FEDERAL EXPRESS</u> Name of Carrier  <u>1/15/85</u> Date Shipped:  <u>350262356</u> Airbill Number:	⑧ Sample Description <input type="checkbox"/> Surface Water <input type="checkbox"/> Mixed Media <input type="checkbox"/> Ground Water <input type="checkbox"/> Solids <input type="checkbox"/> Leachate <input type="checkbox"/> Other (specify) _____																																									
⑨ Special Handling Instructions: (e.g., safety precautions, hazardous waste)		⑩ Sample  AH 719  AH 719  <u>C3-MW/05</u> <u>MATCHES ITR # MA0189</u>																																								

EMO COPY

Figure F-6. EPA organics traffic report



United States Environmental Protection Agency Region 10		<b>RECEIPT FOR SAMPLES</b>		Environmental Services Division U.S. Environmental Protection Agency Region 10 1200 Sixth Avenue, Seattle, Washington 98101					
PROJECT NO.			PROJECT NAME			Name of Facility			
SAMPLER(S): <i>(Signature)</i>			Split Samples Offered ( ) Accepted ( ) Declined			Facility Location			
Section Number	Date	Time	Cont.	Vol.	Depth	Tag Number	Section Description	No. of Containers	Remarks
Transferred by: <i>(Signature)</i>					Received by: <i>(Signature)</i>			Telephone Number	
Date	Time	Title		Date	Time				
Distribution: Original to Coordinator Field Files; Copy to Facility									
No								131	

Figure F-7. Receipt for samples form

### F-2. Packaging and Shipping Procedures

*a. Scope and application.* This section describes procedures for properly packaging and shipping environmental and hazardous waste samples. The procedures described in this section are performed after samples have been collected and placed in the proper containers and correctly preserved. Guidelines for proper container and preservative selection can be found in Appendix I.

*b. Procedures.* The following are procedures for packaging and shipping requirements of environmental and hazardous waste samples.

(1) Environmental samples. Environmental samples are defined as those samples collected from environmental matrices such as soil, groundwater, or sediments. Contaminant levels in these types of samples are normally

less than 10 ppm. Environmental samples should be packaged for shipment as follows:

(a) Sample container is adequately identified with sample labels (Section b(4)(a) in Instruction F-1). Sample labels are placed on samples at this time if required.

(b) All bottles, except the volatile organic analysis (VOA) vials, are taped shut with electrical tape (or other tape as appropriate). Evidence tape or custody seals (Figure F-8) may be used for additional sample security.

(c) Each sample bottle is placed in a separate plastic bag, which is then sealed. For water samples, each VOA vial is wrapped in a paper towel, and the two vials are placed in one bag. If a trip blank is submitted, it should be wrapped and placed in the bag with the two VOA

CUSTODY SEAL	CUSTODY SEAL
Date	Date
Signature	Signature

Figure F-8. Typical custody seals

vials. As much air as possible is squeezed from the bag before sealing. Bags may be sealed with evidence tape or custody seals for additional security.

(d) A picnic cooler (such as a Coleman or other sturdy cooler) is typically used as a shipping container. In preparation for shipping samples, the drain plug is taped shut from the inside and outside, and a large plastic bag is used as a liner for the cooler. Approximately 3 in. of inert packing material, such as asbestos-free vermiculite, perlite, or styrofoam beads, is placed in the bottom of the liner. Other commercially available shipping containers may be used. However, the use of such containers (cardboard or fiber boxes complete with separators and preservatives) should be specified in the sampling plan and pre-approved.

(e) The bottles are placed upright in the lined picnic cooler in such a way that they do not touch and will not touch during shipment. Cardboard separators may be placed between the bottles at the discretion of the shipper.

(f) All samples should be shipped to the laboratory on ice and chilled to 4 °C *except* for the following types of samples, which do not require shipment with ice:

- Low- and medium-concentration water and liquid matrix samples for metals analyses.
- Medium-concentration soil and sediment matrix samples for base, neutral, acids (B/N/A), polychlorinated biphenyls (PCBs), and pesticide analyses.

However, because prior knowledge of analyte concentrations is required to apply this exception, it may be prudent to maintain the cooling requirement.

(g) Additional inert packing material is placed in the cooler to partially cover the sample bottles (more than halfway). If samples are required to be shipped to the

laboratory with ice, ice in double bags must be placed around, among, and on top of the sample bottles. If chemical ice is used, it should be placed in a double plastic bag. The cooler should then be filled with inert packing material and the liner taped shut.

(h) The paperwork going to the laboratory is placed inside a plastic bag. The bag is sealed and taped to the inside of the cooler lid. A copy of the COC form should be included in the paperwork sent to the laboratory. The last block on the COC form should indicate the overnight carrier and air bill number. The air bill must be filled out before the samples are handed over to the carrier. The laboratory should be notified if another sample is being sent to another laboratory for dioxin analysis or if the shipper suspects that the sample contains any other substance that would require laboratory personnel to take additional safety precautions.

(i) The cooler is closed and taped shut with strapping tape (filament-type).

(j) At least two signed custody seals are placed on the cooler, one on the front and one on the side. Additional seals may be used if the sampler or shipper thinks more seals are necessary.

(k) The cooler is handed over to the overnight carrier. A standard air bill is necessary for shipping environmental samples. The shipper should be aware of carrier weight or other policy limitations.

(2) Hazardous samples. Hazardous samples are defined as those which are typically highly contaminated, such as oils, sludges, discarded products, and other materials. Contaminant levels in these types of samples are normally greater than 10 ppm. Hazardous samples must be packaged as follows:

(a) Sample container is adequately identified with sample labels (Section b(4)(a) in Instruction F-1). Sample tags are placed on samples at this time if required.

(b) All bottles, except the VOA vials, are taped closed with electrical tape (or other tape as appropriate). Evidence tape or custody seals may be used for additional security.

(c) Each sample bottle is placed in a plastic bag, and the bag is sealed. As much air as possible is squeezed from the bags before sealing. Evidence tape or custody seals may be used to seal the bags for additional security.

(d) Each bottle is placed upright in a separate paint can, the paint can is filled with vermiculite, and the lid is fixed to the can. The lid must be sealed with metal clips or with filament or evidence tape; if clips are used, the manufacturer typically recommends six clips.

(e) Arrows are placed on the can to indicate which end is up.

(f) The outside of each can must contain the proper Department of Transportation (DOT) shipping name and identification number for the sample. The information may be placed on stickers or printed legibly. A liquid sample of an uncertain nature is shipped as a flammable liquid with the shipping name "FLAMMABLE LIQUID, N.O.S." and the identification number "UN1993." A solid sample of uncertain nature is shipped as a flammable solid with the shipping name "FLAMMABLE SOLID, N. O. S." and the identification number "UN1325." If the nature of the sample is known, 40 CFR 171-177 is consulted to determine the proper labeling and packaging requirements.

(g) The cans are placed upright in a cooler that has had its drain plug taped shut inside and out, and has been lined with a garbage bag. Vermiculite is placed on the bottom. Two sizes of paint cans are used: half-gallon and gallon. The half-gallon paint cans can be stored on top of each other; however, the gallon cans are too tall to stack.

(h) All hazardous samples should be shipped to the laboratory on ice and chilled to 4 °C, except for the following samples which do not require shipment with ice:

- Medium concentration water and liquid matrix samples for metals analysis.
- Medium concentration soil and sediment matrix samples for B/N/A, PCBs, and pesticide analyses.

However, because prior knowledge of the analyte concentrations is required to apply this exception, it may be prudent to maintain the cooling requirement.

(i) Additional inert packing material is placed in the cooler to partially cover the sample bottles. If samples are required to be shipped to the laboratory with ice, bags of ice must be placed around the cans. The cooler must be filled with packing material and the liner taped shut.

(j) The paperwork going to the laboratory is placed inside a plastic bag and taped to the inside of the cooler

lid. A copy of the COC form should be included in the paperwork sent to the laboratory. The sampler keeps one copy of the COC form. The laboratory should be notified if a parallel sample is being sent to another laboratory for dioxin analysis, or if the sample is suspected of containing any substance for which laboratory personnel should take safety precautions.

(k) The cooler is closed and sealed with strapping tape. At least two custody seals are placed on the outside of the cooler (one on the front and one on the back). More custody seals may be used at the discretion of the sampler.

(l) The following markings are placed on the top of the cooler:

- Proper shipping name (49 CFR 172.301).
- DOT identification number (49 CFR 172.301).
- Shipper's or consignee's name and address (49 CFR-172.306).
- "This End Up" legibly written if shipment contains liquid hazardous materials (49 CFR 172.312).

(m) The following labels are required on top of the cooler (49 CFR 172.406(e)):

- Appropriate hazard class label (placed next to the proper shipping name).
- "Cargo Aircraft Only" (if applicable as identified in 49 CFR 172.101).

(n) An arrow symbol(s) indicating "This Way Up" should be placed on the cooler in addition to the markings and labels described above.

(o) Restricted-article air bills are used for shipment. The "Shipper Certification for Restricted Articles" section is filled out as follows for flammable solid or a flammable liquid:

- Number of packages or number of coolers.
- Proper shipping name: if unknown, use
  - Flammable solid, N.O.S., or
  - Flammable liquid, N.O.S.

- Classification; if unknown, use
  - Flammable solid, N. O. S., or
  - Flammable liquid, N.O.S.
- Identification number if unknown, use
  - UN1325 (for flammable solids), or
  - UN1993 (for flammable liquids).
- Net quantity per package or amount of substance in each cooler.
- Radioactive materials section (Leave blank).
- Passenger or cargo aircraft. (Cross off the non-applicable. Up to 25 lb of flammable solid per

cooler can be shipped on a passenger or cargo aircraft. Up to 1 qt of flammable liquid per cooler can be shipped on a passenger aircraft, and up to 10 gal of flammable liquid per cooler can be shipped on a cargo aircraft.)

- Name and title of shipper (printed).
- An emergency telephone number at which the shipper can be reached within the following 24 to 48 hr.
- Shipper's signature.

*c. Sample containers and preservatives.* Appendix I provides information concerning sample containers and preservatives.

**APPENDIX E**

**USACE Sample Manipulation Instructions  
(Appendix E, EM 200-1-3)**

## Appendix E Sample Manipulation Instructions

### E-1. Filtration Techniques (Liquid Media)

*a. Scope and application.* This section outlines two different techniques for the filtration of liquid media (i.e., groundwater, surface water, and potable water). The procedures will address in-line filtration, where the filter assembly is under positive pressure, and vacuum filtration, where the filter assembly is under negative pressure. In addition, the procedures describe and recommend specific filtration equipment. Filtration of aqueous samples is performed when the removal of silt, algae, particulates, and other debris is desired. Predominantly, filtration is employed when water samples are to be tested for dissolved metals. Filtered samples for metals (dissolved fraction) should be analyzed in conjunction with non-filtered samples to determine the metal concentration in solution versus metals associated with solids. Analysis of both filtered and unfiltered samples will allow the determination of metal concentration associated with the solid. Filtration should not be conducted in conjunction with organics analysis.

*b. Filtration techniques.* The following instructions will focus on positive and negative pressure filtration of aqueous media. In the instructions, specific types of filtration devices will be referenced. Because most filtration will be for the purpose of determining "dissolved" versus total metals, these instructions assume a filter pore size of 0.45  $\mu\text{m}$ . Analytical methods used to determine dissolved metal concentrations have historically used 0.45- $\mu\text{m}$  filters to separate dissolved and particulate phases. Filters less than 0.45  $\mu\text{m}$  may be necessary in certain circumstances.

(1) Positive pressure filtration. Aqueous samples that may require positive pressure filtration include groundwater samples, surface water samples, and potable water supply samples. To filter an aqueous sample using the positive pressure technique, a pump, filter, and tubing are required. The following are examples of equipment that may be used for positive pressure in-line filtration.

- (a) Pump:  
 Pump System  
 High Flow Range: 3 - 2,300 mL/min  
 Low Flow Range: 06 - 460 mL/min  
 System Flow Control:  $\pm$  10%

- (b) Filter assembly:  
 Groundwater Sampling Capsule  
 0.45- $\mu\text{m}$  pore size  
 1/4" - 1/2" tapered barb fitting  
 Continuous Use Pressure: 60 psi @ Ambient  
 Maximum Momentary Pressure: 100 psi @ Ambient

(c) Filtration procedure.

- Use polytetrafluoroethylene (PTFE), (PTFE is commonly referred to using the registered name of Teflon) tubing for pump and filter connections.
- Connect the 0.45- $\mu\text{m}$  in-line filter to the discharge tubing from the pump. Make sure the flow arrow on the filter is pointing in the correct direction.
- Apply pressure to the liquid sample (via pump) to force it through the filter into a sample container.
- Replace the in-line filter when the flow becomes too restricted because of buildup on the filter. To replace the filter:
  - Discontinue pumping (turn off pump).
  - Relieve the pressure in the system (line between the pump and the filter).
  - Disconnect the filter and replace with a new one.

(2) Negative pressure filtration. Aqueous samples which may require negative pressure filtration include groundwater samples, surface water samples, and potable water supply samples. To filter an aqueous sample using the negative pressure technique, a pump, filter, sample collection container, and tubing are required. The following equipment may be used for negative pressure (vacuum) filtration:

- (a) Pump:  
 Hand-Operated Vacuum/Pressure Pump  
 Maximum Vacuum: 25-in. Hg  
 Maximum Pressure: 15 psi  
 Composition: Metal or PVC
- (b) Filter Assembly:  
 Nalgene Filter Funnel/Collection Flask  
 Filter Composition: Cellulose nitrate

1 Sep 94

Pore Size: 0.45 or 0.8  $\mu\text{m}$   
 Collection Flask Capacity: 500 mL  
 Composition of Assembly: Polystyrene (sterilized)

## (c) Filtration procedure.

- Select a presterilized filter assembly with a 0.45- $\mu\text{m}$  pore size.
- Connect vacuum tubing to the pump and the filter assembly. Use PTFE tubing for pump and filter connections.
- Pour the aqueous sample into the filter funnel portion of the filtration assembly. Avoid transferring solids that may have settled to the bottom of the collection flask.
- Using the hand pump, create a vacuum in the collection flask portion of the filtration assembly to start filtration.
- Replace the filter funnel portion of the assembly when the filter becomes too restricted because of solids buildup on the filter. To replace the filter:
  - Depress the pressure/vacuum release button.
  - Disconnect the filter funnel and replace it with a new one.
  - Create a vacuum with the hand pump and continue filtering the remaining sample.

*c. Potential problems.* One inherent problem associated with the filtration of aqueous environmental samples is the filter becoming clogged. The following are some considerations regarding liquid filtration.

- (1) Always have extra filters available at the sampling site.
- (2) Prefilter dirty samples with a larger pore size filter.
- (3) For highly turbid samples a negative filtration system may be more efficient.
- (4) Avoid pouring sediments from the bottom of the collection flask into the filter funnel.

(5) When the filtrate flow becomes too slow because of filter loading, change the filter. Avoid increasing the pressure and rupturing the filter membrane.

## E-2. Homogenizing Techniques

*a. Scope and application.* The purpose of this section is to provide instructions for homogenizing samples. Proper homogenization is vital to accurately assessing the condition of a particular site. Correct homogenization techniques are also important for preparing the necessary quality control samples associated with a typical sampling event. Homogenization techniques should not be used when samples for volatile organic analyses or other parameters that require undisturbed samples are collected.

*b. Sample handling and mixing.* An integral part of any sampling investigation is obtaining samples that truly represent the site under investigation. Therefore, applying proper homogenization techniques will help ensure that conditions are being accurately represented. Another assessment that is being made at most sites is field and lab quality control. Generation of field control samples provides a means for evaluating a laboratory's performance and the sampling and handling techniques of field personnel. However, for this evaluation to be meaningful, field sampling personnel must be able to properly homogenize and divide collected samples.

(1) Sampling equipment composition. The composition of sampling equipment can affect sample analytical results. Sampling materials used must not contaminate the sample being collected and the sampling equipment must be decontaminated between samples to prevent the samples from being cross-contaminated. The standard materials for sampling equipment used to collect samples for trace organic compounds or metals analyses are, in order of decreasing desirability: glass, stainless steel, and PTFE. The following table may be used as a guide to select the proper sampling instruments.

(2) Required sample volumes. The volume of sample obtained should be sufficient to perform all required analyses with an additional amount collected to provide for quality control needs, split samples, or repeat examinations. Appendix G discusses typical sample volume requirements for various parameters. The volume of sample required by the laboratory depends on the analyses to be performed. The laboratory receiving the sample should be consulted for any specific volume requirements.

The volumes of samples collected from waste sources at hazardous waste sites or samples from sources that are known to be toxic should be kept to an absolute minimum since disposal costs of excess sample material are high. The laboratory or project personnel may require that excess sample volume be returned to the site because of the hazardous nature of the samples or because of sensitive political issues surrounding the project. If samples are being collected for bench scale or pilot scale remediation studies, larger volumes may be necessary. This scenario normally involves sending large bulk volumes to a laboratory to undergo various applications/manipulations to identify the optimum conditions for remediation of a particular waste stream. The ultimate data user (design engineer) or laboratory should be contacted to determine the volume of material required.

<u>Analysis/Site Condition</u>	<u>Preferred Material</u>
Metals	Glass or PTFE
Organics	Stainless steel, glass, or PTFE
Corrosive Soil/Waste	Glass or PTFE

(3) Aqueous samples. Aqueous samples are typically homogenous because of the physical properties of water, such as diffusion and the ability to flow and freely mix. Therefore, aqueous samples do not require mixing. However, viscous or semi-solid liquids will require mixing. These samples can be shaken well to mix or stirred thoroughly with a tool of appropriate composition. The sampler may encounter contaminants that are not miscible with water and will separate into distinct phases. In these situations, it is advisable to collect a sample from each layer/phase as well as a homogenized sample. When multiple phases are sampled, the sample should be homogenized in the laboratory to achieve the most homogenous sample. Water samples (potable well, monitoring well, surface water) should be obtained by alternately filling sample containers from the same sampling device for each parameter. Split and duplicate samples will be collected simultaneously with the primary samples. Containers for volatile organic analyses (VOA) will be filled first, followed by containers for semivolatile organics, metals, cyanide, and water quality parameters. Each VOA container should be completely filled immediately, rather than splitting the water between bottles and filling the bottles incrementally. The containers will all be filled from the sampling device if possible. If this is not possible, a minimum of two containers (one for the primary sample and one for the split sample) will be filled from each sampling volume. If more than two containers can be filled from one sampling volume, the number of

containers filled must be an even number (i.e., 2 or 4) so that an equal number of containers for the primary and split samples are prepared. The remaining portions of the sample will then be prepared by splitting each sampling volume between containers for the primary and split samples.

(4) Solid samples. Obtaining samples in a soil or sediment matrix requires homogenization of the sample aliquot prior to filling sample containers. However, volatile organic samples are the exception; samples being analyzed for volatile organic compounds (VOCs) must always be taken from discrete locations prior to mixing. This practice is necessary to prevent loss of volatile constituents and to preserve, to the extent practicable, the physical integrity of the volatile fraction. Homogenization of the sample for remaining parameters is necessary to create a representative sample volume. Moisture content, sediments, and waste materials may inhibit the ability to achieve complete mixing prior to filling sample containers. Therefore, it is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample location. Homogenization should be accomplished by filling a properly decontaminated stainless steel tray or bowl with the sample and mixing it with a decontaminated stainless steel or PTFE instrument. The method of choice for mixing is referred to as quartering and can be performed in a bowl or tray of an appropriate material (material depends on the parameters to be analyzed for). The soil in the sample pan is divided into quarters. Each quarter is mixed, then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material over. The extent of mixing required will depend on the nature of the sample and should be done to achieve a consistent physical appearance prior to filling sample containers. Once mixing is completed, the sample should be divided in half and containers should be filled by scooping sample material alternately from each half.

*c. Potential problems.*

(1) The higher the moisture content, the more difficult it is to homogenize the sample.

(2) A true homogenization of soil, sediment, or sludge samples is almost impossible to accomplish under field conditions.



(3) VOC samples are not homogenized due to the possible volatilization of constituents.

### E-3. Compositing Samples

*a. Scope and application.* This instruction provides information on the various types of composite sampling techniques and the proper procedures to obtain a composite sample. The technique of compositing discrete samples is typically employed when the site under investigation is quite large. Composite sampling is not specific to one matrix, rather it can be utilized for solid, semi-solid, and liquid matrices.

*b. Compositing techniques.* There are two principal methods of sampling: grab samples and composite samples. Each method has its own applications, strengths, and weaknesses. Composite samples consist of a series of discrete grab samples that are mixed together to characterize the average composition of a given material. The discrete samples used to make up a composite sample are of equal volume and are collected in an identical fashion. Likewise, the number of grab samples forming a composite should remain consistent (i.e., a number and pattern for collection of grab samples within a grid should be selected and, for a given grid size, should not be changed). Four types of composite samples are discussed below.

(1) Flow-proportioned composite: Flow-proportioned composite samples are collected proportional to the flow rate during the compositing period by either a time-varying/constant volume or a time-constant/varying volume method. Flow-proportioned composite samples are typically collected using automatic samplers that are paced by a flow meter. This type of sampling is usually associated with wastewater sampling. Figure E-1, a and c, illustrates flow-proportioned composite sampling.

(2) Time composite: A time composite sample is composed of a varying number of discrete samples collected at equal time intervals during the compositing period. The time composite sample is typically used to sample wastewater or streams. Time composite samples are typically obtained using automated programmable samplers. When a large number of locations must be sampled, automatic samplers may be set up to sample these locations simultaneously with a minimum of supervision and costs. When sampling activities are relatively complex, as in the case of composite sampling proportional to flow, automatic samplers reduce human error. Automatic samplers can directly correlate flow with both sample size and time.

In hazardous situations, use of automatic samplers can reduce personnel contact with hazardous waste streams or with potentially dangerous sampling environments. The disadvantages of automatic sampling equipment are its high cost and extensive maintenance requirements. These disadvantages can be offset by reduced labor requirements, proper maintenance, and the proper choice of equipment. When access to the waste stream is relatively easy and sufficient labor is available, manual methods are also quite effective. The most significant disadvantage of manual sampling is that it is labor-intensive, particularly with respect to long-term composite sampling. Figure E-1b illustrates equal time compositing.

(3) Areal composite: Areal composite samples are samples collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites are made up of equal volumes of grab samples where all grabs are collected in an identical manner. Areal composite sampling is typically used for stream sediment equal-width compositing and surface/subsurface soil sampling.

(4) Vertical composite: Vertical composite samples are also collected from individual grab samples but taken from a vertical cross section. Vertical composites are also made up of equal volumes of grab samples where all grab samples are collected in an identical manner. Vertical profiles of soil and sediment columns are an example of vertical compositing.

*c. Compositing grab samples.* Typically, composite sampling is the technique of choice when the area under investigation is very large and a large number of discrete samples will be generated. Compositing grab samples lends itself to lowering analytical costs because it reduces the number of analyses. Collecting composite samples also requires decisions, including but not limited to, the type of composite sampling technique that will meet the project needs (i.e., time composite, area composite...); the number of composite samples needed; the number of grab samples in each composite; and the type of sampling grid. These issues are not discussed in this instruction but can be found in other USACE guidance documents.

(1) Solid matrix. Composite samples should be prepared as follows:

(a) Collect discrete grab samples using the appropriate instructions as outlined in Instructions C and D. To obtain a representative composite sample, it is important that all grab samples are collected in identical fashion.

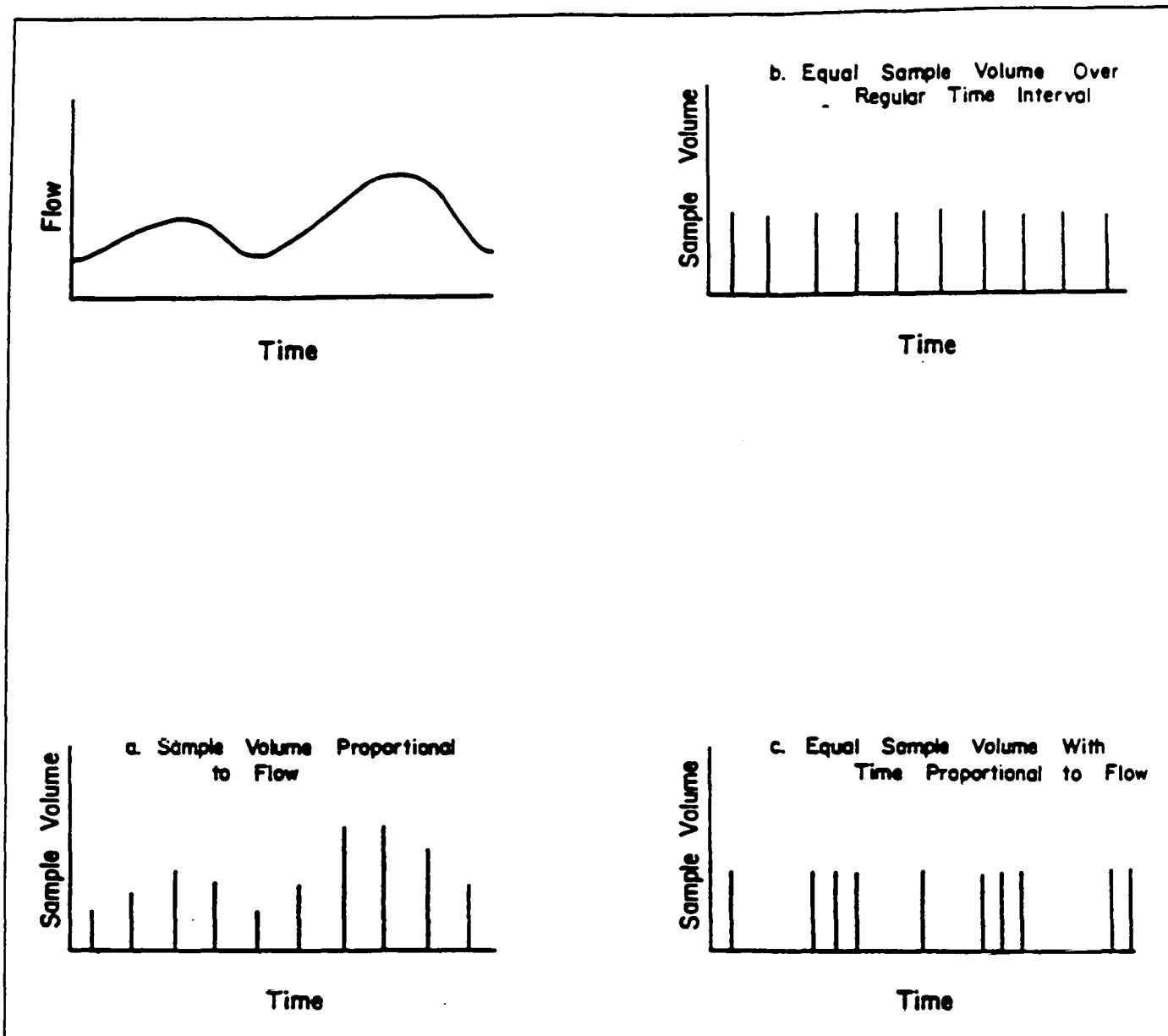


Figure E-1. Composite sampling methods

(b) Homogenize individual grab samples as outlined in Instruction E-2, and place them into proper sample containers.

(c) Assemble the sample containers that contain the grab samples that will make up a specific composite sample.

(d) Remove an aliquot of sample from each sample container and place it into a clean stainless steel mixing

bowl. Each aliquot amount is to be as identical as possible to facilitate representativeness. Avoid generating excess contaminated soil when possible.

(e) Homogenize the aliquots as described in Instruction E-2.

(f) Remove sample amounts from the homogenized composite sample and place them into the proper containers for shipment to the laboratory.

(g) At some sites it may be beneficial to save and store the individual homogenized grab samples after aliquots are removed for compositing. If the composite sample results do not appear to be accurate, subsequent analyses of the individual grab samples that comprised the composite may confirm the results. Confirmatory analyses of these samples would likely be for informational purposes only since the holding times of the samples may have expired.

(2) **Liquid matrix.** The preparation of liquid matrix composite samples is typically easier than solid matrices due to the ease in homogenizing liquids. Also, it is common practice to send liquid grab samples to the laboratory for compositing because of the difficulties in handling larger sample volumes (1 to 4 gal for a typical wastewater sampling event) and the increased potential to introduce contaminants. Good documentation of sampling locations is essential in all field sampling, particularly when several grab samples have been homogenized to form a composite. If a contaminant is detected in a composite sample, each of the discrete grab samples that made up the composite will need to be analyzed individually to determine the actual distribution of the contamination. Procedures should be established by the project manager and the laboratory to ensure that holding times for the discrete grab samples are not exceeded. When composite samples are to be generated in the field, the following procedure should be used.

(a) Assemble all sample containers that contain the grab samples that will make up a specific composite sample.

(b) Shake or stir the individual containers to homogenize.

(c) Using clean, glass pipets, deliver aliquots of the homogenized grab samples directly into a sample container to be sent to the laboratory. (e.g., It will require five 20-mL pipettings from five discrete grab samples to generate a 100-mL composite sample; the standard volume requested for a metals analysis.)

(d) Seal the container and shake well to mix. Avoid stirring samples if possible to lower the potential of introducing contaminants.

(e) At some sites it may be beneficial to save and store the individual homogenized grab samples after aliquots are removed for compositing. If the composite sample results do not appear to be accurate, subsequent analyses of the individual grab samples that comprised the

composite may confirm the results. Confirmatory analyses of these samples would likely be for informational purposes only since the holding times of the samples may have expired.

*d. Potential problems.*

(1) Compositing does not allow the spatial variability of contamination to be determined. Additional analyses of the individual grab samples is required.

(2) Low concentrations of contaminants in individual grab samples may be diluted so that the total composite concentration is below the detection limit. In this case, the existence of the contamination in individual samples would go unnoticed.

(3) It may be very difficult to create a homogeneous sample mixture if the grab samples are moist and clayey. Consequently, the resulting composite may not represent an average of all the grabs.

(4) Obtaining samples by an automatic sampling device is typically difficult for the first time user. However, after the sampler has become familiar with the sampling device and any problems have been addressed, these devices prove to be quite reliable.

#### E-4. Laboratory Sub-sampling

*a. Scope and application.* This instruction provides direction on how to obtain an aliquot of sample for an actual laboratory analysis. Obtaining this aliquot is referred to as laboratory sub-sampling and is performed by laboratory personnel. This instruction addresses sub-sampling techniques for both solid and liquid matrices. Good analytical techniques are required in all sub-sampling to obtain representative sub-sample aliquots and to accurately assess any contamination at the site.

*b. Sub-sampling.* It is common for most analytical methods to require only a portion of the submitted sample to perform the analysis. Additional sample volume is desirable when there is a potential that the sample will be re-analyzed. Because only a portion of the submitted sample is actually involved in the evaluation of the sampling location, it is important that the sub-sample be truly representative of the entire sample. Environmental samples should be homogenized prior to arrival at the laboratory. However, laboratory personnel should not assume that each sample is properly homogenized in the field. In addition, both solid and liquid matrices may experience settling or phase separation during transport. Therefore, it

is critical that submitted samples be visually inspected for homogenization prior to sub-sampling. Laboratory personnel should document the physical appearance of samples upon receipt, including comments about settling and phase separation. Techniques used to homogenize or re-homogenize samples should also be documented. The approaches to sub-sampling techniques are distinguished by the analytical requirements for the state or condition of the aliquot to be tested. There are two main approaches to sub-sampling that are dependent upon the need for undisturbed versus disturbed samples. For example, although homogenization is critical prior to sub-sampling for suspended solids analyses, homogenization prior to sub-sampling may also release volatile constituents resulting in inaccurate organic analyses. The first approach is relevant for samples that are analyzed for volatile organics or other constituents that require an undisturbed sample. Disturbing these types of samples via mixing, blending, homogenizing, shaking, or stirring may alter the physical/chemical state of the sample and cause a release or alteration of the contaminant of concern and a misleading final analytical result. The second approach is relevant to other analyses that require thorough homogenization prior to sub-sampling. Without some type of mixing, blending, homogenizing, shaking, or stirring operation for these samples, the final analytical results would be questionable.

#### (1) Procedure.

(a) Solid matrix. Solid matrix samples are to be sub-sampled as follows:

- Allow the sample and container to equilibrate to room temperature before opening the container.
- Visually inspect and document the appearance of the sample prior to sub-sampling. If the subsequent analysis requires an undisturbed sample, no homogenization is performed and the materials are ready for sub-sampling. If the subsequent analysis does not require an undisturbed sample, the entire sample contents should be removed and the sample homogenized regardless of visual observation. Sieving, if necessary, should be conducted after homogenization. To prepare the sub-sample, the sample should be subdivided (quartered) and approximately equal portions removed from each quarter of the sample for inclusion into a final sample aliquot that will undergo analysis.
- For samples that are analyzed for volatile organics or other constituents that require an undisturbed sample, a clean hand core sampler, or similar

sampling device, should be used to remove a vertical core segment/aliquot of material from the sample.

- For samples that are analyzed for volatile organics or other constituents that require an undisturbed sample, the sample should be removed from the coring device into a clean, glass beaker or similar container from which a portion can be accurately weighed and analyzed.
- For other sample analyses that require homogenization prior to sub-sampling, the entire aliquot generated from subdivisions in the second step should be accurately weighed in a clean glass beaker or similar container and analyzed. Alternatively, if only a portion of the composited aliquot generated in the second step will be used for subsequent analysis, the subdivisions should be sampled equally into a clean glass beaker or similar container from which a portion can be accurately weighed and analyzed.

(b) Liquid matrix. Liquid matrix samples are to be sub-sampled as follows:

- Allow the sample and container to equilibrate to room temperature. If volatile organic analyses are not required, the container may be opened following temperature equilibration.
- Visually inspect and document the appearance of the sample for homogeneity. This may not be possible due to the container material (i.e., amber glass). If, upon inspection, it is discovered that the sample has more than one liquid phase, consult with the client to determine sampling needs.
- If no phase separation exists, homogenize the sample by shaking well to mix. If the liquid is very viscous, the sample may require stirring (i.e., glass or PTFE stirring rod).
- Depending on the analytical method to be employed, sub-sampling should follow the following approach if the entire sample is to be used (e.g., pesticides, polychlorinated biphenyls (PCBs), semivolatile organics, polycyclic aromatic hydrocarbons (PAHs), etc.). In the preferred method for transferring the entire sample contents, the analyst first marks the water level on the sample container, and then, after shaking, pours the entire contents of the container into the extraction

apparatus. Solvent rinsates from the sample container are also added to the extraction apparatus. Tap water is subsequently poured into the sample container to measure the initial sample volume. If only a portion of the sample is needed, the required sub-sample should be measured using a clean pipet, syringe, or comparable measuring device. Samples should not be collected directly from the sample container except for volatile organic analysis. Sub-samples for volatile organics analysis should be obtained directly from the sample container by piercing the septa of the container using a clean syringe.

*c. Potential problems.* Sub-sampling the lower phases of a multi-phase liquid may pose special problems. A pipet or syringe needle passing through the lighter layers may pick up contaminants that can bias analytical results. The pipet tip or syringe needle should be wiped clean before transferring lower phase sub-sample to a preparation flask. Removal of the lighter layer(s) prior to sub-sampling may be required to obtain a representative aliquot. Clay soil samples may be difficult to sub-sample with a coring type device. Some hand coring samplers are equipped with clear plastic liner tubes that make extracting the sub-sample from the corer much easier. However, the goal is to obtain a representative sample. In these situations, professional judgement is required and a clean stainless steel spatula may be the tool of choice.

## E-5. Decontamination Procedures/Sample Contaminant Sources

*a. Scope and application.* The purpose of this section is to provide instruction on deciding an appropriate decontamination scheme(s) for the project field sampling equipment in order to prevent or reduce cross-contamination of project samples. The applicability of each step in a decontamination protocol will depend upon the contaminants present onsite, the subsequent analysis to be performed, the composition of the sampling devices, etc. The appropriateness of a decontamination protocol is vital to the eventual validity of the analytical results and decisions made based upon those results. All sampling equipment that has come in contact with a potentially contaminated media must be cleaned prior to the subsequent use of that device. Devices may include bailers, pumps, shovels, scoops, split spoons, tube samplers, augers, etc. Another approach to minimizing the potential for cross-contamination may be to dedicate or use disposable sampling equipment.

*b. Decontamination procedures.* Refer to the following table for various step-wise decontamination protocols.

(1) Reagents. The detergent wash is a non-phosphate detergent solution used with brushing or circulating techniques to remove gross contamination, and/or as a mild neutralizing agent. Tap water is considered a rinse water, preferably from a water system of known chemical composition. Acid rinses are used as the inorganic solubilizing agent, or as a mild neutralizing agent. These rinses are a 10-percent to 1-percent HCl or HNO<sub>3</sub> solution prepared from reagent grade acids and deionized water, respectively. Solvent rinses are used as an organic solubilizing agent. Requirements for solvent types vary depending upon the nature of known organic contamination requiring solubilization; and any impurities present within the rinse which may potentially interfere or contribute to the subsequent analysis. All solvent rinses used must be of pesticide grade quality. Finally, the deionized water is organic-free reagent water.

(2) Procedure clarifications/exceptions. Refer to Table E-1 for the general necessary procedures based upon site contaminants and/or subsequent analytical protocols. As noted above, the detergent wash is used in conjunction with scrubbing for gross contamination removal, followed by the appropriate rinses. For cleaning of pumping equipment or devices with inaccessible internal mechanisms, suggest circulating/flushing the system with the applicable solutions in the order given below. Solvent rinses for pumping equipment should be limited to a 10-percent dilution (vol./vol.) of acetone or isopropyl alcohol in water. Tubing used with peristaltic pumps may be flushed with hexane or dilute HCl, followed by a distilled water rinse depending on contaminants noted onsite. The decontamination of low carbon steel sampling devices should limit the acid rinse to a dilute 1-percent acid solution. All sampling equipment should be allowed to dry prior to the next use. For this reason it is important to have sufficient sampling devices onsite which may be alternated. This practice will allow a thorough drying of equipment without increasing sampling downtime. Alternatively, larger equipment (e.g., drill rig components, power augers, etc.) may be cleaned with a portable power washer or a steam cleaning machine in lieu of the protocols outlined below. Finally, depending upon the project, it may be appropriate to contain spent decontamination fluids and arrange for eventual disposal as investigation-derived wastes (IDW). Refer to U.S. Army Corps of Engineers guidance on IDW for further information on this subject. In these cases, it is important that these

**Table E-1**  
**Procedure Clarifications/Exceptions**

	Detergent Wash	Tap Water	Acid Rinse	Tap Water	Solvent Rinse <sup>1</sup>	Deionize Water	Air Dry
VOA Low MW CMPDS <sup>2</sup>	✓	✓			Methanol	✓	✓
BNA PEST/ PCBS High MW CMPDS <sup>2</sup>	✓	✓			Hexane	✓	✓
Organic Bases <sup>3</sup>	✓	✓	(dil.acid) 1% Sol.	✓	Iso-propyl Alcohol	✓	✓
Organic Acids <sup>4</sup>	(dil.base) ✓	✓			Iso-propyl Alcohol	✓	✓
Trace Metals	✓	✓	10% Sol.	✓		✓	✓
Salts	✓	✓				✓	✓
Acidic CMPDS	(dil.base) ✓	✓				✓	✓
Basic CMPDS caustic	✓	✓	(dil.acid) 1% Sol.	✓		✓	✓

<sup>1</sup> Solvent rinses vary in polarity which leads to varying solubilizing properties. Deciding appropriate solvent rinses should first identify if a known or suspect contaminant requires removal from sampling equipment. Optimum solvents for contaminants are noted above. Secondly, it should be identified whether the subsequent analytical protocol would be impacted by an impurity of, or the solvent being used (e.g., residual acetone present in isopropyl alcohol would be measured with certain volatile organics analysis).

<sup>2</sup> MW CMPDS = molecular weight compounds

<sup>3</sup> Organic bases include Amines, Hydrazines.

<sup>4</sup> Organic acids include Phenols, Thiols, Nitro and Sulfonic compounds.

containers be suitable for the eventual disposition of the materials, and therefore comply with any potentially applicable U.S. Department of Transportation regulations.

*c. Sample contaminant sources and other potential problems.*

(1) Carryover and leaching. Contaminant carryover between samples, and/or from leaching of the sampling devices, is very complex and requires special attention. Decisions concerning the appropriateness of the device's material composition must account for these carryover or leaching potentials, and whether these contaminants are of concern on the project. Materials potentially encountered

on projects and their associated common contaminants are listed in Table E-2.

Equipment blanks may be used to assess contamination of this nature, and are discussed in detail in Instruction H-2 in Appendix H.

(2) Adsorption. Contaminant adsorption is another problem which must be considered when deciding on an applicable sampling device or the appropriate composition material. This phenomenon is more critical when sampling an aqueous or gaseous media, due to the capability of lower levels of contaminant detection and the fact that the fluid matrix is more apt to potential contaminant

**Table E-2**  
**Materials Potentially Encountered on Projects**

Material	Commonly Related Contaminants
Glass	Silicon Boron
Rigid polyvinyl chloride (PVC) (threaded joints)	Chloroform Vinyl chloride
Rigid PVC (cemented joints)	Methyl ethyl ketone Toluene Acetone Methylene chloride Benzene Tetrahydrofuran Ethyl acetate Cyclohexanone Vinyl chloride
PVC plastic tubing	Phthalate esters Vinyl chloride Low level (zinc, iron, antimony, and copper)
Soldered pipes	Lead Tin
Stainless steel	Chromium Iron Nickel Molybdenum
Brass	Copper Zinc Tin

transfer. PVC and other plastics are known to sorb organics and to leach plasticizers and phthalate esters. Polypropylene, and other thermoplastics, have been shown to sorb organics and environmental mercury efficiently, and should therefore be avoided in sampling devices, especially tubing. For these reasons, PTFE is commonly chosen over the PVC and plastics when working with organic or mercury contaminants. In addition, some pesticides and halogenated compounds preferentially adsorb to glass surfaces. For this reason, it is recommended that when taking aqueous samples, the sample container NOT be rinsed prior to sample collection; and the same container be rinsed with the extraction solvent after the

sample has been quantitatively transferred to an extraction apparatus. Inorganics (metals) adsorption to containers is dependant upon the specific metal element, the concentration, pH, contact time, complexing agents present, and container composition. This is believed to be nominal and proper preservation of samples should prevent this. In deciding appropriate tubing to be used for aqueous sample acquisition, it is important to decide applicable material composition and diameter based upon the contaminant and the purpose of the data. Adsorption is less likely to occur when there is an increase in tubing diameter.

**APPENDIX F**

**USACE Logging Manual**



# LOGGING MANUAL

HTRW DESIGN BRANCH

US ARMY CORPS OF ENGINEERS  
NASHVILLE DISTRICT

**September 1996**

## PREFACE

It is intended all AE Contractors use this manual during their field drilling and sampling operations for the Nashville District. Since we have many Contractors working for us, use of the same log form and logging procedures will provide consistency and standardization. This makes review, interpretation, and evaluation of data easier.

Use the list of abbreviations in Appendix C. Again, this standardizes the log and facilitates review. If an abbreviation is needed that is not included in the list, define the abbreviation on the cover page of each log where it is used.

The official log will be the one prepared in the field at the time of drilling and sampling operations. Field notes shall not be used to create the log at a later time. Although it will be impossible to keep it clean at all times, the log should be kept as neat as possible. The printing shall be legible and all errors should be crossed out and not erased. Read the completed log as if seeing it for the first time to see if everything is discernible and can be understood. The completed log is a detailed record of the drilling, sampling, and/or well installation operations, and is the legal document.

Appendix A contains useful information such as charts for helping classify materials. Examples and forms are found in Appendix B. The list of abbreviations is in Appendix C.

Initially, it will require some effort to learn and become accustomed to the nuances of logging procedures depicted in this manual. However, once they become familiar, it will be second nature and easy. Then, when someone describes the material as a fine, silty sand, all will know what is meant.

## SOIL IDENTIFICATION AND CLASSIFICATION

The Unified Soil Classification System forms the method for field identification and classification of soils.

### Grain Size

**Boulders** - above 12" (300 mm)

**Cobbles** - 12" (300 mm) to 3" (75 mm)

**Gravel** - 3" (75 mm) to No. 4 sieve (4.76 mm)

**Coarse** - 3" (75 mm) to 3/4" (19 mm)

**Fine** - 3/4" (19 mm) to No. 4 (4.76 mm)

**Sand** - No. 4 (4.76 mm) to No. 200 (0.074 mm)

**Coarse** - No. 4 (4.76 mm) to No. 10 (2.0 mm)

**Medium** - No. 10 (2.0 mm) to No. 40 (0.42 mm)

**Fine** - No. 40 (0.42 mm) to No. 200 (0.074 mm)

**Silt or Clay** - Below No. 200 (0.074 mm)

See Grain Size/Texture Chart in Appendix A.

### Consistency of Clays

**Very Soft** - Easily penetrated several inches by fist.  
- SPT - 0 to 2 blows/foot.

**Soft** - Easily penetrated several inches by thumb.  
- SPT - 2 to 4 blows/foot.

**Medium** - Penetrated several inches by thumb with effort.  
- SPT - 4 to 8 blows/foot.

**Stiff** - Readily indented by thumb.  
- SPT - 8 to 15 blows/foot.

(cont.)

(cont.)

**Very Stiff** - Readily indented by thumbnail.  
- SPT - 15 to 30 blows/foot.

**Hard** - Indented with difficulty by thumbnail.  
- SPT - 30 blows/foot and over.

SPT = Standard Penetration Test (ASTM D 1586)  
Results of SPT valid only for thick strata

**Dilatancy** (reaction to shaking)

Prepare a pat of soil 1/2 cubic inch in volume.  
Add enough water to make the soil soft but not sticky.  
Place soil in palm of hand and shake horizontally by striking with other hand. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed, the water and gloss disappear from the surface. Very fine sands exhibit the quickest and most distinct reaction whereas a plastic clay has no reaction. Silts show a moderately quick reaction.

**Plasticity** (for minus No. 40 (0.4 mm) material)

Add enough water to the soil to allow the sample to be readily remolded without sticking to the fingers. Use nonabsorbent surface to rapidly roll into a ball or a thread 1/8" in diameter.

**High Plasticity** (Fat) - Can be remolded into a ball and the ball easily deformed without cracking or crumbling. Moistened sample gives shine when rubbed with fingernail or smooth metal.

**Medium Plasticity** (Lean) - Can be remolded into a ball but the ball will crack and easily crumble (friable) when squeezed. Remains dull in smooth metal test.

(cont.)

(cont.)

**Low Plasticity (Lean)** - Cannot be remolded into a ball without completely breaking apart. Remains dull in smooth metal test.

**Nonplastic Materials** - Cannot be rolled into a thread.

**DEGREE OF DENSITY OF SANDS**

$$\text{Relative Density} = \frac{e_{\max} - e}{e_{\max} - e_{\min}}$$

$e_{\max}$  = void ratio at maximum density

$e_{\min}$  = void ratio at minimum density

$e$  = natural void ratio

Descriptive Term	Degree of Density
<b>Loose</b> -----	0-1/3
<b>Medium</b> -----	1/3-2/3
<b>Dense</b> -----	2/3-1





**Results of Standard Penetration Tests**  
(valid only for thick strata)

Descriptive Term	No. of Blows per Foot
<b>Very Loose</b> -----	0-4
<b>Loose</b> -----	4-10
<b>Medium Dense</b> -----	10-30
<b>Dense</b> -----	30-50
<b>Very Dense</b> -----	50 and over

**DEGREE OF SATURATION**

Descriptive Term	Percent Saturation
<b>Dry</b> -----	0
<b>Slightly Damp</b> -----	1-25
<b>Damp</b> -----	25-50
<b>Moist</b> -----	50-75
<b>Wet</b> -----	75-99
<b>Saturated (water table)</b> -----	100

## Grain Shape

Round	
Sub-round	
Sub-angular	
Angular	

## Color

A color chart may be used as long as the color is described and not just given a number.

If a color chart is not used, basic colors shall be used with modifiers. Examples:

Reddish-brown (the hyphen means that the color is between red and brown but mostly brown)

Yellowish-brown

Brownish-green

Gray (indicates a medium Gray - Dark Gray, Gray, Light Gray)

Light Gray to Black (the word "to" indicates that the color varies throughout the color range from Light Gray to Gray to Dark Gray to Black)

Brown and Gray (the word "and" indicates two colors are present)

Brown mottled Light Brown

Never use terms such as mauve, aqua, lavender, etc. These terms are ambiguous.

**DEGREE OF PERMEABILITY** (for information only)

Descriptive Term ----- k(cm/sec) -----ft/day  
Soil

**High** ----- $10^{-1}$  -----300  
Gravel and coarse sand

**Medium** ----- $10^{-1}$  to  $10^{-3}$  -----300 to 3.0  
Sand and fine gravel

**Low** ----- $10^{-3}$  to  $10^{-5}$  -----3.0 to 0.03  
Very fine sands

**Very Low** ----- $10^{-5}$  to  $10^{-7}$  -----0.03 to 0.0003  
Silts and Clays

**Impermeable** ----- $10^{-7}$  and less --0.0003 and less  
Clay

Examples of Descriptions

Lean Clay (top soil)  
Stiff  
Moist  
Brown

Fat Clay  
Medium  
Wet  
Gray

Fine Sand  
Silty  
Loose  
Moist  
Light Brown

Gravelly Sand  
Sub-round  
Dense  
Saturated  
Brown  
Slightly clayey  
2" maximum diameter gravel

## ROCK DESCRIPTIONS

**Rock Type** - Limestone, sandstone, shale, etc.

### Hardness

**Very Soft** - can be deformed by hand.

**Soft** - can be scratched with a fingernail.

**Moderately Hard** - can be scratched easily with a knife.

**Hard** - can be scratch with difficulty with a knife.

**Very Hard** - cannot be scratched with a knife.

### Degree of Weathering

**Slightly Weathered** - Slight discoloration on surface, slight alteration along discontinuities, less than 10% of the rock volume is altered, strength is substantially unaffected.

**Moderately Weathered** - Discoloring is evident, surface is pitted and altered with alteration penetrating well below rock surfaces, weathering "halos" evident, 10% to 50% of the rock is altered, strength is noticeably less than fresh rock.

**Highly Weathered** - Entire mass is discolored, alteration pervades nearly all of the rock with some pockets of slightly weathered rock noticeable, some minerals leached away, retains only a fraction of original strength.

**Decomposed** - Rock is reduced to a soil with relic rock structure, can be generally molded and crumbled by hand.

### Lithology

Use adjectives such as shaley, sandy, silty, calcareous, etc.



## Texture and Grain Size

### Sedimentary Rocks

Rock Name	Particle Size
Conglomerate	cobble
Conglomerate	gravel
Sandstone	sand
Siltstone	silt
Claystone	clay
Shale	clay

### Igneous and Metamorphic Rocks

Texture	Grain or Crystal Size Diameter
Coarse	> 5 mm
Medium	1-5 mm
Fine	0.1-1 mm
Aphanitic	< 0.1 mm

### Voids

**Porous** - Smaller than pinhead

**Pitted** - > pinhead size to 1/4 inch. If they are numerous enough that only thin walls separate them, the core may be described as "honeycombed."

**Vug** - 1/4 inch to 2 inches.

**Cavity** - > 2 inches

### Rock and Soil Structure

#### Bedding

<b>Massive</b>	beds > 3 feet thick
<b>Thick Bedded</b>	beds 1-3 feet thick
<b>Medium Bedded</b>	beds 4 inches-1 foot thick
<b>Thin Bedded</b>	beds < 4 inches thick

#### Thicknesses

**Partings** - Paper-thin - 0.02 foot (1/4 inch)

**Bands** - 0.02 (1/4 inch)-0.05 foot (5/8 inch)

**Degree of Fracturing (Jointing)**

**Unfractured** - fracture spacing > 6 feet

**Slightly Fractured** - spacing 3-6 feet

**Moderately Fractured** - spacing 1-3 feet

**Highly Fractured** - 4 inches-1 foot

**Intensely Fractured** - < 4 inches

**Discontinuities**

Type

**Joints, bedding, cleavage, foliation, schistosity**

(In angle borings give strike and dip)

Separation

**Open, tight, filled or partly filled** (% , type)

Character of Surface - smooth or rough

APPENDIX A

CHARTS AND AIDS

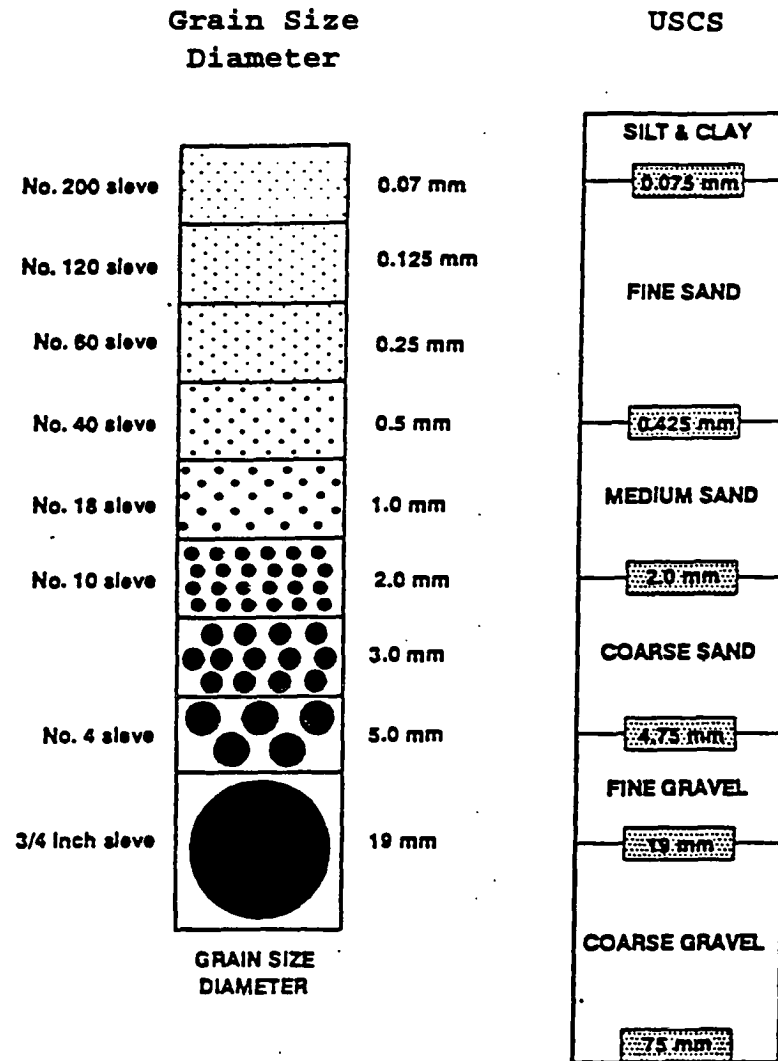
**UNIFIED SOIL CLASSIFICATION SYSTEM**

MAJOR DIVISIONS			GROUP SYMBOLS	MATERIAL TYPES	
COARSE GRAINED SOILS	GRAVELS >50% larger No. 4 sieve	Clean Gravels	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	
		Gravels w/ fines	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.	
		SANDS > 50% smaller No.4 sieve	Clean Sands	GM	Silty gravels, gravel-sand-silt mixtures.
			Sands w/ fines	GC	Clayey gravels, gravel-sand-clay mixtures.
	FINE GRAINED SOILS	SILTS  AND  CLAYS	Low Liquid Limit	SW	Well graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands, gravelly sands, little or no fines.
			High Liquid Limit	SM	Silty sands, sand-silt mixtures.
				SC	Clayey sands, sand-clay mixtures.
Highly organic soils		Low Liquid Limit	ML	Inorganic silts and very fine sands, flour, silty or clayey fine sands, or clayey silts, with slight plasticity.	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	
			OL	Organic silts and organic silty clays of low plasticity.	
		High Liquid Limit	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	
			CH	Inorganic clays of high plasticity (fat clays)	
			OH	Organic clays of medium to high plasticity, organic silts.	
		Pt	Peat and other highly organic silts.		

**Notes:**

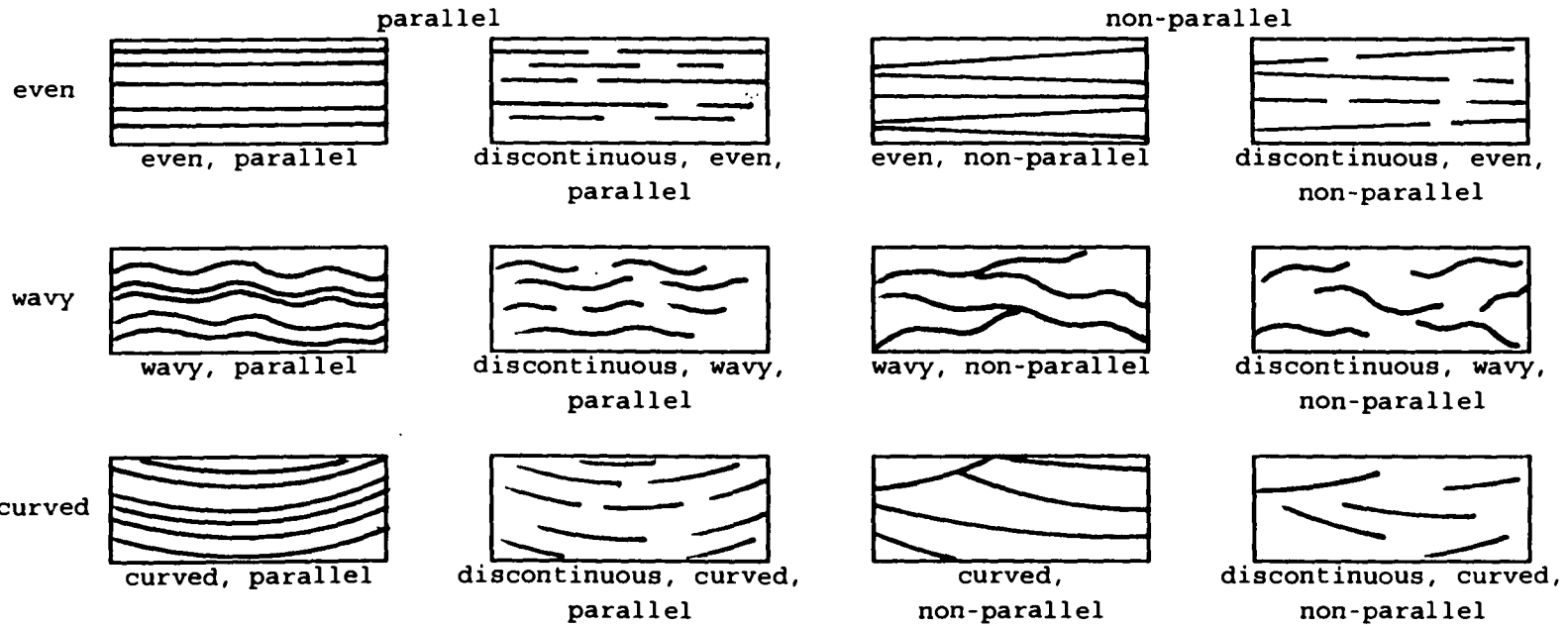
- Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC for well graded gravel-sand mixture with clay binder.
- Well graded means sample has a good distribution of all grain sizes. Geologically, this sample would be described as poorly sorted.

# GRAIN SIZE-TEXTURE CHART

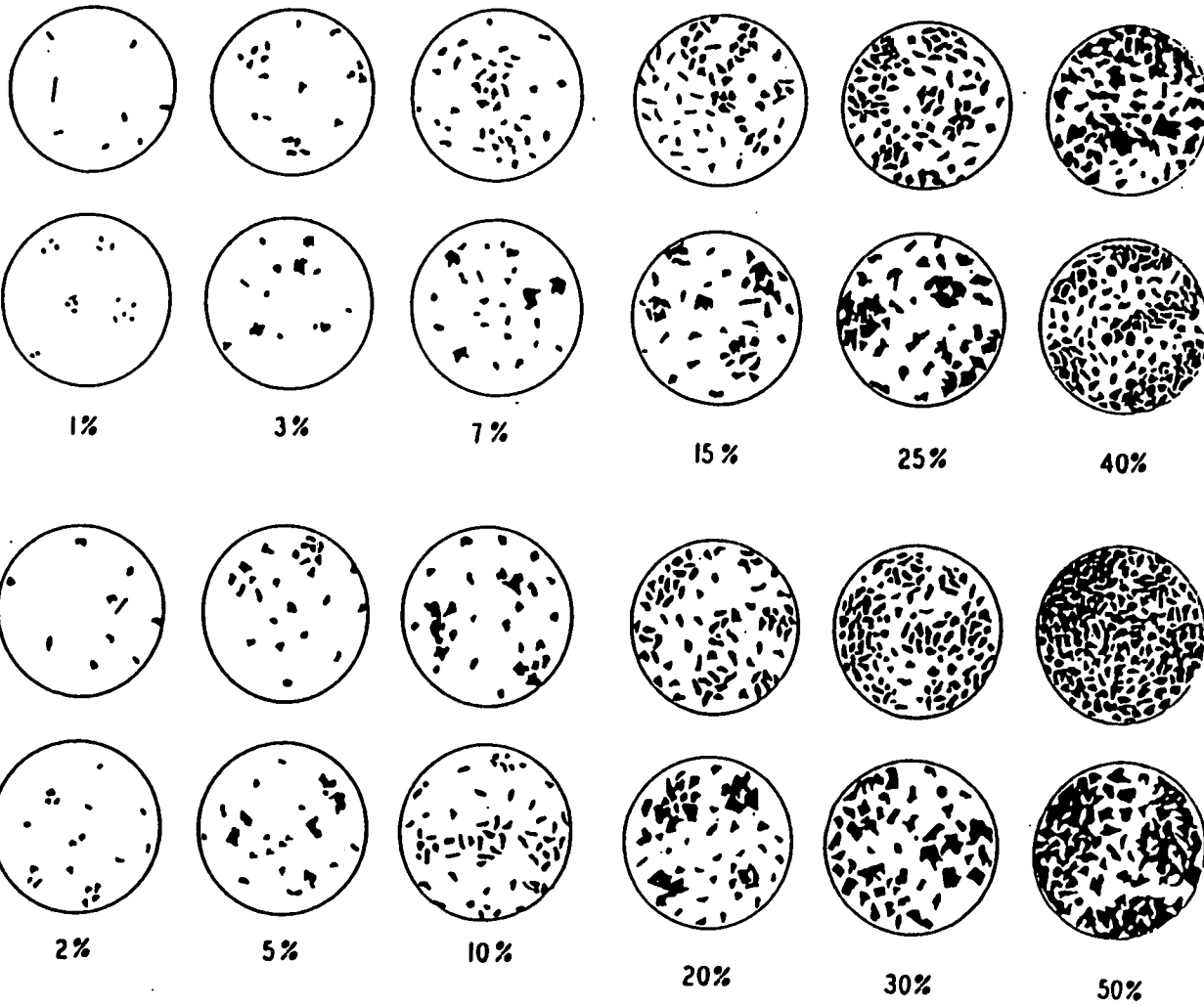


Grain sizes on this photocopy may be distorted.

# SEDIMENTARY LAYERING



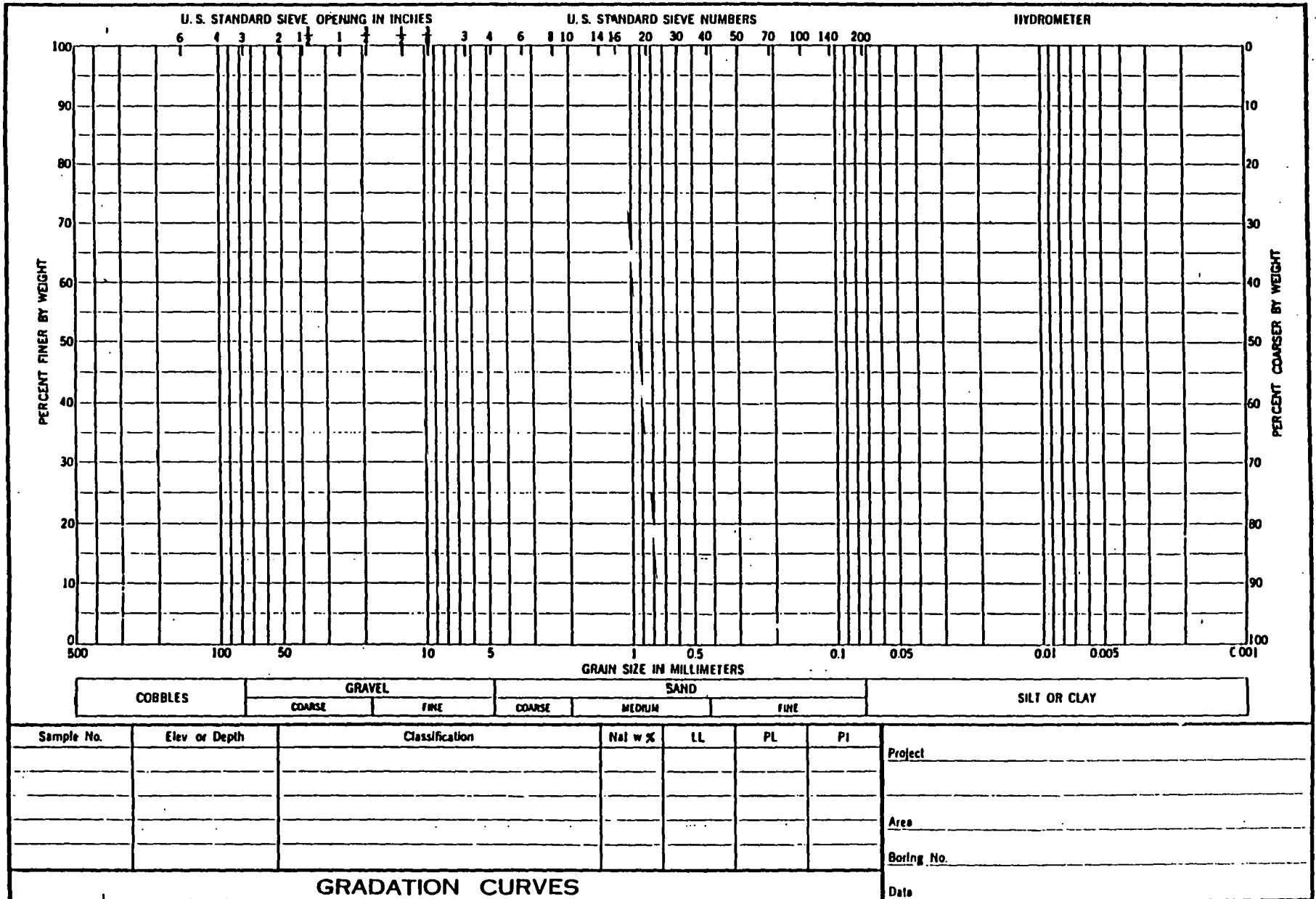
COMPARISON CHART  
FOR  
VISUAL ESTIMATION OF PERCENTAGE COMPOSITION



## GEOLOGIC TIME SCALE

Subdivisions in use by the U.S. Geological Survey			Age estimates of boundaries (my)	
Cenozoic Era (Cz)	Quaternary Period (Q)		Holocene Epoch	0.010
	Tertiary Period (T)	Neogene Subperiod (N)	Pliocene Epoch	5
			Miocene Epoch	24
		Paleogene Subperiod (P <sub>ε</sub> )	Oligocene Epoch	38
			Eocene Epoch	55
			Paleocene Epoch	63
Mesozoic Era (Mz)	Cretaceous Period (K)		Late Cretaceous Epoch	96
			Early Cretaceous Epoch	138
	Jurassic Period (J)		205	
	Triassic Period (T <sub>r</sub> )		~240	
Paleozoic Era (Pz)	Permian Period (P)		290	
	Carboniferous Periods (C)	Pennsylvanian Period (P)	~330	
		Mississippian Period (M)	360	
	Devonian Period (D)		410	
	Silurian Period (S)		435	
	Ordovician Period (O)		500	
	Cambrian Period (C)		~570	
Precambrian (pQ)				





### Equivalents

Volume per Linear Foot			Equivalent Rate Table			Cubic Feet
Diameter (inches)	cubic feet	gallons	gpm	gph	gp24h	
			5	300	7,200	7.48 gallons
1.0	0.006	0.04	10	600	14,400	38.32 liters
1.5	0.012	0.09	20	1,200	28,800	62.428 lb
2.0	0.022	0.16	30	1,800	43,200	Gallon
2.5	0.034	0.26	40	2,400	57,600	8.345 pounds
4.0	0.087	0.65	50	3,000	72,000	3.785 liters
4.5	0.110	0.82	60	3,600	86,400	231 cubic inches
6.0	0.196	1.47	70	4,200	100,800	0.83 imp gallons
6.5	0.230	1.72	80	4,800	115,200	
8.0	0.349	2.61	90	5,400	129,600	Liter
8.5	0.394	2.94	100	6,000	144,000	2.205 pounds
10.0	0.545	4.08	125	7,500	180,000	0.2642 gallons
10.5	0.601	4.50	150	9,000	216,000	61 cubic inches
12.0	0.785	5.89	175	10,500	252,000	
			200	12,000	288,000	Cubic Meter
Misc. Volumes			250	15,000	360,000	2204.5 pounds
Weights & Conversions			300	18,000	432,000	1000 liters
1 gal H <sub>2</sub> O = 8.33 lbs			350	21,000	504,000	264.2 gallons
1 cf H <sub>2</sub> O = 62.4 lbs			400	24,000	576,000	35.4 cubic feet
1 cf H <sub>2</sub> O = 7.48 gal			450	27,000	648,000	265 gallons
1 cfs = 448.8 gpm			500	30,000	720,000	
1 psi = 2.31 feet of H <sub>2</sub> O			600	36,000	864,000	Cubic Yard
0.433 psi = 1 ft of H <sub>2</sub> O			700	42,000	1,008,000	27 cubic feet
			800	48,000	1,152,000	202 gallons
Temperature Conversions			900	54,000	1,296,000	
F = ( Cx9/5)+32			1000	60,000	1,440,000	Misc
C = ( F-32)x5/9						1 kg = 2.2 pounds
or						100 psi = 7.03 kg/cm <sup>2</sup>
F = ( Cx1.8)+32						1 gpm = 3.78 liters/min
C = ( F-32)x.56						10 cfm = 283 liters/min
						1 meter = 39.4 inches
						1 inch = 2.54 cm

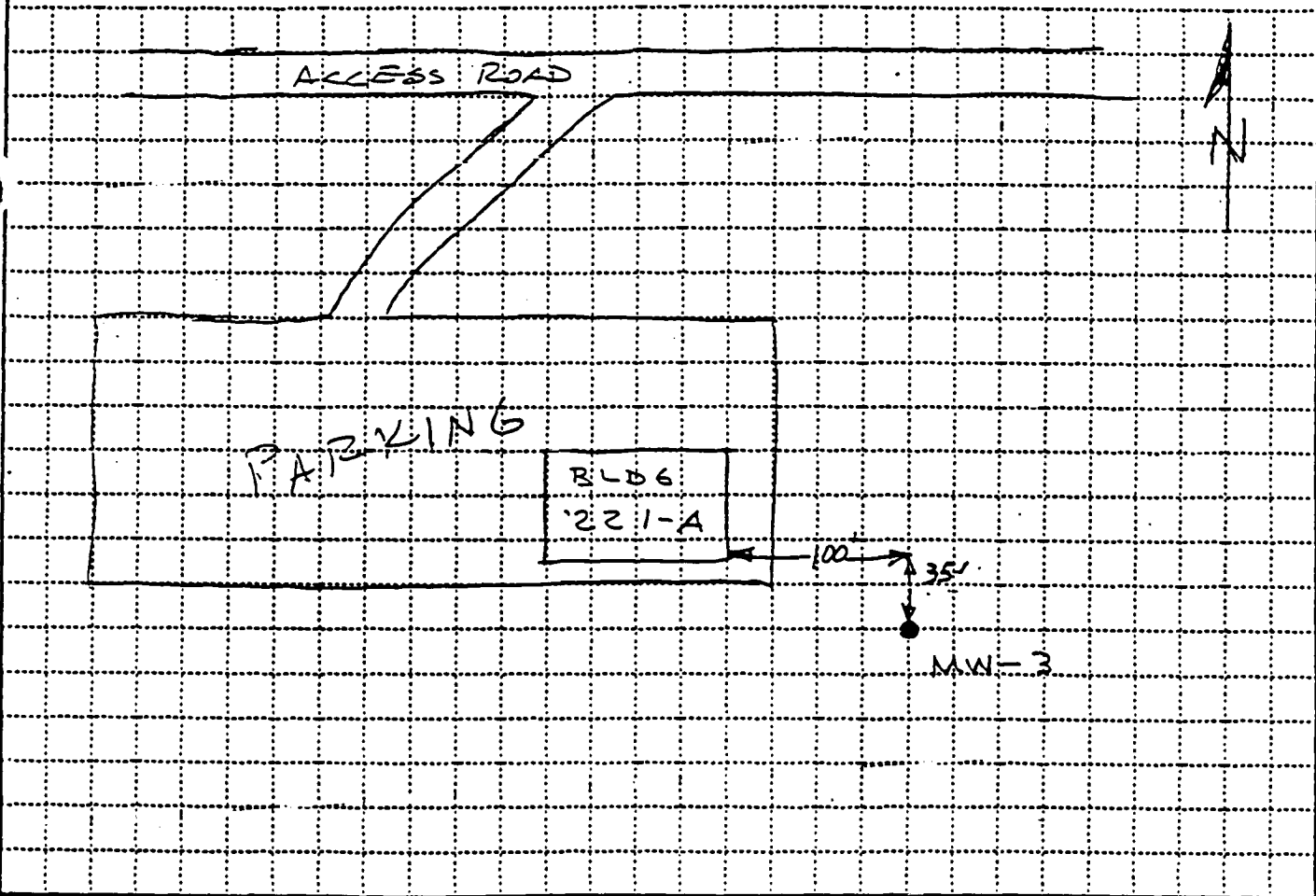
**APPENDIX B**

**EXAMPLES AND FORMS**

<b>HTRW DRILLING LOG</b>		DISTRICT	ANY DISTRICT		HOLE NUMBER	MW-3
1. COMPANY NAME		GOOD ENGINEERING		2. DRILL SUBCONTRACTOR	ANYWHERE DRILLING	
3. PROJECT		BLUE RIVER DISPOSAL		4. LOCATION	SOMEWHERE USA	
5. NAME OF DRILLER		H. HAMMER		6. MANUFACTURER'S DESIGNATION OF DRILL		ARC-51
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		1 1/2" S2/TSP02A NO CORE		8. HOLE LOCATION		SEE SKETCH
				9. SURFACE ELEVATION		576.3 (hand level)
				10. DATE STARTED	13 OCT 1995	
				11. DATE COMPLETED		14 OCT 1995
12. OVERBURDEN THICKNESS		8.9' (567.4)		15. DEPTH GROUNDWATER ENCOUNTERED		4.5' (overburden)
13. DEPTH DRILLED INTO ROCK		20.1		16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED		20.4' (555.9) / 500 15 OCT 1995
14. TOTAL DEPTH OF HOLE		29.0 (547.3)		17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)		N/A
18. GEOTECHNICAL SAMPLES		DISTURBED 2		UNDISTURBED		19. TOTAL NUMBER OF CORE BOXES 2
20. SAMPLES FOR CHEMICAL ANALYSIS		VOC 2		METALS		OTHER (SPECIFY) 2 PLH
22. DISPOSITION OF HOLE		BACKFILLED		MONITORING WELL X		21. SIGNATURE OF INSPECTOR J.T. Doe

LOCATION SKETCH/COMMENTS

SCALE:



PROJECT	BLUE RIVER DISPOSAL	HOLE NO.	MW-3
---------	---------------------	----------	------

# HTRW DRILLING LOG

PROJECT		INSPECTOR		HOLE NUMBER		
BLUE RIVER DISPOSAL		J. T. Dor		MW-3		
ELEV. (1)	DEPTH (2)	DESCRIPTION OF MATERIALS (3)	FIELD SCREENING RESULTS (7)	GEOTECH SAMPLE OR CORE BOX NO. (8)	ANALYTICAL SAMPLE NO. (9)	REMARKS (10)
574.7	1	CLAY lean sdy br mst stf occ gul	PID 10ppm			Sample thru 4 1/4" ID augers using 1 3/8" ID SS split spoon  Ran 2.0 Rec 1.8 Loss 0.2
				1.3		
				JAR 1		
				LAB		
				Prob loss	2.0	Auger to 2.0' 2.0
573.4	2	CLAY fat hd br-gr dmp L v sdy Grades into sd		2.0	MW-3-1	
				VOC		
				PAH	2.5	
						Ran 2.0 Rec 2.0 Loss 0.0
	3	SAND siy gr med gra wet	PID 0ppm			Auger to 4.0' 4.0
	4					
		Becomes sat below 4.5' Unstabilized WL 4.7' on 13 Oct at 1115				
	5		PID 0ppm	5.0		Ran 2.0 Rec 1.5 Loss 0.5
				JAR 2		
				5.5		
	6	prob edge of soil loss		Prob loss	6.0	Auger to 6.0' 6.0
569.8						
	7	SAND siy sl clay br-gr med gra sat	PID		7.0	Ran 2.0 Rec 2.0 Loss 0.0
				VOC	MW-3-2	
				PAH	7.5	
	8	cl lams, dk gr, siy, dmp	50ppm			Auger to 9.0' 8.0
						Ran 0.9 Rec 0.9 Loss 0.0
567.4		TOP OF WEA ROCK 8.9				8.9
	9	Refusal on SHALE				
						Rock too wet to core. Continued augering to 11.5'- auger refusal
	10					

PROJECT  
BLUE RIVER DISPOSAL

HOLE NO.  
MW-3

SHEET  
OF 2 SHEETS 4

# HTRW DRILLING LOG

HOLE NUMBER  
MW-3

PROJECT  
BLUE RIVER DISPOSAL

INSPECTOR  
J. T. Doe

SHEET  
OF 3 SHEETS 4

ELEV. (0)	DEPTH (0)	DESCRIPTION OF MATERIALS (0)	FIELD SCREENING RESULTS (0)	CEMENTED SAMPLE OR CORE BOX NO. (0)	ANALYTICAL SAMPLE NO. (0)	REMARKS (0)
		SHALE (cont)				Set 12.0' of 4" PVC csg to 11.5' - Grouted in csg
564.8	11	Auger refusal 11.5		11.5		11.5
	12	SHALE, lt gr, slwey, fs, mod hd, calc spin		BOX 1		14 Oct 1995 Began coring @ 11.5' using 13.5' (10.5') NO core bbl and clear water
	13	ti break				P-1 End 1130 Start 1100 Time 30 min Ran 5.0 Rec 4.8 Loss 0.2 L.C. 0.0 WP 50 psi WL 14.2 @ 1145
	14	spin				
	15	spin				
	16					CD 16.3 16.5
559.2	17	LIMESTONE, gr, c gra, fos, hd, sh ptgs 17.1				P-2 End 1300 Start 1200 Time 60 min Ran 10.0 Rec 10.2 Gain 0.2 w.P. 50psi w.L. 20.4 @ 1315
	18	ti odd breaks				
	19					
	20					

PROJECT  
BLUE RIVER DISPOSAL

HOLE NO.  
MW-3

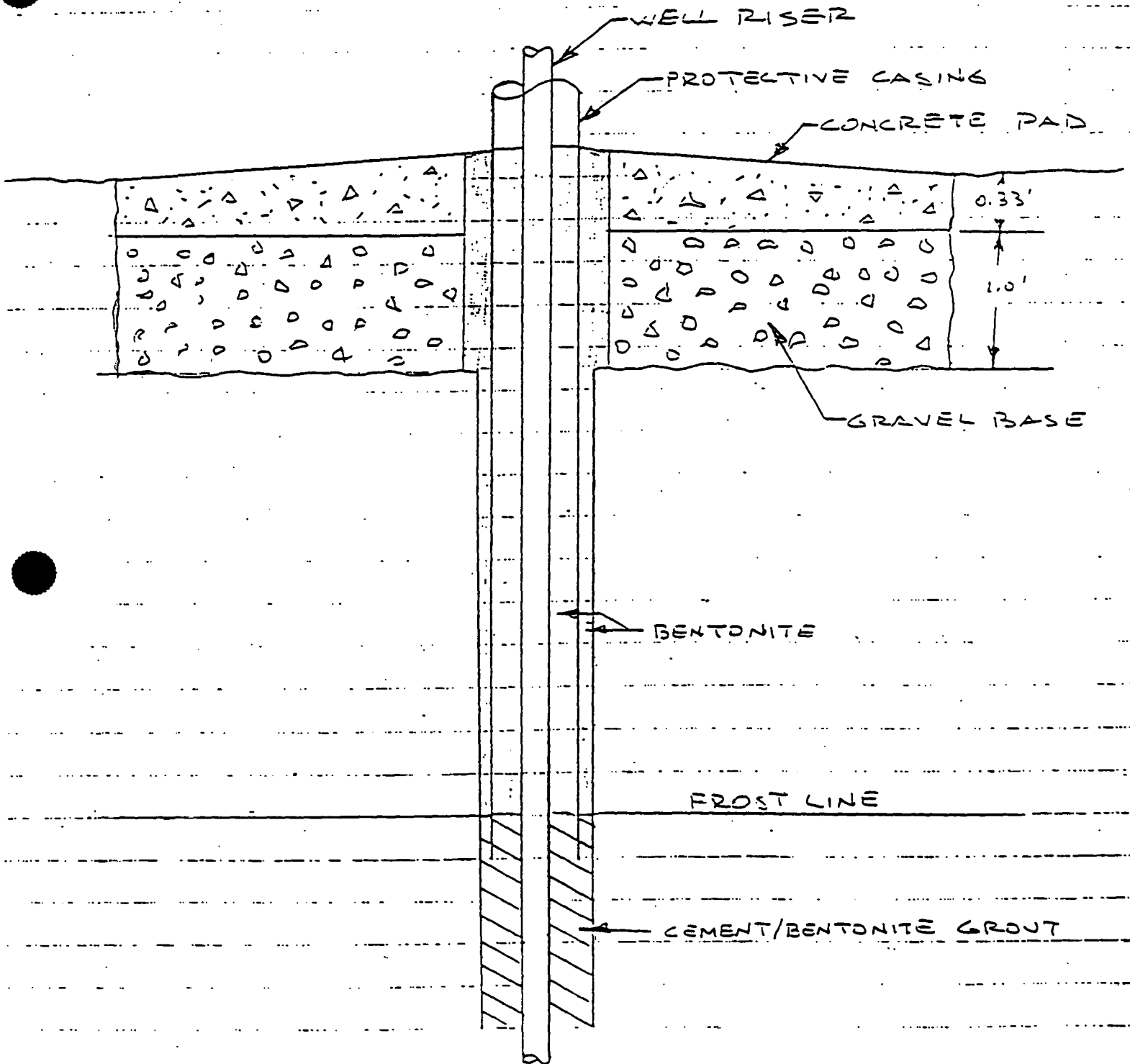
# HTRW DRILLING LOG

PROJECT BLUE RIVER DISPOSAL		INSPECTOR J. T. Dye			HOLE NUMBER MW-3		
ELEV. (ft)		DESCRIPTION OF MATERIALS (ft)			FIELD SCREENING RESULTS (ft)		
DEPTH (ft)		GEOTECH SAMPLE OR CORE BOX NO. (ft)			ANALYTICAL SAMPLE NO. (ft)		
REMARKS (ft)		REMARKS (ft)					
		LIMESTONE (cont)			BOX 1 (cont)		p-2 (cont)
21		w/a 2250° frac, op, fe st					
		op bdd break, fe st			21.8		
22					BOX 2		
23		ti bdd break					
24							
25		1/a ≈ 30° frac, ti					
26							
							CD 26.5
27		v frac, fe st, prob zone of 0.3' L.C.					p-3
		ti break					End 1350
							Start 1330
							Time 20 min
							Run 2.5
							Rec 2.2
							Loss 0.3
							L.C. 0.3
							w.p. 50 fsi
							w.L. 27.3 @ 1400
547.3	29	B.O.H. 29.0			29.0		B.O.H. CD 29.0
30							

PROJECT: BLUE RIVER DISPOSAL

HOLE NO: MW-3

SURFACE COMPLETION  
FROST HEAVE RESISTANT WELL INSTALLATION





<b>HTRW DRILLING LOG</b>		DISTRICT		HOLE NUMBER	
1. COMPANY NAME		2. DRILL SUBCONTRACTOR		SHEET SHEETS OF	
3. PROJECT			4. LOCATION		
5. NAME OF DRILLER			6. MANUFACTURER'S DESIGNATION OF DRILL		
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		8. HOLE LOCATION			
		9. SURFACE ELEVATION			
		10. DATE STARTED		11. DATE COMPLETED	
12. OVERBURDEN THICKNESS		13. DEPTH GROUNDWATER ENCOUNTERED			
13. DEPTH DRILLED INTO ROCK		16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED			
14. TOTAL DEPTH OF HOLE		17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)			
18. GEOTECHNICAL SAMPLES		DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES	
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)
					21. TOTAL CORE RECOVERY %
22. DISPOSITION OF HOLE		BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR

LOCATION SKETCH/COMMENTS

SCALE:

--

PROJECT	HOLE NO.
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# HTRW DRILLING LOG

HOLE NUMBER

PROJECT

INSPECTOR

SHEET

OF SHEETS

ELEV. (10')	DEPTH (10')	DESCRIPTION OF MATERIALS (10')	FIELD SCREENING RESULTS (10')	GEO TECH SAMPLE OR CORE BOX NO. (10')	ANALYTICAL SAMPLE NO. (10')	REMARKS (10')

PROJECT

HOLE NO.

**MONITORING WELL CONSTRUCTION**  
FORM

FACILITY/PROJECT NAME	LOCAL GRID LOCATION OF WELL N. <input type="checkbox"/> E. <input type="checkbox"/> S. <input type="checkbox"/> W. <input type="checkbox"/> FT. _____ FT. _____	WELL NAME
FACILITY LICENSE, PERMIT OR MONITORING NUMBER	GRID ORIGIN LOCATION LAT. _____ LONG. _____ OR ST. PLANE FT. N. _____ FT. E. _____	WELL NUMBER
TYPE OF PROTECTIVE COVER: ABOVE-GROUND <input type="checkbox"/> FLUSH-TO-GROUND <input type="checkbox"/>	SECTION LOCATION OF WASTE/SOURCE _____ OF _____ OF SEC. _____ T. _____ N. _____ R. _____ <input type="checkbox"/> E. <input type="checkbox"/> W.	DATE WELL INSTALLED MM / DD / YY
DISTANCE WELLS FROM WASTE/SOURCE BOUNDARY	LOCATION OF WELL RELATIVE TO WASTE/SOURCE U <input type="checkbox"/> UPGRADIENT      S <input type="checkbox"/> SIDEGRADIENT D <input type="checkbox"/> DOWNGRADIENT      N <input type="checkbox"/> NOT KNOWN	WELL INSTALLED BY: (PERSON'S NAME AND FIRM)
MAXIMUM DEPTH OF FROST PENETRATION		

A. PROTECTIVE PIPE, TOP ELEVATION \_\_\_\_\_ FT. MSL

B. WELL CASING, TOP ELEVATION \_\_\_\_\_ FT. MSL

C. LAND SURFACE ELEVATION \_\_\_\_\_ FT. MSL

D. SURFACE SEAL, BOTTOM \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.

12. USCS CLASSIFICATION OF SOIL NEAR SCREEN:

GP  GM  GC  GV  SV  SP   
 SM  SC  ML  MH  CL  CH   
 BEDROCK

13. STEVE ANALYSIS ATTACHED?  YES  NO

14. DRILLING METHOD USED:  
     ROTARY   
     HOLLOW STEM AUGER   
     OTHER \_\_\_\_\_

15. DRILLING FLUID USED: WATER  AIR   
     DRILLING MUD  NONE

16. DRILLING ADDITIVES USED?  YES  NO  
 DESCRIBE \_\_\_\_\_

17. SOURCE OF WATER (ATTACH ANALYSIS):

E. BENTONITE SEAL, TOP \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.

F. FINE SAND, TOP  
 A. \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.  
 B. \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.

G. FILTER PACK, TOP \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.

H. SCREEN JOINT, TOP \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.

I. WELL BOTTOM \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.

J. FILTER PACK, BOTTOM \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.

K. BOREHOLE, BOTTOM \_\_\_\_\_ FT. MSL OR \_\_\_\_\_ FT.

L. BOREHOLE, DIAMETER \_\_\_\_\_ IN.

M. O.O. WELL CASING \_\_\_\_\_ IN.

N. I.O. WELL CASING \_\_\_\_\_ IN.

1. CAP AND LOCK?  YES  NO

2. PROTECTIVE COVER PIPE:  
 A. INSIDE DIAMETER: \_\_\_\_\_ IN.  
 B. LENGTH: \_\_\_\_\_ FT.

3. SURFACE SEAL:      GRAVEL BLANKET   
                             BENTONITE   
                             CONCRETE   
                             OTHER \_\_\_\_\_

A. CAP  
                             BENTONITE   
                             CONCRETE   
                             OTHER \_\_\_\_\_

B. ANNULAR SPACE SEAL:  
                             BENTONITE   
                             CONCRETE   
                             OTHER \_\_\_\_\_

4. MATERIAL BETWEEN WELL CASING AND PROTECTIVE PIPE:  
                             BENTONITE   
                             ANNULAR SPACE SEAL   
                             OTHER \_\_\_\_\_

5. ANNULAR SPACE SEAL: A. GRANULAR BENTONITE   
 B. \_\_\_\_\_ LBS/GAL MUD WEIGHT, BENTONITE-SAND SLURRY   
 C. \_\_\_\_\_ LBS/GAL MUD WEIGHT, BENTONITE SLURRY   
 D. \_\_\_\_\_ % BENTONITE, BENTONITE-CEMENT GROUT   
 E. \_\_\_\_\_ FT.<sup>3</sup> VOLUME ADDED FOR ANY OF THE ABOVE

F. HOW INSTALLED:  
     TRENIE   
     TRENIE PUMPED   
     GRAVITY

6. BENTONITE SEAL: A. BENTONITE GRANULES   
 B.  IN.  IN.  IN. BENTONITE PELLETS   
 C. \_\_\_\_\_ OTHER

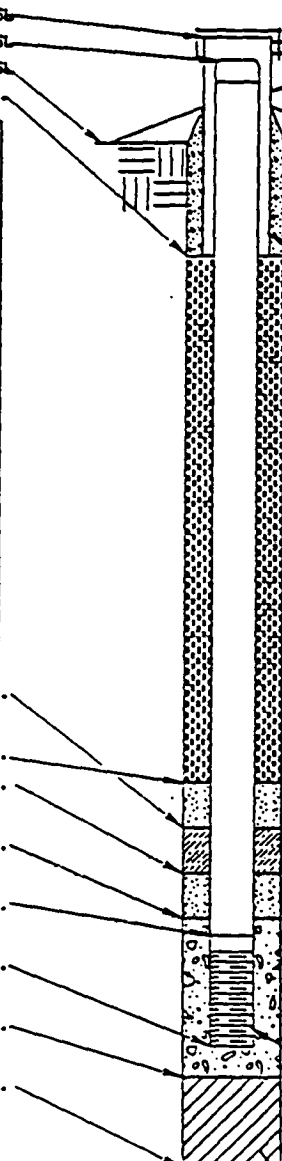
7. FINE SAND MATERIAL: MANUFACTURER, PRODUCT NAME & MESH SIZE  
 A.  YES  NO    B.  YES  NO  
 B. VOLUME ADDED \_\_\_\_\_ FT.<sup>3</sup>

8. FILTER PACK MATERIAL: MANUFACTURER, PRODUCT NAME & MESH SIZE  
 A. \_\_\_\_\_  
 B. VOLUME ADDED \_\_\_\_\_ FT.<sup>3</sup>

9. WELL CASING: FLUSH THREADED PVC SCHEDULE 40   
                             FLUSH THREADED PVC SCHEDULE 80   
                             OTHER \_\_\_\_\_

10. SCREEN MATERIAL:  
 A. SCREEN TYPE:      FACTORY CUT   
                             CONTINUOUS SLOT   
                             OTHER \_\_\_\_\_   
 B. MANUFACTURER \_\_\_\_\_  
 C. SLOT SIZE:      B. \_\_\_\_\_ IN.  
 D. SLOTTED LENGTH: \_\_\_\_\_ FT.

11. BACKFILL MATERIAL (BELOW FILTER PACK): NONE   
                             OTHER \_\_\_\_\_



HEREBY CERTIFY THAT THE INFORMATION ON THIS FORM IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE.

SIGNATURE

FIRM

## ABBREVIATIONS

When describing soil or rock samples the abbreviations listed below shall be used. If abbreviations are used on the log that are not listed below, they shall be explained on the cover page of the log. When using plural, add "s" to the abbreviation.

@	at	dmp	damp
approx	approximate(ly)	dol	dolomite
argil	argillaceous		dolomitic
bbl	barrel	drl	drilled
bd	bed		drilling
bdd	bedded	DWR	drill water
	bedding		return
bdr	bedrock	el	elevation
bifur	bifurcating	est	estimate
bky	blocky		estimated
bl	black	excl	excluding
bld	boulder	f	fine(ly)
BOH	bottom of hole	fe	iron
br	brown	fld	filled
brec	brecciated	fm	formation
brk	broken	fos	fossil
c	coarse		fossiliferous
cal	calcite	frac	fracture
calc	calcareous	frag	fragment
carb	carbonaceous	fri	friable
cav	cavity	fsl	fissle
cbl	cobble	gen	generally
CD	corrected depth	glau	glauconite
cem	cement		glauconitic
CH	core in hole	gr	gray
cht	chert	gra	grain
circl	circulation		grained
cl	clay	grad	gradational
cly	clayey	grn	green
cmtd	cemented	grt	grout
conc	concrete	gvl	gravel
congl	conglomerate	gyp	gypsum
crm	crumbly	h/a	high angle
d	dense	hd	hard
dis	disseminated	hem	hematite
dk	dark	hld	healed

hor	horizontal	pit	pit (ted)(ting)
imbdd	imbedded	PL	plastic limit
incl	including	pl	plastic
intbdd	interbed	pla	platy
	interbedded	pln	plane
intlam	interlaminated	pwdr	powder(ed)
irr	irregular(ly)	prob	probable
jt	joint		probably
l/a	low angle	pt	paper thin
lam	lamina(e)	PT	pressure test
LC	lost core	ptg	parting
LDW	lost drill water	qtz	quartz
lea	leached	rec	recovered
lg	large	rk	rock
lig	lignitic	rnd	round
lim	limonite	RQD	rock quality designaation
LL	liquid limit		
ln	lense	sat	saturated
lo	loose	scat	scattered
ls	limestone	sd	sand
lt	light	sdv	sandy
med	medium	sh	shale
mic	micaceous	shy	shalely
min	mineralized	si	silt
	mineralization	siy	silty
mod	moderate(ly)	sl	slight(ly)
mot	mottled	slcs	siliceous
	mottling	slick	slickenside
mss	massive	sml	small
mst	moist	so	soft
mtl	material	ss	sandstone
mtx	matrix	st	stain(ed)(ing)
nod	nodule	stf	stiff
NR	no recovery	strg	stringer
num	numerous	styl	stylolite
ovb	overburden		stylolitic
occ	occasional	sur	surface
ool	oolitic	ti	tight
op	open (ed)	TR	top of rock
org	organic	tr	trace
part	partial(ly)	UL	unaccountable
pbl	pebble		loss
petro	petroliferous	unacct	unaccountable
	petroleum	v	very
PI	plasticity index	var	vary

vert  
vgy  
w/  
wea  
wht

vertical  
vuggy  
with  
weathered  
white

WL  
xbdd  
xl  
xln  
yel

water level  
cross-bedded  
crystal  
crystalline  
yellow

**APPENDIX G**

**USACE Well Installation Guidelines  
(EM 1110-1-4000)**



US Army Corps  
of Engineers

EM 1110-1-4000  
31 August 1994

ENGINEERING AND DESIGN

---

# Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites

ENGINEER MANUAL



CECW-EG  
CEMP-RT

DEPARTMENT OF THE ARMY  
U.S. Army Corps of Engineers  
Washington, DC 20314-1000

EM 1110-1-4000

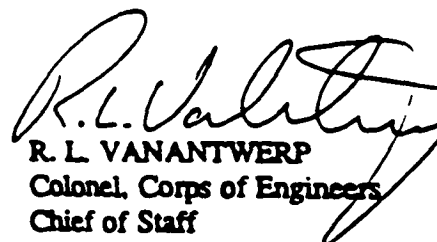
Manual  
No. 1110-1-4000

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**Engineering and Design  
MONITOR WELL DESIGN, INSTALLATION, AND DOCUMENTATION  
AT HAZARDOUS AND/OR TOXIC WASTE SITES**

- 1. Purpose.** This manual provides the minimum elements for consideration in the design, installation, and documentation of monitor well placement (and other geotechnical activities) at projects known or suspected to contain chemically hazardous and/or toxic waste (HTW).
- 2. Applicability.** This manual applies to all U.S. Army Corps of Engineers (USACE) elements having military and/or civil works responsibilities and/or programs within Superfund, the Defense Environmental Restoration Program, non-mission work for other (non-USACE) offices, host nation agreements, and/or any other USACE-managed activities involving known or suspected HTW components. This manual is not necessarily applicable to those projects involving radioactive, biological, or mixed (chemical and radioactive) waste components. Applicable guidance for those projects should be obtained directly from the USACE Hazardous, Toxic, and Radioactive Waste (HTRW) Mandatory Center of Expertise (MCX) in Omaha, Nebraska.
- 3. Discussion.** The technical understanding and evaluation of HTW studies involves an appreciation of the interactions between geology, hydrology, geotechnical engineering, and chemistry. This scenario is complicated by the trace (low parts per billion) levels of regulated chemical species that are detectable in the environment and which when detected or suspected may trigger intricate and costly response actions. Slight deviations from prescribed drilling, well installation, sampling, or analytical procedures may bias or invalidate both the reported concentrations of these regulated species and the technical basis upon which the Corps makes decisions. These relationships are further entangled by the heterogeneous, anisotropic character of the natural environment itself. This situation requires environmental characterization based upon procedures that are standardized, documented, understood, and followed. This manual outlines that effort.

FOR THE COMMANDER:

  
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Colonel, Corps of Engineers  
Chief of Staff

**Engineering and Design  
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## Chapter 1 Introduction

### 1-1. Purpose

This manual provides geotechnical and chemical guidelines for U.S. Army Corps of Engineers (USACE) elements in the planning, installation, and reporting of soil and/or bedrock borings, monitor wells, and other geotechnical and geochemical devices at hazardous and/or toxic waste (HTW) sites. These guidelines are a compilation of those procedures necessary for the acquisition of environmentally representative geotechnical data and samples, using conservative methods documented in a comprehensive manner.

### 1-2. Applicability

a. This manual applies to all USACE elements and their contractors (including architect-engineers (AE's)) having military and/or civil works HTW site responsibilities and/or engaged in programs within the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Resource Conservation and Recovery Act (RCRA); the Superfund Amendments and Reauthorization Act (SARA); the Defense Environmental Restoration Program (DERP); also for non-mission HTW work for other (non-Corps) offices; work within host nation agreements; or any other Corps-managed HTW activities.

b. Only HTW work involving *chemical* issues are covered within this manual. Radiological, biological, and mixed waste components of HTW are not addressed. Supplemental instructions will be provided as appropriate procedures are identified. In the interim, any requests for assistance in those areas should be directed to the Hazardous, Toxic, and Radioactive Waste (HTRW) Mandatory Center of Expertise (MCX) within the U.S. Army Engineer Division, Missouri River (MRD), Attention: HTRW and Engineering Directorate, Geotechnical and Technical Engineering Division, Geotechnical Branch (CEMRD-ED-TG); or Headquarters, U.S. Army Corps of Engineers (HQUSACE), Attention: Directorate of Military Programs, Environmental Restoration Division, Environmental and Chemical Engineering Branch (CEMP-RT).

c. The specific application of and adherence to these guidelines must be tailored to each project as a function of the contaminants of concern, local geohydrologic

setting, geotechnical judgment, available resources, applicable regulatory requirements, policy and guidance, public concerns, and project mission.

### 1-3. References

Appendix A contains a list of those publications referenced by and relevant to this manual.

### 1-4. Terminology

a. *General.* As in any relatively new field using the principles, terminology, and personnel of several other fields, there is a certain lack of communication over the language used to express data and mechanisms within this new field. The situation is further compounded by alternative methods, both traditional and innovative, to complete actual projects. The additional requirements for permits, licenses, and other Federal and state regulatory procedures, and the potential for litigation, add to the HTW site complexities.

#### b. *Corps situation.*

(1) Within USACE, a given HTW project may be performed totally in-house, partially in-house, or totally by one or more contractors/AE's (either independently reporting to the Corps or through a system of prime- and subcontracting). One Corps office may even broker the work of another who in turn contracts the effort. In some cases, one Corps district may design a project and award the contract while a second district supervises construction.

(2) Providing program level technical guidance in this administrative situation requires the guidance to be specific, while allowing any field activity to adapt the guidance to its needs. The intent is to foster the defense of variances, not the defense of recommended methods and procedures. This approach is warranted to provide the Corps with compatibility and continuity of HTW investigations while allowing functional flexibility. With this in mind, the following three terms are introduced: the *field activity* (FA); the *field drilling organization* (FDO); and the *drilling and well installation plan*. These terms are defined in paragraphs 1-4c(2), (3), and (1), respectively. Generically, these terms refer to a client-contractor-contract relationship. This relationship can be applied to both in-house and contracted efforts, thereby providing consistency for the geotechnical portion of the Corps HTW involvements.

*c. Definitions (alphabetically arranged).* These definitions are intended to guide the reader through the use of this manual. While other terms with equivalent definitions may be familiar to some readers, the terminology as defined here provides a common basis for the CONSISTENT understanding by ALL readers.

(1) Drilling and well installation plan/drilling plan. A document, approved by the FA or FDO before field activities begin. The plan specifies the particulars of the field effort; for example: borehole/well/sample locations, depths, equipment, materials, procedures and alternatives, quality control measures, and other topics required by the responsible FA. Implementation is by the FDO.

(2) Field activity (FA). That Corps element minimally headed by a Commander or Director, e.g., district, laboratory, or agency, assigned or otherwise acquiring the responsibility to administer a contract, agreement, or in-house Corps procedure to research, investigate, design, and/or construct a project involving hazardous and/or toxic wastes. For civil works projects, the FA would be the geographic Corps district during all phases of a civil works project.

(3) Field drilling organization (FDO). That office within the Corps or contracted by the Corps responsible for execution of the drilling plan. In a contracted arrangement, the prime contractor is regarded as the FDO. Subcontractors, even though they may physically perform the field work, are the responsibility of the prime contractor, whom the Corps holds contractually accountable.

(4) Firm bedrock. That portion of solid, or relatively solid, bedrock where the frequency of loose and/or fractured rock is markedly less than in any overlying bedrock.

(5) Geotechnical data quality management. The development and application of those policies and procedures required to obtain and utilize accurate and representative geotechnical information throughout the entire HTW project cycle, from predesign investigations to post-construction monitoring.

(6) Hazardous and/or toxic waste. A USACE idiom referring to substances which because of their properties, occurrence, concentration, or regulatory status, may potentially pose a threat to human health and welfare, or to the environment. This includes materials defined by Federal regulations as hazardous waste, hazardous substances, and pollutants.

(7) Monitor well. A monitor well is a device designed and constructed for the acquisition of ground-water samples that are representative of the chemical quality of the aquifer adjacent to the screened interval, unbiased by the well materials and installation process; and which, if so designed, provides access to measure the potentiometric surface across the screened interval.

(8) Redevelopment/well rehabilitation. A procedure which restores the original or near original pumping capacity to an existing well by the removal of sediment, precipitation, flocculent, surface run-in, or other built-up materials from within that well.

(9) Screened interval. That portion of a well which is directly open to the host environment/aquifer by way of openings in the well screen and indirectly open to that environment by way of the filter pack (or other permeable material) extending continuously above and/or below the screen.

(10) Site-specific health and safety plan/safety plan. A project-unique document approved by the responsible FA for FDO compliance. The plan includes the identification of hazardous substances present, recommended action upon encountering those substances, project/site safety requirements, organizational safety responsibilities, and the identification of supporting health and safety activities.

(11) Well development. A procedure which locally improves or restores the aquifer's hydraulic conductivity and removes well drilling fluids, muds, cuttings, mobile particulates, and entrapped gases from within and adjacent to a newly installed well.

*d. Acronyms.* Appendix B contains a list of the abbreviations used in this manual.

## 1-5. Background

*a. HTW Management Plan.* The Corps' HTW program is described in the "Hazardous/Toxic Waste Management Plan" (HQUSACE 1988). That program includes elements of Superfund, DERP, and non-mission HTW work for others. Within the Management Plan, the concept of Geotechnical Data Quality Management (GDQM) is introduced. Though definitions may vary, the essence of GDQM is to develop and apply policies and procedures to obtain and utilize accurate and representative geotechnical information throughout the entire HTW project cycle from predesign investigations to postconstruction monitoring.

b. *EM 1110-1-4000*. As a GDQM mechanism, this manual provides guidance for collection and documentation of geotechnical information. Site-specific deviations should be described and supported in the drilling and well installation plan.

(1) Technical understanding and evaluation of HTW studies involve an appreciation of the interactions among many fields including geology, hydrology, geotechnical engineering, and chemistry. This scenario is complicated by the trace (low parts per billion) levels of regulated chemical species that are detectable in the environment and which, when detected or suspected, trigger intricate and costly response actions. Slight deviations from prescribed drilling, well installation, sampling, or analytical procedures may bias or invalidate the reported concentrations. This sensitivity requires that procedures be relevant, standardized, documented, understood, and followed. Despite these procedures, the normal heterogeneity and anisotropy of natural field occurrences are, in themselves, frequently sufficient to confuse the appropriate interpretation of the gathered field data.

(2) The specific content of this manual will be periodically updated based upon reader suggestions, lessons

learned, technological advances, and Corps needs. Issues of significant concern will be disseminated Corpswide in a more expeditious manner.

(3) Not all geotechnical personnel will agree on every practice advocated herein. Any such variations should be over a matter of degree, not substance. If the reader perceives a technical difficulty in any of this manual's contents, the reader is requested to contact the proponent.

#### 1-6. Proponency

Technical proponency for this manual is shared between the Geotechnical and Materials Branch, Engineering Division, Directorate of Civil Works, Headquarters, U.S. Army Corps of Engineers (CECW-EG) and Environmental and Chemical Engineering Branch, Environmental Restoration Division, Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers (CEMP-RT). All comments and suggestions should be directed to HQUSACE, CECW-EG or CEMP-RT, 20 Massachusetts Avenue, N.W., Washington, D.C. 20314-1000.

## **Chapter 2**

### **Boreholes and Wells: Site Reconnaissance, Locations, Quantities, and Designations**

#### **2-1. Site Reconnaissance**

Site visits are suggested for project geotechnical personnel as early as practical in the planning for any subsurface exploration. The purpose of this reconnaissance is to evaluate physical site conditions and logistical support availability. Particular items of interest would include geologic and geographic settings, site access, proximal utilities, service areas, sample shipment facilities, and potential hazards. Application of this knowledge will contribute to enhancing the technical approach and cost realism for subsequent project development.

#### **2-2. Locations and Quantities**

The locations and quantities of boreholes and wells should be selected to effectively ascertain desired geologic, hydrologic, and/or chemical parameters. The FDO should

neither relocate a boring or well nor alter the number of borings or wells specified in the drilling plan without prior coordination with the FA. The drilling and installation plan should allow relocations when necessitated by proximal utilities or drilling difficulties.

#### **2-3. Designations**

Borehole and well designations (identification numbers) should not be unilaterally changed in the field or in a centralized computer database without prior approval of the installing Corps organization or non-Corps agency. After receiving approval, the requesting FA should physically renumber those sites where a designation is posted in the field. Temporary conversions not involving the alteration of either field markings or a centralized database may be done for reporting purposes without approval of the installing organization or agency. Such temporary changes may be necessary, for instance, if the data entry format of a given computer system is not compatible with the characters in the existing well designation. A conversion table should be included in the final report to document any permanent or temporary boring/well designation changes.

## Chapter 3 Drilling Operations

### 3-1. Physical Security

The FDO should comply with all security policies at the project site. The FDO is totally responsible for securing its own equipment. The FDO should address any special situations in the drilling plan.

### 3-2. Drilling Safety and Underground Utility Detection

When drilling in areas of known or suspected hazardous materials, appropriate health and safety precautions should be implemented. Guidance adaptable for drilling activities is available in Occupational Safety and Health Administration (OSHA) documents (particularly, 29 CFR 1910.120 and 29 CFR 1926), ER 385-1-92, and EM 385-1-1. The FDO should determine all applicable regulations, requirements, and permits with regard to drilling safety and underground utility detection. These items should be included in the safety plan. The safety plan should be approved by the FA prior to any drilling.

### 3-3. Permits, Licenses, Professional Registration, and Rights-of-Entry

The FA should be responsible for identifying all applicable permits, licenses, professional registration, rights-of-entry, and applicable state and local regulatory procedures for drilling, well installation, well decommissioning/abandonment, and topographic surveying (to include any requirements for the submission of well logs, samples, etc.). Acquisition and submission of these items to state or local authorities should be coordinated between the FA and FDO, with the responsibilities of each specified in the drilling plan. The need for any rights-of-entry should be specified in the drilling plan along with the organization(s) responsible for their acquisition.

### 3-4. Site Geologist

A "site geologist" (defined as an earth science or engineering professional with a college degree in geology, civil engineering, or related field; experienced in HTW projects, soil and rock logging, and monitor well installation), should be present at each operating drill rig. This geologist should be responsible for logging, acquisition (and possibly shipment) of samples, monitoring of drilling

operations, recording of water losses/gains and ground-water data, preparing the boring logs and well diagrams, and recording the well installation and decommissioning procedures conducted with that rig. Each site geologist should be responsible for only one operating rig. The geologist should have onsite sufficient tools, forms, and professional equipment in operable condition to efficiently perform the duties as outlined in this manual and other relevant project documents. Items in the possession of each site geologist should include, as a minimum, a copy of this manual, a copy of the approved drilling and well installation plan, log forms, the approved safety plan, a 10-power (minimum) hand lens, and a measuring tape (weighted with stainless steel or chemically stable, non-metallic material) long enough to measure the deepest boring/well within the project, heavy enough to reach that depth, and small enough to readily fit within the appropriate annulus or opening. Each site geologist should also have onsite a water-level measuring device (preferably electrical), pH and electric conductivity meters, and materials necessary to prepare the samples for storage or shipment. At some sites, the geologist may be also responsible for monitoring gases during drilling. If so, the geologist should have the necessary instruments and be proficient in their use and calibration.

### 3-5. Equipment

*a. Condition.* All drilling, sampling, and support equipment brought to a site should be in operable condition and free of leaks in the hydraulic, lubrication, fuel, and other fluid systems where fluid leakage would or could be detrimental to the project effort. All switches (to include safety switches), gages, and other electrical, mechanical, pneumatic, and hydraulic systems should be in a safe and operable condition prior to arrival onsite.

*b. Cleaning.* All drilling equipment should be cleaned with steam or pressurized hot water before arriving at the project installation/site. After arrival but prior to project commencement, all drilling equipment to include rigs, support vehicles, water tanks (inside and out), augers, drill casings, rods, samplers, tools, recirculation tanks, etc., should be cleaned with steam or pressurized hot water using approved water (see paragraph 3-9b) at the installation decontamination point. Samplers should also receive a final rinse with approved water. A similar cleaning should also occur between each boring/well site. After the onsite cleaning, only the equipment used or soiled at a particular boring or well should need to be recleaned between sites. Unless circumstances require otherwise, water tank interiors may not need to be cleaned



between each boring/well at a given project. Prior to use, all casings, augers, recirculation and water tanks, etc., should be devoid both inside and out of any asphaltic, bituminous, or other encrusting or coating materials, grease, grout, soil, etc. Paint, applied by the equipment manufacturer, may not have to be removed from drilling equipment, depending upon the paint composition and its contact with the environment and contaminants of concern. All equipment should be decontaminated before it is removed from the project site. If drilling requires telescoping casing because of differing levels of contamination in subsurface strata, then decontamination may be necessary before setting each string of smaller casing and before drilling beyond any casing. To the extent practical, all cleaning should be performed in a single remote area that is surficially crossgradient or downgradient from any site to be sampled. Waste solids and water from the cleaning/decontamination process should be properly collected and disposed. This may require that cleaning be conducted on a concrete pad or other surface from which the waste materials may be collected.

### 3-6. Drilling Methods

*a. Objective.* The objective of selecting a drilling method for monitor well installation is to use that technique which

- (1) Provides representative data and samples.
- (2) Eliminates or minimizes the potential for subsurface contamination and/or cross-contamination.

- (3) Minimizes drilling costs.

*b. Methods.*

(1) To this end, the following drilling methods are typically used:

- (a) Hollow stem augers.
- (b) Cable tool/churn drill.
- (c) Water/mud rotary.
- (d) Air/pneumatic methods.

(2) Of these, hollow stem augers are technically advantageous in most situations because of their "dry" method of drilling. The drilling method should be specified and described in the drilling plan. The drilling plan

should further include detailed rationale for the selection of the specified method including but not limited to how the anticipated drilling conditions are accounted for by the selected method and how cross-contamination would be prevented. The drilling plan should reference relevant Corps, American Society for Testing and Materials (ASTM), U.S. Environmental Protection Agency (USEPA), and other publications.

*c. Special concerns.*

(1) Dry methods. As mentioned earlier, a dry drilling method is preferred for HTW work. Dry methods advance a boring using purely mechanical means without the aid of an aqueous or pneumatic drilling "fluid" for cuttings removal, bit cooling, or borehole stabilization. In this way, the chemical interface with the subsurface is minimized, though not eliminated. Local aeration of the borehole wall, for example, may occur simply by the removal of compacted or confining soil or rock.

(2) Aqueous methods.

(a) Aqueous drilling methods use a fluid, usually water, or a water and bentonite mix, for cuttings removal, bit cooling, and hole stabilization. For HTW work, the use of these materials increases the potential to add a new contaminant or suite of contaminants to the subsurface environment adjacent to the boring. Even the removal of one or more volumes of water equal to that which was lost during drilling will not remove all of the lost fluid. In addition, the level of effort to be expended upon well development is directly tied to the amount of water loss during drilling: a minimum of five times the volume lost to be removed during development. Therefore, the less fluid loss, the less the development effort (time and cost).

(b) The situation is further complicated when bentonite is used. While bentonite tends to reduce the amount of drilling fluid loss, the residual bentonite remaining around the boring after development may provide sufficient sorptive material to modify local groundwater chemistry for some parameters (for example, metals).

(3) Pneumatic methods. Pneumatic methods are separately covered in paragraph 3-7.

### 3-7. Pneumatic/Air Methods

*a. Precautions.* Drilling with air is prohibited on embankments and their foundations as discussed in

ER 1110-2-1807. When air usage is allowed in other situations, that usage should be detailed in the drilling plan, to include the following items:

- (1) Situation favoring air usage.
- (2) Air drilling method to be used.
- (3) Expected subsurface contaminants, and how field personnel will be protected from any adverse effects caused by these contaminants in the returned air and particles blown from the borehole or well.
- (4) The potential effects of air usage upon the chemical analyses of groundwater and soil (especially for volatile species) and the mitigation procedures to negate the detrimental aspects of these effects.
- (5) The potential effects of air usage upon the physical, hydrological, and structural character of the surrounding soil and/or rock and the mitigation to address the negative aspects of these effects.
- (6) Measures to be taken to reduce oil usage and to limit aquifer aeration.

*b. Criteria.* In general, air system plans should:

- (1) Specify the type of air compressor and compressor lubricating oil and require that sufficient samples of the initial reservoir (and any refill) oil be retained by the FDO, along with a record of oil loss (recorded on the boring log), for evaluation in the event of future problems. The oil sample(s) may be disposed of upon project completion.
- (2) Require an air line oil filter and that the filter be changed per manufacturer's recommendation during operation with a record kept (on the boring log) of this maintenance. More frequent changes should be made if oil is visibly detected in the filtered air, as by an oil stain on clean, writing paper after directing the filtered air from a hose onto the paper "300 mm" ("a foot") away for "15 seconds." (While these numbers are arbitrary, they are provided as examples for FDO guidance and intra/interproject consistency.)
- (3) Prohibit the use of any additive except approved water for dust control and cuttings removal.

(4) Detail the use of any downhole hammer/bit with emphasis upon those procedures to be taken to preclude residual groundwater sample contamination caused by the lubrication of the downhole equipment.

(5) Discuss the volume of air and pressure rating required for drilling and whether a downhole hammer, rotary bit, or both can be used. The air volume and pressure required should be adequate for the hole diameter, boring depth, available equipment, and site conditions.

(6) Detail the use of any bottled gas with emphasis on air composition, quality, quantity, method of bottling, and anticipated use.

*c. Reporting.* Air usage should be fully described in the boring log to include equipment description(s), manufacturer(s), model(s), air pressures used, frequency of oil filter change, and evaluation of the system performance, both design and actual.

### 3-8. Recirculation Tanks and Sumps

Portable recirculation tanks should be used for mud/water rotary operations and similar functions. The use of dug sumps or pits (lined or unlined) should be expressly prohibited to minimize cross-contamination and to enhance both personal safety and work area restoration.

### 3-9. Materials

*a. Bentonite.* Bentonite is the only drilling fluid additive that is typically allowed under normal circumstances. This includes any form of bentonite (powders, granules, or pellets) intended for drilling mud, grout, seals, etc. Organic additives should not be used. Exception might be made for some high yield bentonites, to which the manufacturer has added a small quantity of polymer. The use of any bentonite should be discussed in the drilling plan and approved by the FA. Bentonite should only be used if absolutely necessary to ensure that the borehole will not collapse or to improve cuttings removal. The following data should be included in the drilling plan and submitted along with a sample of the material for approval:

- (1) Brand name(s).
- (2) Manufacturer(s).

(3) Manufacturer's address and telephone number(s).

(4) Product description(s) from package label(s) or manufacturer's brochure(s), to include any polymer or other additives.

(5) Intended use(s) for this product.

(6) Potential effects on chemical analyses of subsequent samples.

*b. Water.*

(1) To the extent practical, the use of drilling water should be held to a minimum at HTW sites. When water usage is deemed necessary, the source of any water used in drilling, grouting, sealing, filter placement, well installation, well decommissioning/abandonment, equipment washing, etc. should be approved by the FA prior to arrival of the drilling equipment onsite and specified in the drilling plan. Desirable characteristics for the source include:

(a) An uncontaminated aquifer origin.

(b) Wellhead upgradient of potential contaminant sources.

(c) Be free of survey-related contaminants by virtue of pretesting (sampling and analysis) by the FDO using a laboratory validated by USACE for those contaminants using methods within that validation. Knowledge of the water-chemistry is the most important factor in water approval.

(d) The water is untreated and unfiltered.

(e) The tap has accessibility and capacity compatible with project schedules and equipment.

(f) Only one designated tap for access.

(2) Surface water bodies should not be used, if at all practical.

(3) If a suitable source exists onsite, that source should be used. If no onsite water is available, the FDO should both locate a potential source and submit the following data in writing to the FA for approval prior to the arrival of any drilling equipment onsite. A suggested format is given in Figure 3-1.

(a) Owner/address/telephone number.

(b) Location of tap/address.

(c) Type of source (well, pond, river, etc.). If a well, specify static water level (depth), date measured, well depth, and aquifer description.

(d) Type of any treatment and filtration prior to tap (e.g., none, chlorination, fluoridation, softening, etc.).

(e) Time of access (e.g., 24 hours per day, 7 days per week, etc.).

(f) Cost per cubic meter (gallon) charged by owner/operator.

(g) Results and dates of all available chemical analyses over past 2 years. Include the name(s) and addresses of the analytical laboratory(s).

(h) Results and date(s) of chemical analysis for project contaminants by a laboratory validated by USACE for those contaminants.

(4) The FDO should have the responsibility to procure, transport, and store the water required for project needs in a manner to avoid the chemical contamination or degradation of the water once obtained. The FDO also should be responsible for any heating, thermal insulation, or agitation of the water to maintain the water as a fluid for its intended uses.

*c. Grout.*

(1) Materials and mixing sequence. Grout, when used in monitor well construction or borehole/well decommissioning, should be composed of Type I portland cement (Annual Book of ASTM Standards: Volume 04.01; C 150), bentonite (0-10% dry bentonite per 42.6-kg (94-lb) sack of dry cement) and a maximum of 0.02-0.03 m<sup>3</sup> (6-7 gal) of approved water per sack of cement. The amount of water per sack of cement required for a pumpable mix will vary with the amount of bentonite used. The amount of water used should be kept to a minimum. When a sulfate resistant grout is needed, Types II or V cement should be used instead of Type I. Neither additives nor borehole cuttings should be mixed with the grout. The bentonite may more fully hydrate if mixed first with dry cement. This mixture may, however, require slightly more water for a pumpable mix. The use

WATER APPROVAL

Project for Intended Use:

1. Water source:  
Owner:  
Address:  
Telephone Number:
2. Water tap location:  
Operator:  
Address:
3. Type of source:  
Aquifer:  
Well depth:  
Static water level from ground surface:  
Date measured:
4. Type of treatment prior to tap:
5. Type of access:
6. Cost per cubic meter (gallon) charged by Owner/Operator:
7. Attach results and dates of chemical analyses for past 2 years. Include name(s) and address(s) of analytical laboratory(s).
8. Attach results and dates of chemical analyses for project analytes by the laboratory certified by, or in the process of being certified.

SUBMITTED BY:

Company:

Person:

Telephone Number:

Date:

FOA APPROVAL (A)/DISAPPROVAL (D)

(Check one)

Project Officer:

A    D

Project Geologists/Date:

A    D

Figure 3-1. Suggested format for use in obtaining water approval

of air-entrained cement should be avoided to negate potential analytical interference in groundwater samples by the entraining additives.

(2) Equipment. All grout materials should be combined in an aboveground rigid container or mixer and mechanically (not manually) blended onsite to produce a thick, lump-free mixture throughout the mixing vessel. The mixed grout should be recirculated through the grout pump prior to placement. Grout should be placed using a grout pump and pipe/tremie. The grout pipe should be of rigid construction for vertical control of pipe placement. Drill rods, rigid polyvinyl chloride (PVC) or metal pipes are suggested stock for tremies. If hoses or flexible plastics must be used, they may have to be fitted with a length of steel pipe at the downhole end to keep the flexible material from curling and embedding itself into the borehole wall. This is especially true in cold weather when the coiled material resists straightening. Grout pipes should have SIDE discharge holes, NOT end discharge. The side discharge will help to maintain the integrity of the underlying material (especially the bentonite seal).

*d. Granular filter pack.*

(1) All granular filters should be approved by the FA prior to drilling and should be discussed in the drilling plan. Discussions should include composition, source, placement, and gradation. If the actual gradation is to be determined during drilling, then more than one filter pack gradation should be on hand so that well installation will not be unnecessarily delayed. A 500-cm<sup>3</sup> (one-pint) representative sample for visual familiarization of each proposed granular filter pack, accompanied by the data below, should be submitted by the FDO to the FA for approval prior to drilling. Each sample should be described, in writing (see Figure 3-2 for submittal format), in terms of:

- (a) Lithology.
- (b) Grain size distribution.
- (c) Brand name, if any.
- (d) Source, both manufacturing company and location of pit or quarry of origin.
- (e) Processing method: e.g., pit run, screened and unwashed, screened and washed with water from well/river/pond, etc.

(f) Slot size of intended screen.

(2) Granular filter packs should be visually clean (as seen through a 10-power hand lens), free of material that would pass through a No. 200 (75-micrometer (um)) sieve, inert, siliceous, composed of rounded grains, and of appropriate size for the well screen and host environment. A chemical analysis, including analytes of project concern, may be advisable in some circumstances. However, the reproducibility of that result should be evaluated against the spatial and temporal variability of the aggregate source and processing methods. The filter material should be packaged in bags by the supplier and therein delivered to the site.

*e. Well screens, casings, and fittings.*

(1) Typically, only PVC, polytetrafluoroethylene (PTFE), and/or stainless steel should be used. All PVC screens, casings, and fittings should conform to National Sanitation Foundation (NSF) Standard 14 for potable water usage or Annual Book of ASTM Standards: Volume 08.04; F 480 and bear the appropriate rating logo. If the FDO uses a screen and/or casing manufacturer or supplier who removes or does not apply this logo, the FDO should include in the drilling plan a written statement from the manufacturer/supplier (and endorsed by the FDO) that the screens and/or casing have been appropriately rated by NSF or ASTM. Specific materials should be specified in the drilling plan approved by the FA. All materials should be as chemically inert as technically practical with respect to the site environment.

(2) All well screens should be commercially fabricated, slotted or continuously wound, and have an inside diameter (ID) equal to or greater than the ID of the well casing. An exception may be needed in the case of continuously wound screens because their supporting rods may reduce the full ID. Stainless steel screens may be used with PVC or PTFE well casing. No fitting should restrict the ID of the joined casing and/or screen. All screens, casings, and fittings should be new. Screens should have the largest open area per unit length that is practical for the adjacent aquifer and available filter.

(3) Couplings within the casing and between the casing and screen should be compatibly threaded. Thermal or solvent welded couplings on plastic pipe should not be used. This caution also applies to threaded or slip-joint couplings thermally welded to the casing by the manufacturer or in the field. Several thermally welded

GRANULAR FILTER PACK APPROVAL

Project for Intended Use:

1. Filter Material Brand Name:
2. Lithology:
3. Grain Size Distribution:
4. Source:  
  
    Company that made product:  
  
    Location of pit/quarry of origin:
5. Processing Method:
6. Slot Size of Intended Screen:

Submitted by:

Company:

Person:

Telephone:

Date:

FOA APPROVAL (A)/DISAPPROVAL (D) (Check one)

Project Officer Name/Date: A    D

Project Geologist Name/Date: A    D

Figure 3-2. Suggested format for obtaining approval for filter pack

joints have been known to break during well installation on a single project. The avoidance should remain until the functional integrity of thermal welds has been substantiated.

(4) Gaskets, pop rivets, or screws should not be used on monitor wells. Particular problems with their use include anomalous analytical results, restriction of the

well ID, and a loss of well integrity at the point of application.

*f. Well caps and centralizers.*

(1) The tops of all well casings should be telescopically covered with a slip-joint-type cap. Each cap should be composed of PVC, PTFE, or stainless steel and

LOOSELY fitted to the riser. Each cap should be constructed to preclude binding to the well casing due to tightness of fit, unclean surface, or frost, and secure enough to preclude debris and insects from entering the well. Caps and risers may be threaded. However, sufficient annular space should be allowed between the well and protective casing to enable one to thaw any frosted shut caps. Preferably, vents should *not* be placed in these caps or in the well riser/stickup. Vents may compromise water sample integrity by allowing foreign materials to enter the well between sampling events. Caps should be LOOSE enough to allow equilibration between hydrostatic and atmospheric pressures. Special cap (and riser) designs should be provided by the FA or FDO for wells in floodplains and those instances where the top of the well may be below grade; e.g., in roadways and parking lots.

(2) The use of well centralizers should be considered for wells deeper than 6 m (20 ft). When used, they should be of PVC, PTFE, or stainless steel and attached to the casing at regular intervals by means of stainless steel fasteners or strapping. Centralizers should not be attached to the well screen or to that part of the well casing exposed to the granular filter or bentonite seal. Centralizers should be oriented to allow for the unrestricted passage of the tremie pipe(s) used for filter pack and grout placement.

*g. Well protection materials.* Elements of well protection are intended to protect the monitor well from physical damage, to prevent erosion and/or ponding in the immediate vicinity of the monitor well, and to enhance the validity of the water samples.

(1) The potential for physical damage is lessened by the installation of padlocked, protective iron/steel casing over the monitor well and iron/steel posts around the well. The casing and posts should be new. The protective casing diameter or minimum dimension should be 100 mm (4 in.) greater than the nominal diameter of the monitor well; and the nominal length should be 1.5 m (5 ft). The posts should be at least 80 mm (3 in.) in diameter and the top modified to preclude the entry of water. Nominal length of the posts should be 1.8 m (6 ft). Special circumstances necessitating different materials should be addressed in the drilling plan.

(2) Erosion and/or ponding in the immediate vicinity of the monitoring well may be prevented by assuring that the ground surface slopes away from the monitor well protective casing and by the spreading of a 150-mm

(6-in.) thick, 2.4-m (8-ft) diameter blanket of 19- to 75-mm (3/4- to 3-in.) gravel around the monitor well. Plastic sheeting under the gravel blanket would temporarily divert infiltration from the wellhead area before the plastic tears or weathers.

(3) The validity of the water samples is enhanced by a locking cover on the protective casing. The cover should be hinged or telescoped but not threaded. (Threaded covers tend to rust and/or freeze shut. Lubricants applied to the threads to reduce this closure tend to adhere to sampling personnel and their equipment.) All locks on these covers should be opened by a single key and, if possible, should match any locks previously installed at the site(s).

*h. Glues and solvents.* The use of glues and solvents in monitor well installation should be prohibited.

*i. Tracers.* Tracers or dyes should not be used or otherwise introduced into borings, wells, grout, backfill, groundwater, or surface water unless specifically approved in the drilling plan. The drilling plan should describe any approved usage; chemical, radiological, and/or biological composition of the substances; and potential effects upon subsequent chemical, radiological, or biological analyses of the injected media. Discussion should also be provided of the expected, post-injection visual appearance of the media into which the substances are to be introduced. The discussion should also include relevant Federal and state regulations and those agencies' opinions relative to the approved usage.

*j. Lubricants.* If lubrication is needed on the threads or couplings of downhole drilling equipment, only vegetable oil/shortening or PTFE tape should be used. Additives containing lead or copper should not be used. The only lubricant recommended for monitor well joints is PTFE tape. The use and type of lubricants should be included in the drilling plan and boring logs/well construction diagrams.

*k. Hydraulic fluids.* Any hydraulic or other fluids in the drilling rig, pumps, transmissions, or other field equipment/vehicles should NOT contain any polychlorinated biphenyls (PCBs).

*l. Antifreeze.* The use of any antifreeze (either a commercially available automotive variety or a local derivation) to prevent overnight water line freezing should require FA approval. If antifreeze is added to any pump, hose, etc., where contact with drilling fluid is possible,

this antifreeze should be completely purged with approved water prior to the equipment's use in drilling, mud mixing, or any other part of the overall drilling operation. A sample of the clean (approved) water that has been circulated through the equipment after antifreeze removal should be retained for laboratory analysis. Only antifreeze without rust inhibitors and/or sealants should be considered. Antifreeze usage should be noted on the boring log, including the dates, reasons, quantities, composition, and brand names of antifreeze used. Antifreeze usage should be a last resort option. No antifreeze should be used in the drilling operation.

*m. Agents and additives.* The use of any materials or substances other than those recommended herein for drilling, well installation, or development should be prohibited. Included in this suggested prohibition are lead shot, lead wool, burlap, dispersing agents (e.g., phosphates), acids, explosives, disinfectants, organic based drilling additives, metallic based lubricants, chlorinated and petroleum based solvents, adhesives, etc.

*n. Summary.* A materials usage summary should be provided of any drilling/well construction materials which potentially could have a bearing on subsequent interpretation of the analytical results. An example summary is provided at Figure 3-3.

### 3-10. Surface Runoff

Surface runoff, e.g., precipitation, wasted or spilled drilling fluid, and miscellaneous spills and leaks, should not enter any boring or well either during or after construction. To help avoid such entry, the use of starter casing, recirculation tanks, berms around the borehole, surficial bentonite packs, etc., is recommended.

### 3-11. Drilling Through Contaminated Zones

Many borings and wells are drilled in areas that are clean relative to the deeper zones of interest. However, circumstances do arise which require drilling where the overlying soils or shallow aquifer may be contaminated relative to the underlying environment. This situation may be addressed by the placement of, at least, double casing: an outer permanent (or temporary) casing sealed in place and cleared of all previous drill fluids prior to proceeding into the deeper, "cleaner" environment. In this procedure, the outer drill casing is set and sealed within an "impermeable" layer or at a level below which the underlying environment is thought to be "cleaner" than the overlying environment. The drilling fluids used to reach this point

are appropriately discarded, replaced by a new or fresh supply. This system can be repeated, resulting in telescopic drill casing through which the final well casing is placed. These situations should be addressed on a case-by-case basis in the drilling plan.

### 3-12. Soil Sampling

*a. Intact samples.* Unless otherwise specified in the drilling plan, intact soil samples for physical descriptions, retention, and physical analyses should be taken continuously and retained for the first 3 m (10 ft) and every 1.5 m (5 ft) or at each change of material, whichever occurs first, thereafter. These samples should be representative of their host environment and should be obtained with driven- (e.g., split spoon), pushed (e.g., thin wall), or rotary (e.g., Denison) type samplers. Borehole cuttings do not usually provide the desired information and, therefore, are not usually satisfactory. Sampling procedures should be detailed in the drilling plan.

*b. Odors.* At the detection of any anomalous odors (or vapor readings) from the boring or intact samples, drilling should cease for an evaluation of the odors and to determine the crew's safety. After the field safety representative completes this evaluation and implements any appropriate safety precautions, drilling can resume. If the odors or vapor readings are judged by the field personnel to be contaminant-related, intact soil samples should be continuously taken until the odors/readings are within background ranges. These samples should be retained and preserved in appropriate screw-capped sample jars for possible chemical analysis. With the resumption of background readings, routine sampling should resume. Specific procedures should be detailed in the drilling and safety plans.

*c. Volume.* Representative soil samples of sufficient volume for physical testing from each sampled interval should be retained for future reference or appropriate analysis. Upon boring completion, the number of samples retained from that boring may be reduced, retaining at least representative samples of major units, key samples, and those for testing requirements. Minimum information on each sample container should include the project, depth below surface, and boring and sample number. All samples known or suspected to contain contaminants of concern should be so marked on both the sample container and boring log. No geotechnical data should appear on the container that is not specified on the boring log. Containers should be kept from becoming frozen. Soil



MATERIALS SUMMARY

PROJECT: GENERAL AAP

Date: Oct-Nov 1987

<u>Material</u> <u>(Example Entries)</u>	<u>Brand/Description</u> <u>(Example Entries*)</u>	<u>Source/Supplier</u> <u>(Example Entries*)</u>
PVC casing	4.0" ID, Schedule 40, flush threaded; 2" ID, Schedule 40, flush threaded	ABC Mfg; Aville, Minnesota
PVC screen	0.05" slot, 4.0" ID, Schedule 40, flush threaded, 0.02" slot, 2" ID, Schedule 40, flush threaded	ABC Mfg; Aville, Minnesota
Bentonite (drilling fluid and grout)	Tru-gel	A. O. Bentonite; Bville, Wyoming
Granular bentonite (seal)	Gran-Bent	White Mud, Cville, Montana
Bentonite pellets (seal)	(No brand name available)	PELBENT, Dville, Utah
Sand (filter pack)	8-12 silica sand	State Sand, Mville, Colorado; supplier: EFG Co., Eville, Utah
Cement (grout)	Portland Type II	A. Lumber Co., Eville, Utah
Drilling water	St. Peter Sandstone	Production Well #1, Tap at well house
Drilling rod lubricant	Slick Turn	Oil Products Co., Fville, Texas
Air compressor oil	Oil #40	Oil Products Co., Fville, Texas

\*All commercial brands and suppliers named in these examples are fictitious.

Figure 3-3. Example materials summary

samples known or suspected of being contaminated may have to be handled, stored, tested, and/or disposed of as hazardous waste. Storage, packaging, and shipment instructions for soil samples for physical testing should be prescribed in the drilling plan. USEPA has published additional guidance concerning the management of investigation-derived wastes for Superfund projects (USEPA, EPA/540/ G-91/009 and USEPA, OSWER Publication 9345.3-03FS) that should be incorporated into the drilling plan, as appropriate.

*d. Physical testing.* Physical soil testing is a function of the project. The drilling plan should detail specific testing guidance and requirements. Physical soil testing should be conducted on 10 to 20 percent of the soil samples using procedures and equipment described in the current EM 1110-2-1906 (or Annual Book of ASTM Standards: Volume 04.08, D 2487). Downhole geophysical logging may reduce the need for sampling. Tested samples should be representative of the range and frequency of soil types encountered in the project area and should specifically include the screened interval of each completed well. In addition, samples should be obtained from borings that cover the geographic and geologic range within the project area. The FDO should select the particular samples. Tests should include moisture content and those tests necessary to determine the soil classification as described in D 2487. Laboratory and summary sheets should be submitted to the FA after final test completion. The drilling and safety plans should address any contaminant-related safety precautions for the physical analysis of these samples. The FDO is responsible for communicating these concerns to the laboratory performing the soil testing. The testing laboratory is responsible for taking all the necessary health and safety precautions adequate to protect the laboratory personnel. Samples for physical analysis which are known or suspected to be contaminated should be tested only in a soils laboratory equipped and managed to process contaminated samples.

*e. Soil samples for chemical analysis.*

(1) Samples should be extracted from their in situ environment in as near an intact, minimally disturbed condition as technically practical. Once at the surface, the sampler should be opened, sample extracted, peeled, and bottled in as short a time as possible. "Peeling" is a process whereby that portion of the sample which was in direct contact with the sampler, as well as the ends of the sample, are removed and discarded. Samples for volatile analysis should be peeled, bottled, and capped within a

VERY short time (about 15 seconds from the time of opening the sampler). Each soil sample for volatile analysis should have minimal head space for representative analytical results.

(2) All sampling equipment that will contact the sample should be thoroughly decontaminated between samples. This can be accomplished by the use of a hot-water pressure washer or as follows:

(a) Scrub equipment with a low-sudsing, nonphosphate detergent in approved water.

(b) Rinse with approved water.

(c) When sampling for metals, rinse with 0.1 N nitric acid (4.2 ml of concentrated nitric acid added to 1,000 ml of water). (CAUTION: Add acid to water, never add water to concentrated acid.) Continue rinsing the sampling equipment now with distilled or deionized water. If the sampling equipment being used is made of stainless steel, the use of 0.1 N hydrochloric acid (rather than 0.1 N nitric acid) is preferred to avoid oxidation (rusting) of the stainless steel. The 0.1 N hydrochloric acid is prepared by adding 3.1 ml of concentrated hydrochloric acid to 1,000 ml of water. The same CAUTION applies: add the concentrated acid to the water, not the water to the acid.

(d) When sampling for organic volatiles, semivolatiles, or pesticides/PCBs, rinse with pesticide grade isopropanol followed by rinsing with distilled or deionized water.

(3) Additional acquisition, preservation, and handling criteria for the chemical analysis of soils are found in the most recent editions of USEPA SW-846 and ER 1110-1-263.

*f. Liners.* If sample liners are used, the following should apply:

(1) Use clear liners or take extra samples to ensure that the sample is of sufficient quantity and quality for the intended analyses.

(2) Liner seams and ends should be "airtight"; i.e., "moisture impermeable."

(3) Borehole/drilling fluids should not be trapped within the liner.

(4) Liner or sealant interaction with the sample should not alter the sample's chemical composition.

*g. Location.* All soil samples, except those for physical and/or chemical analysis and reference should remain onsite, neatly stored at an FA-designated location. The disposition of these samples should be arranged by the FA. Samples from HTW sites, other than those samples which will be subjected to physical or chemical analyses, may have to be stored, and later disposed of as hazardous waste. Sample retention and disposal should be given detailed attention in the drilling and well installation plan.

### 3-13. Rock Coring

Bedrock should be cored unless the drilling plan specifies otherwise. Coring, using a diamond- or carbide-studded bit, produces a generally intact sample of the bedrock lithology, structure, and physical condition. The use of a gear-bit, tricone, etc., to penetrate bedrock should only be considered for the confirmation of the "top of rock" (where penetration is limited to a few meters (feet)), the enlargement of a previously cored hole, or the drilling of highly fractured intervals.

*a.* The coring of bedrock or any firm stratigraphic unit should be conducted in a manner to obtain maximum intact recovery. The physical character of the bedrock (i.e., fractures, poor cementation, weathering, or solution cavities) may lessen recovery, even with the best of drillers and equipment.

*b.* The minimum core size should be an "N" series, 50-mm (2 plus-in.) diameter. Larger bit (hence, core) diameters may be needed to enhance core recovery.

*c.* While drilling in bedrock, and especially while coring, drilling fluid pressures should be adjusted to minimize drilling fluid losses and hydraulic fracturing. All pumping pressures should be recorded.

*d.* Rock cores should be stored in covered core boxes to preserve their relative position by depth. Intervals of lost core should be noted in the core sequence. Boxes should be marked on the cover (both inside and outside) and on the ends to provide project name, boring number, cored interval, and box number in cases of multiple boxes. Any core box known or suspected to contain contaminated core should be appropriately marked on the log and on the box cover (inside and out), and on both ends. The weight of each fully loaded box should not exceed 34 kg (75 lb). No geotechnical or contaminant

data should appear on or within the box that is not specified on the boring log. As a minimum, the estimated number of boxes required for a given boring should be on hand prior to coring that site.

*e.* The core within each completed box should be photographed after the core surface has been cleaned or peeled, as appropriate, and wetted. Photos should be taken using color film (film speed as appropriate), 35mm camera, 55mm (or normally provided) lens, light meter, with one box per frame. Each photo should be in sharp focus and contain both a legible scale in centimeters (feet and tenths of feet) and an FA-supplied photographic color chart for color comparison. The core should be oriented so that the top of the core is at the top of the photo. Each photo should be annotated on the back with the project name, bore/well designation, box number, cored depths pictured, and date photographed. One set of glossy color prints should be sent to the FA after the last coring. In addition, all negatives should be delivered to the FA after the FA has received the prints. (See ER 1110-1-1803 for additional guidance on core management.)

*f.* All rock core, except that for analysis and reference, should be neatly stored at an FA-designated location. The disposition of these samples should be arranged by the FA. Specific instructions for the storage or required packaging and method of shipment to the laboratory should be provided in the drilling plan.

*g.* Bedrock cores known or suspected of being contaminated may have to be handled, stored, tested, and/or disposed of as hazardous waste. Such a consideration and determination should be made prior to drilling plan approval. This determination may alter drilling methods, coring frequency, data quality, costs, etc. Geophysical downhole logging or borehole camera techniques could be considered as alternatives in some cases. The drilling plan should reflect the final decision and possible alternatives that retain viability.

### 3-14. Abandonment/Decommissioning

Abandonment (also termed decommissioning) is that procedure by which any boring or well is permanently closed. Abandonment/decommissioning procedures should preclude any current or subsequent fluid media from entering or migrating within the subsurface environment along the axis or from the endpoints of any boring or well penetrating that environment.

a. Planned abandonment requirements and procedures should be described in the drilling plan and incorporate USACE guidance and applicable state and/or Federal regulatory abandonment requirements.

b. The closure of any borings or wells not scheduled for abandonment per drilling plan should be approved by the FA prior to any casing removal, sealing, or back-filling. Abandonment requests should be submitted telephonically by the FDO to the FA with the following data, plus recommendation:

- (1) Designation of boring/well in question.
- (2) Current status (depth, contents of hole, stratigraphy, water level, etc.).
- (3) Reason for closure.
- (4) Action taken, to include any replacement boring or well.

c. Each boring or well to be abandoned/decommissioned should be sealed by grouting from the bottom of the boring/well to ground surface. This should be done by placing a tremie pipe to the bottom of the boring/well (i.e., to the maximum depth drilled/bottom of well screen) and pumping grout through this pipe until undiluted grout flows from the boring/well at ground surface. Any open or ungrouted portion of the annular space(s) between the innermost well casing and borehole (to include any casings in between) should be grouted in the same manner.

d. After 24 hours, the FDO should check the abandoned site for grout settlement. That day, any settlement depression should be filled with grout and rechecked 24 hours later. Additional grout should be added using a tremie pipe inserted to the top of the firm grout, unless the depth of the unfilled portion of the hole is less than 4.5 m (15 ft) and this portion is dry. This process should be repeated until firm grout remains at ground surface.

e. An abandoned well may be grouted with the well screen and casing in place. However, local regulations or a lack of data concerning well construction, condition, or other factors may require the removal of the well materials and a partial or total hole redrilling prior to sealing the well site. See ASTM D 5299 in *Annual Book of ASTM Standards*, Volume 04.09, for a discussion of other decommissioning procedures.

f. For each abandoned boring/well, a record should be prepared to include the following as applicable.

- (1) Project and boring/well designation.
- (2) Location with respect to the replacement boring or well (if any); e.g., 6 m (20 ft) north and 6 m (20 ft) west of Well 14.
- (3) Open depth of well/annulus/boring prior to grouting.
- (4) Casing or items left in hole by depth, description, composition, and size.
- (5) Copy of the boring log.
- (6) Copy of construction diagram for abandoned well.
- (7) Reason for abandonment.
- (8) Description and total quantity of grout used initially.
- (9) Description and daily quantities of grout used to compensate for settlement.
- (10) Dates of grouting.
- (11) Disposition of materials removed/displaced from decommissioned boring/well; e.g., objects, soil, and groundwater.
- (12) Water or mud level (specify) prior to grouting and date measured.
- (13) Remaining casing above ground surface: type (well, drill, protective), height above ground, size, and composition of each.
- (14) Report all depths/heights from ground surface.
- (15) The original record should be submitted to the FA.

g. Replacement well/borings (if any) should be offset at least 6 m (20 ft) from any abandoned site in a presumed up- or cross-gradient groundwater direction.

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### **3-15. Work Area Restoration and Disposal of Drilling and Cleaning Residue**

All work areas around the wells and/or borings should be restored to a condition essentially equivalent to that of preinstallation. This includes the disposal of borehole cuttings and rut removal. Borehole cuttings, discarded samples, drilling fluids, equipment cleaning residue, and water removed from a well during installation, development, and aquifer testing should be disposed of in a manner approved by the FA, host installation, and consistent with applicable state and Federal regulations. These

types of materials are considered investigation-derived wastes (IDW). (See USEPA EPA/540/G-91/009 for USEPA guidance on the management of these materials.) Whatever procedures are followed, the leaving of barrels containing drill cuttings, excess samples, and water at various unsecured locations around the site at the completion of well installation is not appropriate. All drums/barrels filled onsite should be labeled (in a water-proof manner) and inventoried as to their contents and source. Restoration and disposal procedures (to include disposal location(s)) should be discussed in the drilling and well installation plan.

## Chapter 4 Borehole Logging

### 4-1. General

Each boring log should fully describe the subsurface environment and the procedures used to gain that description.

### 4-2. Format

All borings should be recorded in the field on Engineer (ENG) Form 1836 and 1836-A, per EM 1110-1-1804 (Figure 4-1) or on ENG Form 5056-R and 5056A-R, developed for HTRW work (see Figure 4-2). This guidance applies to in-house and contracted activities. Suggested data for recording are discussed throughout this manual. Because of the large quantity of information routinely required on logs at HTW sites, a scale of 25 mm (1 in.) on the log equaling 300 mm (1 ft) of boring is usually adequate.

### 4-3. Submittal

Each original boring log should be submitted directly from the field to the FA after each boring is completed. In those cases where a monitor well or other instrument is to be inserted into the boring, both the log for that boring and the installation diagram may be submitted together.

### 4-4. Original Logs and Diagrams

Only the "original" boring log (and diagram) should be submitted from the field to the FA. Carbon, typed, or reproduced copies are not considered "original." The original should be of sufficient legibility and contrast so as to provide comparable quality in reproduction.

### 4-5. Time of Recording

Logs should be recorded directly in the field without transcribing from a field book or other document. This technique lessens the chance for errors of manual copying and allows the completed document to be field-reviewed closer to the time of drilling.

### 4-6. Routine Entries

In addition to the data desired by the FDO and uniquely required by the drilling plan, the following information should be routinely entered on the boring log:

a. Each boring and well (active and abandoned) should be uniquely numbered and located on a sketch map as part of the log.

b. Depths/heights should be recorded in meters (feet) and decimal fractions thereof (millimeters) (tenths of feet). Metric (SI) measurements are acceptable if typically used by the site geologist.

c. Field estimates of soil classifications shall be in accordance with the *Annual Book of ASTM Standards*, Volume 04.08, D 2488, and shall be prepared in the field at the time of sampling by the geologist.

d. Each soil sample taken should be fully described on the log. The descriptions of intact samples should include the parameters shown in Table 4-1.

e. In the field, visual numeric estimates should be made of secondary soil constituents; e.g., "silty sand with 20 percent fines" or "sandy gravel with 40 percent sand." If such terms as "trace," "some," "several," etc., are used, their quantitative meaning should be defined on each log.

f. When used to supplement other sampling techniques, disturbed samples (e.g., wash samples, cuttings, and auger flight samples) should be described in terms of the appropriate soil/rock parameters to the extent practical. "Classification" should be minimally described for these samples, along with a description of drill action and water losses/gains for the corresponding depth. Notations should be made on the log that these descriptions are based on observations of disturbed material rather than intact samples.

g. Rock core should be fully described on the boring log. Typical rock core parameters are shown in Table 4-2.

h. For rock core, a scaled graphic sketch of the core should be provided on or with the log, denoting by depth, the location, orientation, and nature (natural or coring-induced) of all core breaks. Also mark the breaks purposely made to fit the core into the core boxes. If fractures are too numerous to be individually shown, their location may be drawn as a zone and described on the log. Also note, by depth, the intervals of all lost core and hydrologically significant details. This sketch should be prepared at the time of core logging, concurrent with drilling.

(24)  
Fox 2861

DRILLING LOG		DIVISION		INSTALLATION		NO. 87-14	
PROJECT		ABD		EE DISTRICT		SHEET 1 OF 3 SHEETS	
GENERAL AAP				NO. SIZE AND TYPE OF BIT 2" ROCK SAWL & CORE			
SEE SKETCH				11. ELEVATION FOR ELEVATION INDICATOR OF WELL		GROUND SURFACE	
ACME COMPANY				12. ELEVATION AT DEPTH OF WELL		ABC 20	
87-14				13. TOTAL NO. OF CORES (INCLUDES NUMBER SAMPLES TAKEN)		8	
JACK JONES				14. TOTAL NUMBER CORE BOXES		1	
				15. ELEVATION GROUND WATER		7.0' (8 NOV 87)	
				16. DATE BORE		STARTED 7 NOV 87 COMPLETED 8 NOV 87	
10.9'				17. ELEVATION TOP OF SOIL			
19.1'				18. TOTAL CORE DECOMPOSED PER BOXES		BU-6	
30.0'				19. SIGNATURE OF INSPECTOR		D. Smith	
ELEVATION	DEPTH	LOGGING	CLASSIFICATION OF MATERIAL	NO. OF SAMPLES	TYPE OF SAMPLE	REMARKS	REMARKS
0	0	DL	ORE CLAY / SANDY DK RED BRN STR 2H (MUNDW) V. MOIST L. PLAST, ROOT MAT TOPSOIL	501	JAR	3	NOTES
1	1.5	SM	TRANSITIONAL - 8-1.5 SILTY SAND 20% FINES F-M SAND - 60% F 20% M	502	JAR	4	1. ALL SAMPLES DRIVEN BY 140# HAMMER, 30" DROP
2	2.5		MOIST, LOOSE YEL BRN 10YR 8/4 FAINTLY BEDDED FIAT LYMR, Y-BEDS	503	JAR	2	2. DEPTHS + RECOVERY IN FT
3	3.0		5% SILTY CLAY (CL) LAMINAE FLUVIAL	504	JAR	6	NOTE 0'
4	3.5			505	JAR	2	1. DRAW 2X TO 1.5
5	4.0			506	JAR	4	2. DRAW 2X TO 3.5
6	4.6		SHARP 4.6	507	JAR	5	3. DRAW STD TO 5.0
7	5.0	SP	SAND 45% FINES F.C SAND { 60% C 10% M 25% F	508	JAR	10	4. SET HSA W/ PLUG TO 5', PULLED PLUG
8	6.0		V. MOIST - SAT NO APPARENT BEDDING	509	JAR	5	(HSA = 3 1/4" ID) 7" OD
9	6.5		LT BRN 5YR 6/4 FLUVIAL	510	JAR	8	END 7 NOV 87
10	7.5			511	JAR	2X	START 8 NOV
11	8.0			512	JAR	8	NOTE 5'
12	8.5	GP	SANDY GRAVEL 20% F.C SAND 80% F FRAGL LT RED BRN 5YR 6/4 MED DENSE SAT, NO APPARENT BEDDING, FLUVIAL	513	JAR	4	1. HOLE DRY + OPEN TO 5'
13	9.0			514	JAR	2	2. DRAW 2X TO 6.5
14	9.5			515	JAR	4	3. DRAW 2X TO 8.5
15	9.8			516	JAR	8	4. FREE WATER ON SAMPLER 1 IN SAMPLE
16	10.0			517	JAR	2	5. MEAS. H <sub>2</sub> O AT 7.0' W/ BLC. TAP.
17	10.5			518	JAR	4	6. AFTER 5 MIN, STILL AT 7.0'
18	11.0			519	JAR	2	7. DRAW STD TO 10'
19	11.5			520	JAR	4	8. SET HSA W/ PLUG TO 10', PULLED PLUG

Texture  
Mineralogy  
Moisture  
Hardness

- Recovery -  
Labeling  
contacts -  
Depth for  
each contact -

Proceduralizing -  
Don't like  
uniform soil  
classification  
in field -  
classification  
symbol -  
Field Determination

Figure 4-1. Boring log format

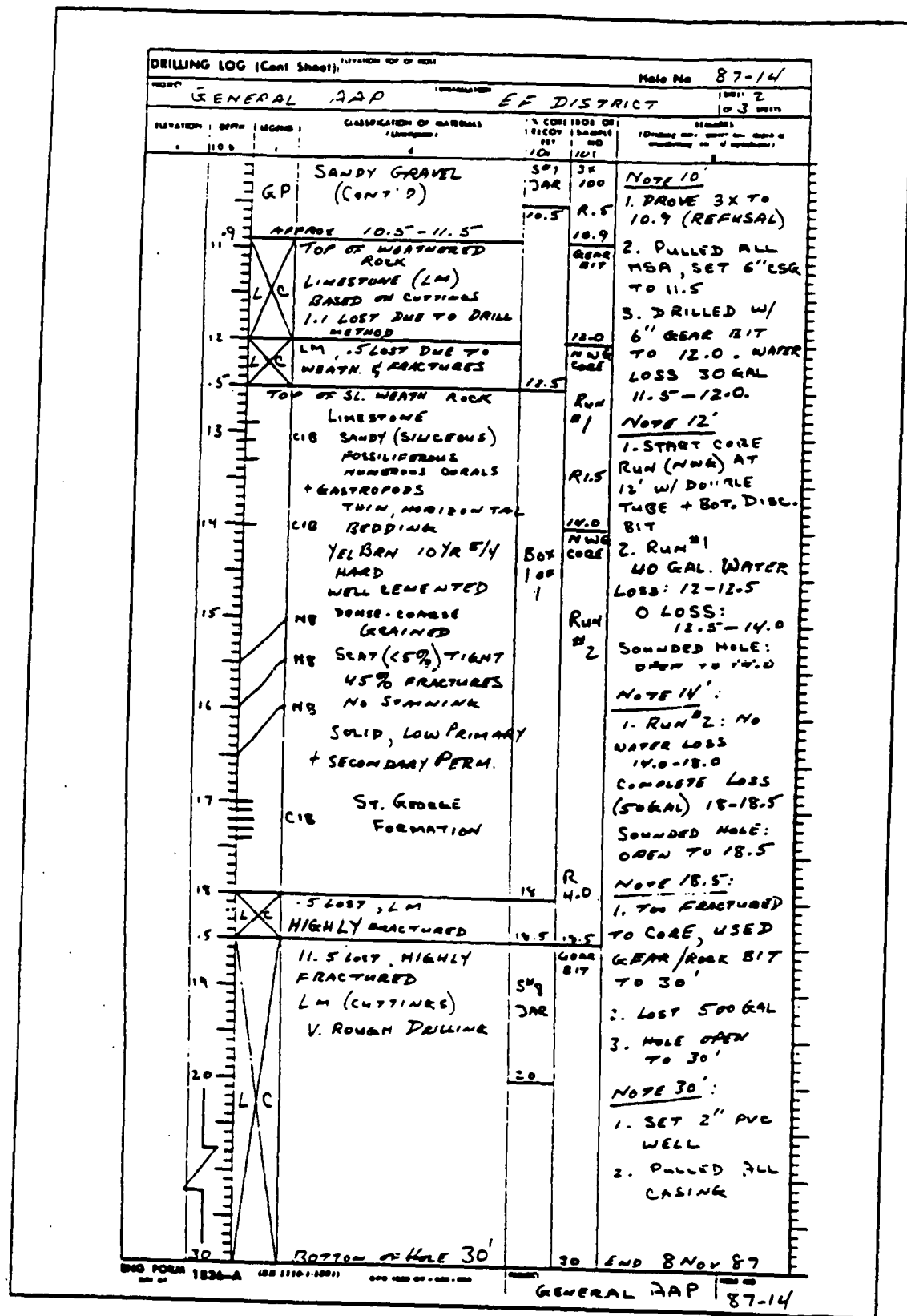


Figure 4-1. (Continued)



DRILLING LOG (Cont Sheet)			Mole No. 87-14		
GENERAL AAP			EF DISTRICT		
DATE	DEPTH	LOG	CLASSIFICATION OF MATERIALS	NO. OF SAMPLES	REMARKS
<p><u>ABBREVIATION</u></p> <p>3x3/2 or 3x 2x2 1/2 or 2x STD (-1 3/8 x 2)</p> <p>R - RECOVERY</p> <p>CIB - CORING INDUCED BREAK</p> <p>NB - NATURAL BREAK</p> <p>LC - LOST CORE</p> <p>AAP - ARMY AMMUNITION PLANT</p> <p>S# - SAMPLE NUMBER</p> <p>HSA - HOLLOW STEM AUGER</p> <p>F, M, C - FINE, MEDIUM, COARSE</p> <p><u>NOTE</u>: COMPONENT PERCENTAGES ARE ONLY APPROXIMATIONS (FIELD VISUALS)</p>			<p><u>MEANING</u></p> <p>ID + OD OF SPLIT BARREL SAMPLER</p>		
<p><u>LOCATION</u></p>					
1836-A			GENERAL AAP 87-14		

Figure 4-1. (Concluded)

<b>HTRW DRILLING LOG</b>		DISTRICT			HOLE NUMBER	
1 COMPANY NAME		2 DRILL SUBCONTRACTOR			SHEET    SHEETS OF	
3 PROJECT			4 LOCATION			
5 NAME OF DRILLER			6 MANUFACTURER'S DESIGNATION OF DRILL			
7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT				8 HOLE LOCATION		
				9 SURFACE ELEVATION		
				10 DATE STARTED		11 DATE COMPLETED
12 OVERBURDEN THICKNESS			13 DEPTH GROUNDWATER ENCOUNTERED			
13 DEPTH DRILLED INTO ROCK			16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED			
14 TOTAL DEPTH OF HOLE			17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)			
18 GEOTECHNICAL SAMPLES		DISTURBED	UNDISTURBED		19 TOTAL NUMBER OF CORE BOXES	
20 SAMPLES FOR CHEMICAL ANALYSIS		VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)
						21 TOTAL CORE RECOVERY %
22 DISPOSITION OF HOLE		BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR	
LOCATION SKETCH/COMMENTS				SCALE		
PROJECT					HOLE NO	

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

Figure 4-2. HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)							HOLE NUMBER
PROJECT				INSPECTOR		SHEET OF SHEETS	
ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

Figure 4-2. (Concluded)

**Table 4-1  
SOIL PARAMETERS FOR LOGGING**

PARAMETER	EXAMPLE
Classification	Sandy clay
Depositional environment and formation, if known	Glacial till, Twin Cities Formation
ASTM D 2488 Group Symbol	CL (field estimate)
Secondary components and estimated percentages	Sand: 25 percent Fine sand 5 percent Coarse sand 20 percent
Color (using Munsell Soil or Geological Society of America (GSA) Rock Color Chart). Each chart can be used for both soil and rock. Give both narrative and numerical description and note which chart was used.	Gray: 7.5 YR 5.0 (Munsell)
Plasticity	Low plasticity
Consistency (cohesive soil)	Very soft, soft, medium stiff, very stiff, hard
Density (noncohesive soil)	Loose, medium loose, dense, very dense
Moisture content Use a relative term. Avoid a percentage unless a value has been measured.	Dry, moist, wet, saturated
Structure and orientation	No apparent bedding: numerous vertical, iron-stained, tight fractures
Grain angularity	Rounded

i. A record of the brand name and amount of any bentonite used for each boring should be made on the log, along with the reason for and start (by depth) of this use. If measured, record mud viscosities and weight.

j. The drilling equipment used should be generally described on each log. Include such information as rod size, bit type, pump type, rig manufacturer, and model.

k. Each log should record the drilling sequence; e.g.

(1) Opened hole with 8-in. auger to 9 ft.

(2) Set 8-in. casing to 10 ft.

(3) Cleaned out and advanced hole with 8-in. roller bit to 15 ft (clean water, no water loss).

(4) Drove 1-3/8-in. ID X 2-in. outside diameter (OD) sampler to 16.5 ft.

(5) Advanced with 8-in. roller bit to 30 ft, 15-gal water loss.

(6) Drove 1-3/8-in. ID X 2-in. OD sampler to 31.5 ft.

(7) Hole heaved to 20 ft.

(8) Mixed 25 lb of ABC bentonite in 100 gal of water for hole stabilization and advanced with 8-in. roller bit to 45 ft. etc.

l. All special problems and their resolution should be recorded on the log; e.g., hole squeezing, recurring problems at a particular depth, sudden tool drops, excessive grout takes, drilling fluid losses, unrecovered tools in hole, lost casings, etc.

m. The dates and times for the start and completion of borings should be recorded on the log along with notation by depth for drill crew shifts and individual days.

n. Each sequential boundary between the various soils and individual lithologies should be noted on the log by depth. When depths are estimated, the estimated range should be noted along the boundary.

**Table 4-2  
ROCK CORE PARAMETERS FOR LOGGING**

PARAMETER	EXAMPLE
Rock type	Limestone, sandstone, granite
Formation	Anytown Formation
Modifier denoting variety	Shaly, calcareous, siliceous, micaceous
Bedding/banding characteristics	Laminated, thin bedded, massive, cross bedded, foliated
Color (using Munsell Soil or GSA Rock Color Chart). Each chart can be used for both soil and rock. Give both narrative and numerical description and note which chart was used.	Moderate brown: 5 YR 3/4 (GSA)
Hardness	Soft, very hard
Degree of cementation	Poorly cemented, well cemented
Texture	Dense, fine-, medium-, coarse-grained, glassy, porphyritic, crystalline
Structure and orientation	Horizontal bedding, dipping beds at 30 degrees, highly fractured, open vertical joints, healed fractures, slickensides at 45 degrees, fissile
Degree of weathering	Unweathered, slightly weathered, highly weathered
Solution or void conditions	Solid, cavernous, vuggy with partial infilling by clay
Primary and secondary permeability, include estimates and rationale	Low primary; well cemented High secondary: several open joints
Lost core interval and reason for loss	50-51 ft, noncemented sandstone likely

*o.* The depth of first encountered free water should be indicated along with the method of determination; e.g., "37.6 ft from direct measurement after drilling to 40.0 ft"; or "40.1 ft from direct measurement in 60-ft hole when boring left overnight, hole dry at end of previous shift"; or "25.0 ft based on saturated soil sample while sampling 24-26 ft." Before proceeding, the first encountered water should be allowed to partially stabilize (5 to 10 minutes) and recorded along with the time between measurements. Any other distinct water level(s) found below the first should also be described.

*p.* The interval by depth for each sample taken, classified, and/or retained should be noted on the log. Record the length of sampled interval, length of sample recovery, and the sampler type and size (diameter and length).

*q.* A record of the blow counts, hammer type and weight, and length of hammer fall for driven samplers

should be made. For thin wall samplers, indicate whether the sampler was pushed or driven and the pressure/blow count per drive. Blow counts should be recorded in half-foot increments when standard penetration samplers (1-3/8 in. ID X 2 in. OD) are used. For penetration less than a half foot, annotate the count with the distance over which the count was taken. Blow counts, in addition to their engineering significance, may be useful for stratigraphic correlation. (See Hsai-Wong Fang (1991) for interpretation of blow counts when 75-mm (3-in.) samplers are used).

*r.* When drilling fluid is used, a quantitative record should be maintained of fluid losses and/or gains and the interval over which they occur. Adjustment should be made for fluid losses due to spillage and intentional wasting (e.g., recirculation tank cleaning) to more closely estimate the amount of fluid lost to the subsurface environment.

s. Record the drilling fluid pressures typically used during all drilling operations (aqueous and pneumatic) and the driller's comments on drillability, drill speed, down pressure, rotation speed, etc.

t. Note the total depth of drilling and sampling on the log.

u. Record significant color changes in the drilling fluid return, even when intact soil samples or rock core are being obtained. Include the color change (from and to), depth at which change occurred, and a lithologic description of the cuttings before and after the change.

v. Soil gas readings, if taken, should be recorded on the log. Each notation should include interval sampled and reading. A general note on the log should indicate meter manufacturer, model, serial number, and calibration material. If several meters are used, key the individual readings to the specific meter.

w. Special abbreviations used on a log and/or well diagram should be defined in the log/diagram where used.

## Chapter 5 Monitor Well Installation

### 5-1. General

A "monitor well" is a device principally designed and constructed for the acquisition of groundwater samples that are representative of the chemical quality of the aquifer adjacent to the screened interval, unbiased by the well materials and installation process, and which, if so designed, provides access to measure the potentiometric surface for that screened interval. The "screened interval" consists of that portion of the device which is directly open (i.e., horizontally adjacent) to the host aquifer by way of openings in the well casing (hereafter called the "screen") AND indirectly open (i.e., vertically adjacent) to the aquifer by way of the filter pack (or other permeable material) extending below and/or above the screen. While the maximum length of the screened interval is fixed for a given well (by the length of the filter pack), the effective or functional length may vary with water table fluctuations or sampling techniques.

### 5-2. Well Clusters

Each monitor well is a mechanism through which to obtain a representative sample of groundwater and, if so designed, to measure the potentiometric surface in that well. To help ensure this representation in the case of well clusters, each well of a cluster should be installed in a separate boring. Multiple well placements in a single boring are too difficult for effective execution and evaluation to warrant single hole usage.

### 5-3. Well Screen Usage

Each well, overburden or bedrock, should have a screen, as per Figure 5-1, 5-2, or 5-3 (or of a technically equivalent construction). The extra effort for screen installation in bedrock wells can be more than offset by the assurance of an unobstructed opening to the required depth during repeated usage. Well integrity and consistent access to the original sampled interval during prolonged monitoring is thereby maintained.

### 5-4. Beginning Well Installation

a. The installation of each monitor well should begin within 12 hours of boring completion for holes uncased or partially cased with temporary drill casing. Installation

should begin within 48 hours in holes fully cased with temporary drill casing. Once installation has begun, no breaks in the installation process should be made until the well has been grouted and drill casing removed. Anticipated exceptions should be requested in writing by the FDO to the FA prior to drilling. Data to include in this request are:

- (1) Well(s) in question.
- (2) Circumstances.
- (3) Recommendation and alternatives.

b. In cases of unscheduled delay such as personal injury, equipment breakdowns, or sudden inclement weather or scheduled delays such as borehole geophysics, no advance approval of delayed well installation should be needed. In those cases, resume installation as soon as practical. However, partially completed borings should be properly secured during periods of drilling inactivity to preclude the entry of foreign materials or unauthorized personnel to the boring. In cases where a partially cased hole into bedrock is to be partially developed prior to well insertion, the well installation should begin within 12 hours after this initial development.

c. Temporary casing and hollow stem augers may be withdrawn from the boring prior to well installation if the potential for cross-contamination is not likely and if the borehole walls will not slough during the time required for well installation. This procedure is usually successful in firm clays and in bedrock that is not intensely fractured or highly weathered.

d. If the borehole will not remain stable long enough to complete placement of all necessary well materials in their proper position, it may be necessary to install some or all of the well materials prior to removal of the casing or hollow stem augers. In this situation, the hollow stem augers or casing should have an inside diameter sufficient to allow the installation of the prescribed diameter screen and casing plus annular space for a pipe through which to place the filter pack and grout.

e. Any materials, especially soils, blocking the bottom of the drill casing or hollow stem auger should be dislodged and removed from the casing prior to well insertion. This action both reduces the potential for cross-contamination and makes well installation easier.

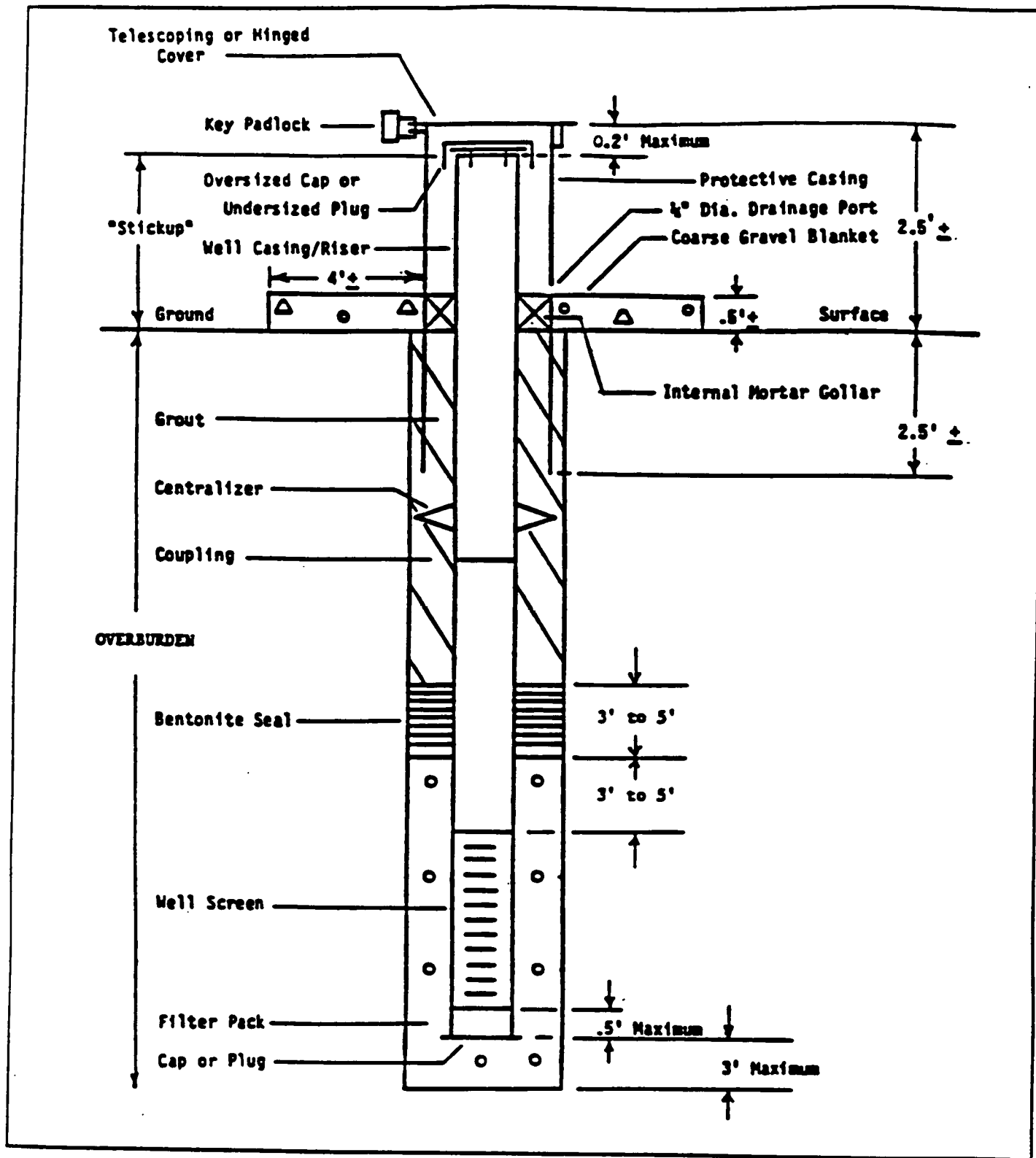


Figure 5-1. Schematic construction of overburden well



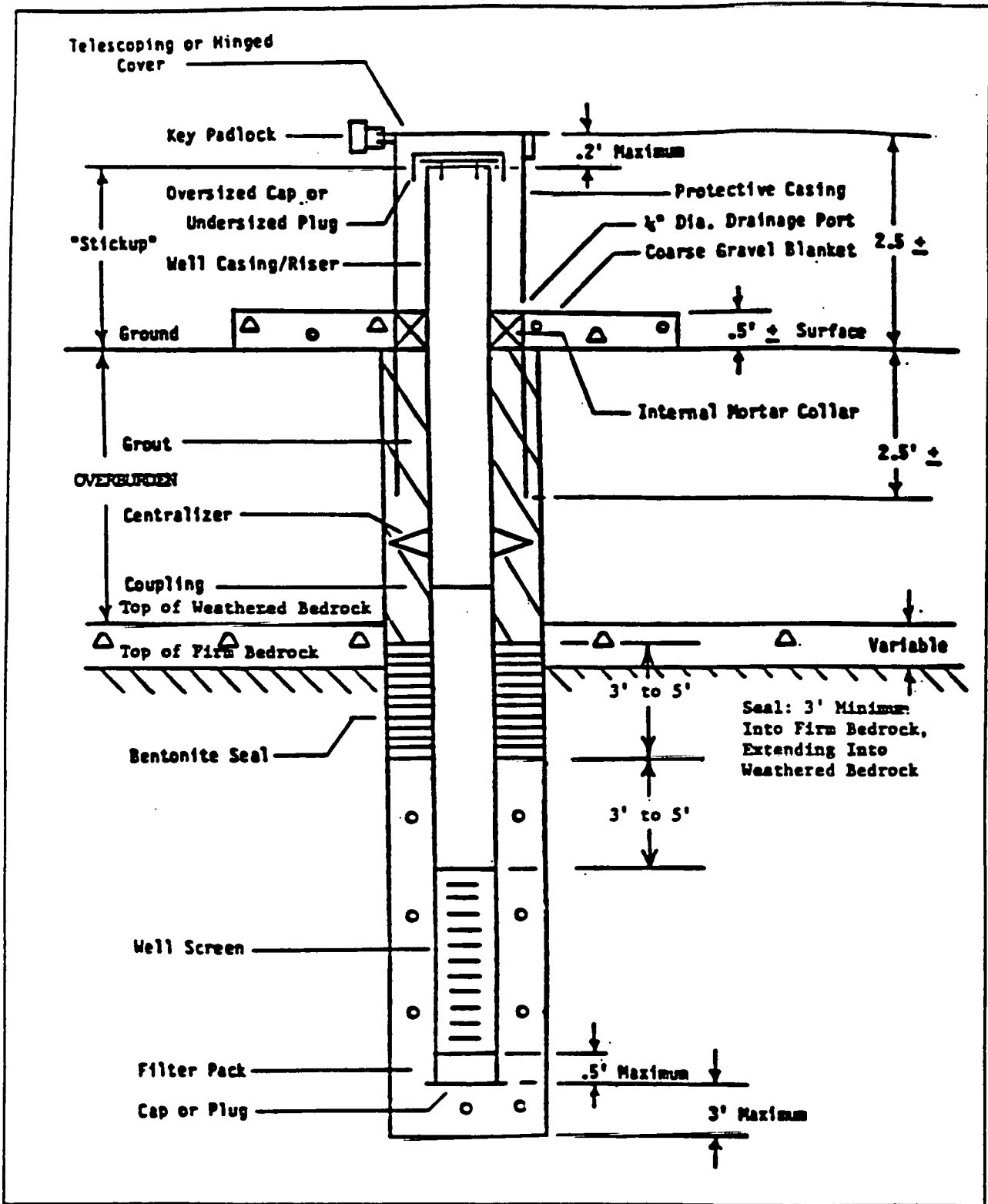


Figure 5-2. Schematic construction of bedrock well

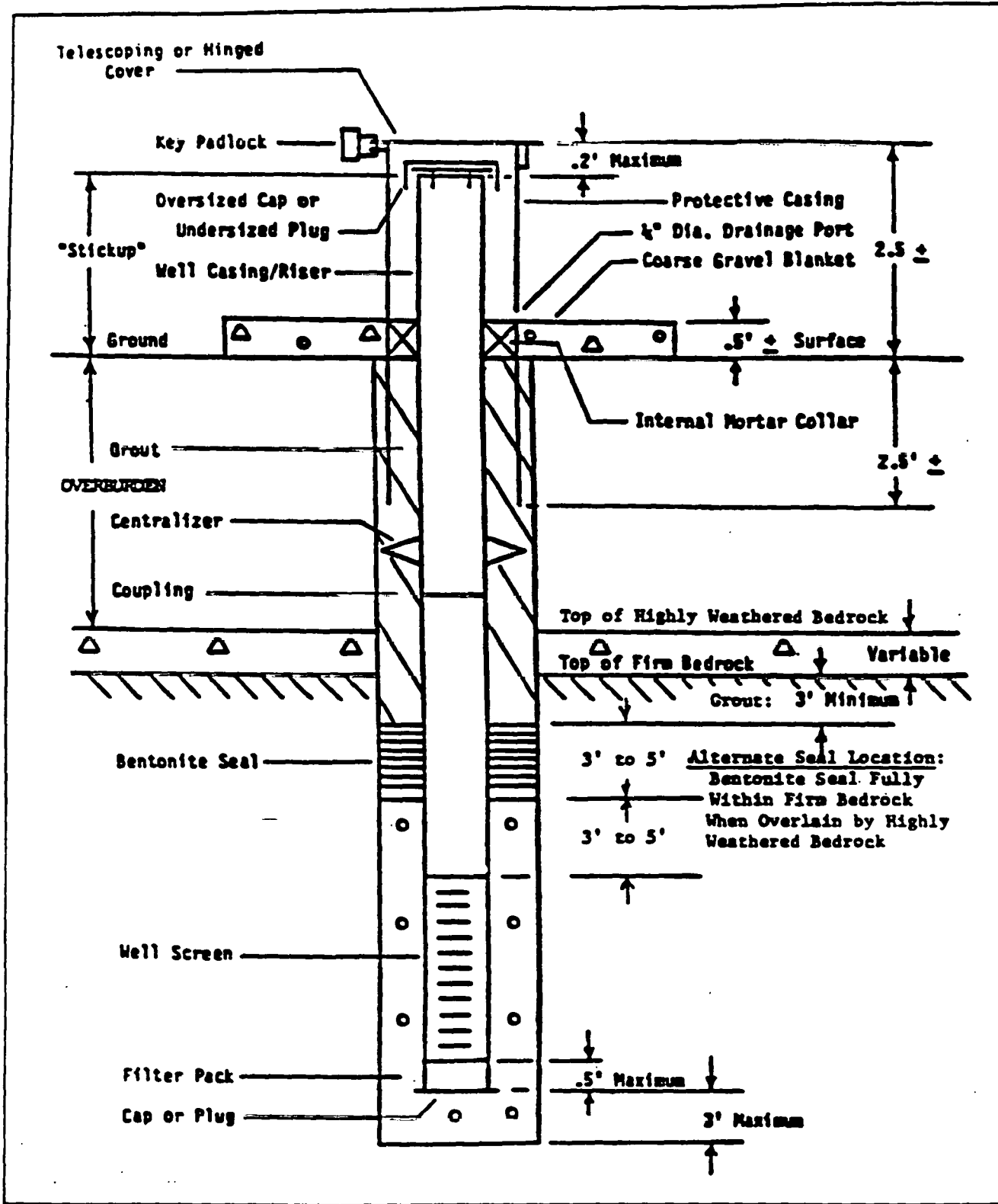


Figure 5-3. Schematic construction of bedrock well, alternate seal location

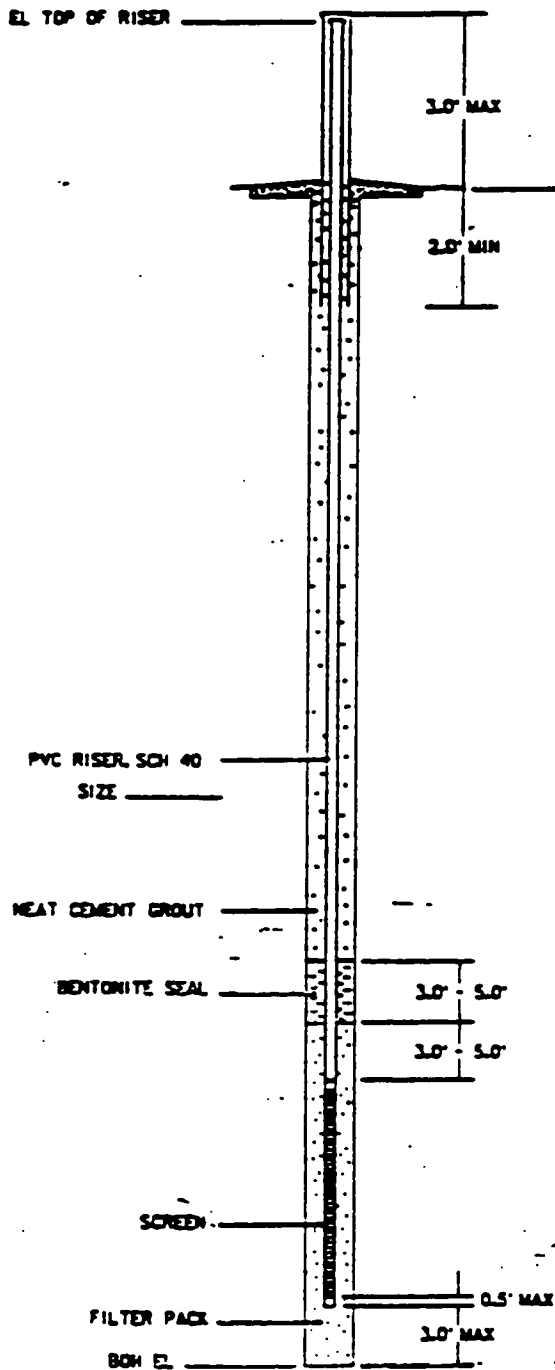
*State*

# MONITORING WELL INSTALLATION DIAGRAM

PROJECT \_\_\_\_\_

WELL No. \_\_\_\_\_

LOCATION \_\_\_\_\_



**NOTE:**  
INSTALLATION SHOWN WITHOUT  
STEEL PROTECTIVE POSTS

- TOP OF PROTECTIVE PIPE ELEVATION \_\_\_\_\_
- TOP OF RISER ELEVATION \_\_\_\_\_
- TOP OF GROUND ELEVATION \_\_\_\_\_
- TOP OF ROCK ELEVATION \_\_\_\_\_
- BOTTOM OF HOLE ELEVATION \_\_\_\_\_
- SCREEN TYPE & SIZE \_\_\_\_\_
- TOP OF BENTONITE SEAL ELEVATION \_\_\_\_\_
- TOP OF GRANULAR FILL ELEVATION \_\_\_\_\_
- TOP OF SCREEN SLOT ELEVATION \_\_\_\_\_
- BOTTOM OF SCREEN SLOT ELEVATION \_\_\_\_\_
- HOLE DIAMETER \_\_\_\_\_
- WATER LEVEL BEFORE INSTALLATION \_\_\_\_\_
- WATER LEVEL AFTER INSTALLATION \_\_\_\_\_
- DATE INSTALLED \_\_\_\_\_
- GEOLOGIST \_\_\_\_\_
- DRILLER \_\_\_\_\_
- REMARKS \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

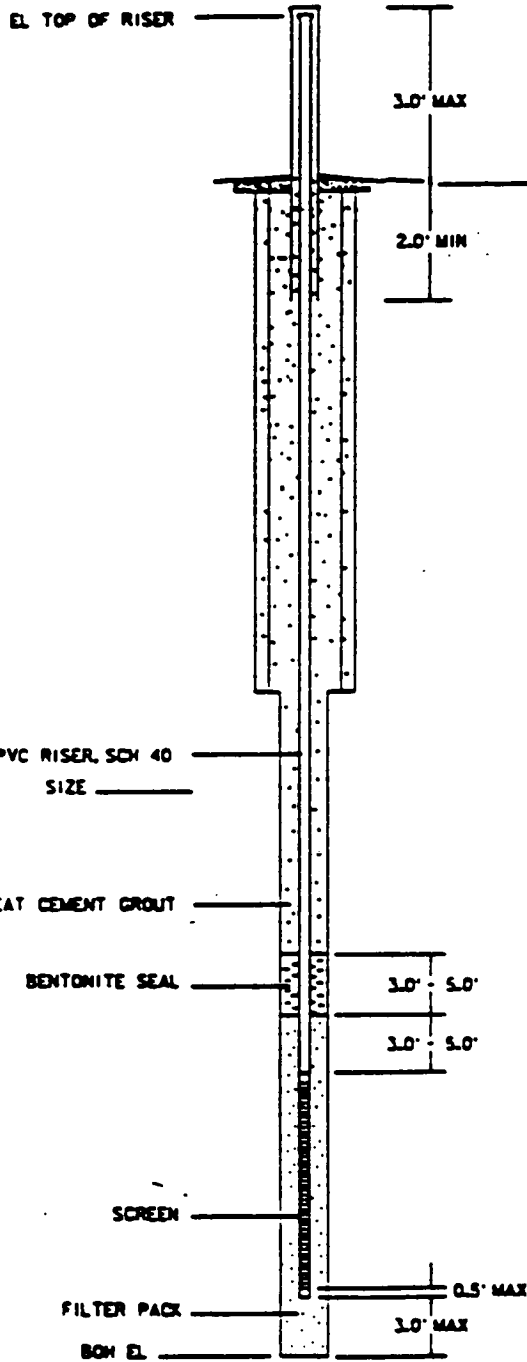
\_\_\_\_\_

# MONITORING WELL INSTALLATION DIAGRAM LOWER GROUNDWATER ZONE INSTALLATION

PROJECT \_\_\_\_\_

WELL NO. \_\_\_\_\_

LOCATION \_\_\_\_\_



**NOTE:**  
INSTALLATION SHOWN WITHOUT  
STEEL PROTECTIVE POSTS

- TOP OF PROTECTIVE PIPE ELEVATION \_\_\_\_\_
- TOP OF RISER ELEVATION \_\_\_\_\_
- TOP OF GROUND ELEVATION \_\_\_\_\_
- TOP OF ROCK ELEVATION \_\_\_\_\_
- BOTTOM OF HOLE ELEVATION \_\_\_\_\_
- SCREEN TYPE & SIZE \_\_\_\_\_
- TOP OF BENTONITE SEAL ELEVATION \_\_\_\_\_
- TOP OF GRANULAR FILL ELEVATION \_\_\_\_\_
- TOP OF SCREEN SLOT ELEVATION \_\_\_\_\_
- BOTTOM OF SCREEN SLOT ELEVATION \_\_\_\_\_
- HOLE DIAMETER \_\_\_\_\_
- WATER LEVEL BEFORE INSTALLATION \_\_\_\_\_
- WATER LEVEL AFTER INSTALLATION \_\_\_\_\_
- DATE INSTALLED \_\_\_\_\_
- GEOLOGIST \_\_\_\_\_
- DRILLER \_\_\_\_\_
- REMARKS \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

f. Once begun, well installation should not be interrupted due to the end of the driller's work shift, darkness, weekend, or holiday.

g. The FDO should ensure that all materials and equipment for drilling and installing a given well are available and onsite prior to drilling that well. The FDO should have all equipment and materials onsite prior to drilling and installing any well if the total well drilling and installation effort is scheduled to take 14 days or less. For longer schedules, the FDO should ensure that the above-mentioned materials needed for at least 14 days of operation are onsite prior to well drilling. The balance of materials should be in transit prior to well drilling. Any site-specific factors that preclude the availability of needed secure storage areas should be identified and resolved in the drilling plan.

#### 5-5. Screens, Casings, and Fittings

a. All well screens and well casings should be free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.) and washed with approved water prior to use. Pre-washing may not be necessary if the materials have been packaged by the manufacturer and have their packaging intact up to the time of installation. Pipe nomenclature stamped or stenciled directly on the well screen and/or blank casing within and below the bentonite seal should be removed by means of SANDING, unless removable in approved water. Solvents, except approved water, should NOT be used for removal of marking. Washed screens and casings should be stored in plastic sheeting until immediately prior to insertion into the borehole.

b. Bottoms of well screens should be placed no more than 0.9 m (3 ft) above the bottom of the drilled borehole. If significant overdrilling is required (as for determining stratigraphy), a pilot boring should be used. The intent here is to narrow the interval of aquifer being sampled, limit the potential for stagnant or no-flow areas near the screen, and preclude unwanted backfill materials (e.g., grout or bentonite) from entering or passing through the interval to be screened and sampled.

c. All screen bottoms should be securely fitted with a threaded cap or plug of the same composition as the screen. This cap/plug should be within 150 mm (0.5 ft) of the open portion of the screen. No solvents or glues should be permitted for attachment.

d. Silt or sediment traps (also called cellars, tail pipes, or sumps) should NOT be used. A silt trap is a

blank length of casing attached to and below the screen. Trap usage fosters a stagnant, turbid environment which could influence analytical results for trace concentrations.

e. The top of each well should be level such that the difference in elevation between the highest and lowest points on the top of the well casing or riser should be less than or equal to 6 mm (0.02 ft).

f. The borehole should be of sufficient diameter to permit at least 50 mm (2 in.) of annular space between the borehole wall and all sides of the well (centered riser and screen). When telescoping casings (one casing within another), the full 50-mm (2-in.) annulus may not be practical or functional. In this case, a lesser spacing may be acceptable, depending on site specifics.

g. Well screen lengths may be a function of hydrostratigraphy, temporal considerations, environmental setting, analytes of concern, and/or regulatory mandate. Screen lengths should be specified in the drilling plan.

h. The actual inside diameter of a nominally sized well is a function of screen construction and the wall thickness/schedule of both the screen and casing. In the case of continuously wound screens, their interior supporting rods may reduce the full inside diameter. This consideration is critical when planning the sizes for pumps, bailers, surge devices, etc.

i. When physical or biological screen clogging is anticipated, the larger open-area per unit length of continuously wound screens has an advantage over the slotted variety.

#### 5-6. Granular Filter Pack

a. The use of a tremie pipe for filter pack placement is recommended, especially when the boring contains drilling fluid or mud. A record should be maintained of the amount of water used to place the filter pack. This usage should be added to the volume of water to be removed during well development.

b. The filter pack should extend from the bottom of the boring to 0.9 to 1.5 m (3 to 5 ft) above the top of the screen unless otherwise specified in the drilling plan. This extra filter allows for settlement (from infiltration and compaction) of the filter pack during development and repeated sampling events. The additional filter helps to maintain a separation between the bentonite seal and well screen.

c. The final depth to the top of the granular filter should be directly measured (by tape or rod) and recorded. Final depths should not be estimated, for example, as based on volumetric measurements of placed filter.

## 5-7. Bentonite Seals

a. Bentonite seals (especially those set in water) should be composed of commercially available pellets. Pellet seals should be 0.9 to 1.5 m (3 to 5 ft) thick as measured immediately after placement, without allowance for swelling. Granular bentonite may be an alternate if the seal is set in a dry condition. Tremie pipes are not recommended.

b. Slurry seals should be used only as a last resort, as when the seal location is too far below water to allow for pellet or containerized-bentonite placement or within a narrow well-borehole annulus. Typically, the specific gravity of cement grout placed atop the slurry seal will be greater than that of the slurry. Therefore, the intent to use a slurry seal should be detailed in the drilling plan, and details should include a discussion of how the grout will be precluded from migrating through the slurry. Slurry seals should have a thick, batter-like (high viscosity) consistency with a placement thickness of 0.9 to 1.5 m (3 to 5 ft).

c. In wells designed to monitor firm bedrock, the bottom of the bentonite seal should be located at least 0.9 m (3 ft) below the top of firm bedrock, as determined by drilling. "Firm bedrock" refers to that portion of solid or relatively solid, moderately to unweathered bedrock where the frequency of loose and fractured rock is markedly less than in the overlying, highly weathered bedrock. Figures 5-2 and 5-3 denote possible seal locations. Special designs will be needed to monitor fractured bedrock.

d. The final depth to the top of the bentonite seal should be directly measured (by tape or rod) and recorded. Final depths should not be estimated, as, for example, based on volumetric measurements of placed bentonite.

e. Numerous opinions have been expressed regarding bentonite hydration time, bentonite placement procedures under water versus in a dry condition, and the potential installation delays and other consequences caused by these factors. Until these issues are more thoroughly understood, the use of a 0.9-m (3-ft) minimum bentonite pellet seal is considered an adequate barrier to protect the screen

and filter pack from downhole grout migration. If the bentonite seal is located above any borehole fluid levels, a 0.3- or 0.6-m (1- or 2-ft) layer of fine to medium sand placed atop the bentonite seal may enhance barrier resistance to downward grout migration. Therefore, any time delay in well installation to allow for bentonite hydration, in a wet or dry hole, is not necessary.

## 5-8. Grouting

All prescribed portions of grout material should be combined in an aboveground rigid container and mechanically (not manually) blended to produce a thick, lump-free mixture throughout the mixing vessel. The mixed grout should be placed around the monitor well as follows:

a. The grout should be placed from within a rigid grout pipe located just over the top of the seal.

b. Prior to exposing any portion of the borehole above the seal by removal of any drill casing (to include hollow-stem augers), the annulus between the drill casing and well casing should be filled with sufficient grout to allow for planned drill casing removal. The grout should not penetrate the well screen or granular filter pack. Disturbance of the bentonite seal should be minimal.

(1) If all drill casing is to be removed in one operation, the grout should be pumped through the grout pipe until undiluted grout flows from the annulus at ground surface, forming a continuous grout column from the seal to ground surface. The drill casing should then be removed, making certain that borehole exposure to the atmosphere is minimal. During the removal of hollow stem augers, the grout pipe may have to be periodically reinserted for additional grouting to compensate for the larger annular space created by the augers' helical coil.

(2) If drill casing is to be incrementally removed with intermittent grout addition, the grout should be pumped through the grout pipe until the grout reaches a level which will permit at least 3 m (10 ft) of grout to remain in the well/drill casing annulus AFTER removing the selected length of drill casing. Using this method, at least 6 m (20 ft) of grout should be within the drill casing before removing 3 m (10 ft) of driven casing or considerably more than 6 m (20 ft) of grout for the removal of 3 m (10 ft) of hollow stem auger. With this method, the grout pipe needs only to be reinserted to the base of the casing yet to be removed before repeating the grout insertion process.

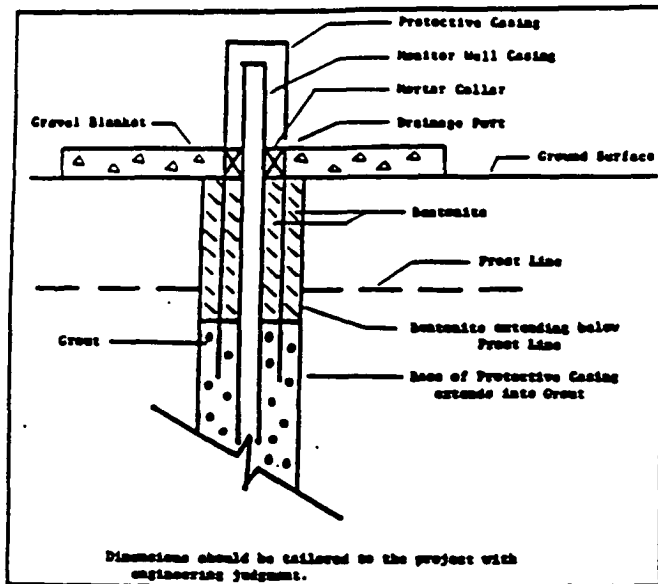


Figure 5-6. Well design parameters to minimize frost heave

### 5-10. Shallow Wells

Shallow (less than 4.5 m (15 ft)) well construction may be more problematical than deep. Sufficient depth may not be available to utilize the full lengths of typical well components when the aquifer to be monitored is near the surface. The FA should tailor design criteria to the actual environment and project objectives for appropriate shallow well construction.

### 5-11. Drilling Fluid Removal

When a borehole, made with or without the use of drilling fluid, contains an excessively thick, particulate-laden fluid which would preclude or hinder the specified well installation, the borehole fluid should be removed or displaced with approved water. This removal is intended to remove or dilute the thick fluid and thus facilitate the proper placement of casing, screen, granular filter, and seal. Fluid losses in this operation should be recorded on the well diagram or boring log and later on the well development record. Any fluid removal prior to well placement should be contingent upon the driller's and the geologist's evaluation of hole stability, i.e., long enough for the desired well and seal placement.

### 5-12. Drilling Fluid Losses in Bedrock

If large drilling fluid losses occur in bedrock and if the hole is cased to bedrock, the FDO may remove at least

five times this volumetric loss prior to well insertion. The intent here is to allow the placement of a larger pump in the borehole than otherwise possible in the well casing, thereby reducing subsequent development time and removing the lost water closer to the time of loss. Development of the completed well could then be reduced by a volume equal to that which was removed through the above procedure.

### 5-13. Well Construction Diagrams

a. Each installed well should be depicted in a well diagram. This diagram should be attached to the original bore log for that installation and graphically denote, by depth from ground surface:

- (1) The bottom of the boring (that part of the boring most deeply penetrated by drilling and/or sampling) and boring diameter(s).
- (2) Screen location.
- (3) Joint locations.
- (4) Granular filter pack.
- (5) Seal.
- (6) Grout.
- (7) Cave-in.
- (8) Centralizers.
- (9) Height of riser (stickup) without cap/plug above ground surface.
- (10) Protective casing detail.
  - (a) Height of protective casing, without cap/cover, above ground surface.
  - (b) Base of protective casing below ground surface.
  - (c) Drainage port location and size.
  - (d) Internal mortar collar location.
  - (e) Gravel pad height and extent.
  - (f) Protective post configuration.

(11) Water level 24 hours after completion with date and time of measurement.

*b.* Describe on the diagram:

(1) The actual quantity and composition of the grout, bentonite seals, and granular filter pack used for each well.

(2) The screen slot size in millimeters (inches), slot configuration, total open area per meter (foot) of screen, outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer.

(3) The material between the bottom of the boring and the bottom of the screen.

(4) The outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer of the well casing.

(5) The joint design and composition.

(6) Centralizer design and composition.

(7) Depth and description of any permanent pump or sampling device. For pumps, include the voltage, phase requirements, and electrical plug configuration.

(8) Protective casing composition and nominal inside diameter.

(9) Special problems and their resolutions: e.g., grout in wells, lost casing and/or screens, bridging, casing repairs or adjustments, etc.

(10) Dates and times for the start and completion of well installation.

*c.* Each diagram should be attached to the original boring log and submitted from the field to the FA.

*d.* Only the original well diagram and boring log should be submitted to the FA. Carbon, typed, or reproduced copies should be retained by the FDO. A legible copy of the well diagram may be used as a base for the supplemental protection diagram.

*e.* Special abbreviations used on the well completion diagram should be defined on the diagram.



c. If the ungrouted portion of the hole is less than 4.5 m (15 ft) deep and without fluids after casing removal, the ungrouted portion may be filled by pouring grout from the surface without a pipe.

d. If drill casing (to include hollow-stem auger) was not used, grouting should proceed to surface in one, continuous operation.

e. Once begun, the grouting process should be continuous until all the drill casing has been removed and all annular spaces are grouted to the ground surface.

f. Protective casing should be installed on the same day as grouting is begun.

g. After 24 hours, the FDO should check the site for grout settlement and that day add more grout to fill any depression. Repeat this process until firm grout remains at ground surface. Incremental quantities of grout added in this manner should be recorded on the well completion diagram to be submitted to the FA.

h. For grout placement in a dry and open hole less than 4.5 m (15 ft) deep, the grout may be manually mixed and poured in from the surface as long as seal integrity is maintained.

i. No grout should be placed or allowed to migrate below the well screen.

## 5-9. Well Protection

a. Protective casing should be installed around each monitor well the same day as initial grout placement around that well. Any annulus formed between the outside of the protective casing and borehole or between the monitor well and protective casing should be filled to ground surface with grout as part of the overall grouting procedure. Specific details of well protection should be approved by the FA. These details and specific elements to be included in the well construction diagrams should be described in the drilling and well installation plan.

b. All protective casing should be steam or hot-water-pressure cleaned prior to placement; free of extraneous openings; and devoid of any asphaltic, bituminous, encrusting, and/or coating materials (except the black paint or primer applied by the manufacturer).

c. Recommended minimum elements of protection design include:

(1) A 1.5-m (5-ft) minimum length of new, black iron/steel pipe extending about 0.75 m (2.5 ft) above ground surface and set in grout (see Figures 5-1, 5-2, and 5-3).

(2) A protective casing inside diameter at least 100 mm (4 in.) greater than the nominal diameter of the well riser.

(3) A hinged cover or loose-fitting telescopic slip-joint-type cap to keep direct precipitation and cap runoff out of the casing. Threaded covers should be avoided because of the tendency to rust/freeze shut.

(4) All protective casing covers/caps secured to the casing by means of a padlock from the date of protective casing installation.

(5) If practical, all padlocks at a given site opened by the same key. The FDO should provide four of these keys to an FA-designated representative at the project.

(6) No more than 60 mm (0.2 ft) from the top of protective casing to the top of well casing. This, or a smaller spacing, is needed for subsequent water-level determinations by some acoustical equipment which must rest upon the well casing in order to function.

(7) The outside only of the protective casing, hinges (if present), and covers/caps painted orange with a paint-brush (not aerosol can). Painting should be completed and dry prior to initially sampling that well. Any color deviations should be conveyed to the FDO by the FA.

(8) The painting of the well designation on the outside of the protective casing, using white paint and a brush. The identification should be done after the casing is painted as described above. Painting should be completed and dry prior to initially sampling that well. As an alternative, a metal tag containing the well designation may be attached to the protective casing.

(9) The erection of four steel posts with a minimum diameter of 80 mm (3 in.). Each post should be radially located 1.2 m (4 ft) from the well and placed 0.6 to 0.9 m (2 to 3 ft) below ground surface, having 0.9 m (3 ft) minimally above ground surface. Flagging in areas of high vegetation may be helpful (see Figure 5-4). The post should be painted orange, using a brush. Installation should be completed prior to sampling the well.

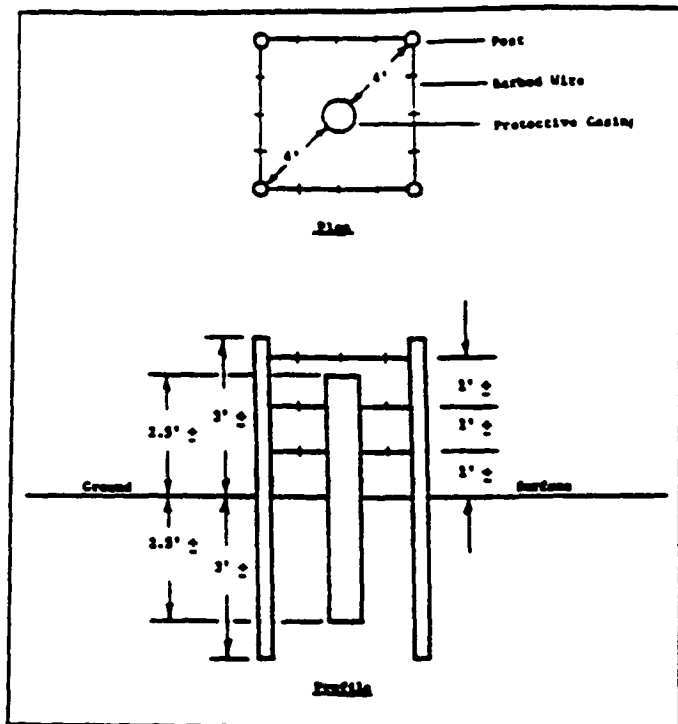


Figure 5-4. Post placement around wells

(10) When posts are used in conjunction with concrete pads, the posts should be located **OUTSIDE** of the pad. Posts inside of a pad (especially near a corner or edge) may cause the pad to crack, either by normal stress relief or, if the posts were to be severely struck, as by a vehicle.

(11) The above-mentioned posts should be supplemented with three-strand barbed wire in livestock grazing areas. Post and wire installation should be accomplished prior to sampling.

(12) The placement of an internal mortar collar within the well-protective casing annulus from ground surface to 150 mm (1/2 ft) above ground surface and a 6-mm (1/4-in.) diameter hole (drainage port) in the protective casing centered 3 mm (1/8 in.) above this level. The mortar mix should be (by weight) 1 part cement to 2 parts sand (the granular filter used around the well screen), with minimal water for placement. Placement is suggested on the day of firm grout remaining at ground surface and at least 48 consecutive hours prior to well development.

(13) The application of at least a 150-mm (0.5-ft) thick coarse gravel 19- to 75-mm (3/4- to 3-in. particle

size) pad extending 1.2 m (4 ft) radially from the protective casing (see Figure 5-5 for layout and dimensions). Prior to placement of this gravel pad, any depression around the well should be backfilled to slightly above the level of the surrounding ground surface with uncontaminated cohesive soil. This will prevent a "bathtub" effect of water collecting in the gravel pad around the well casing. Construction of the gravel pad is suggested prior to development. Some long-term, heavy traffic, or high visibility locations may warrant a concrete pad, specially designed for site conditions. Any concrete pad usage, especially in cold climates, should be designed to withstand frost heaving. Frost uplift may adversely affect well and pad integrity.

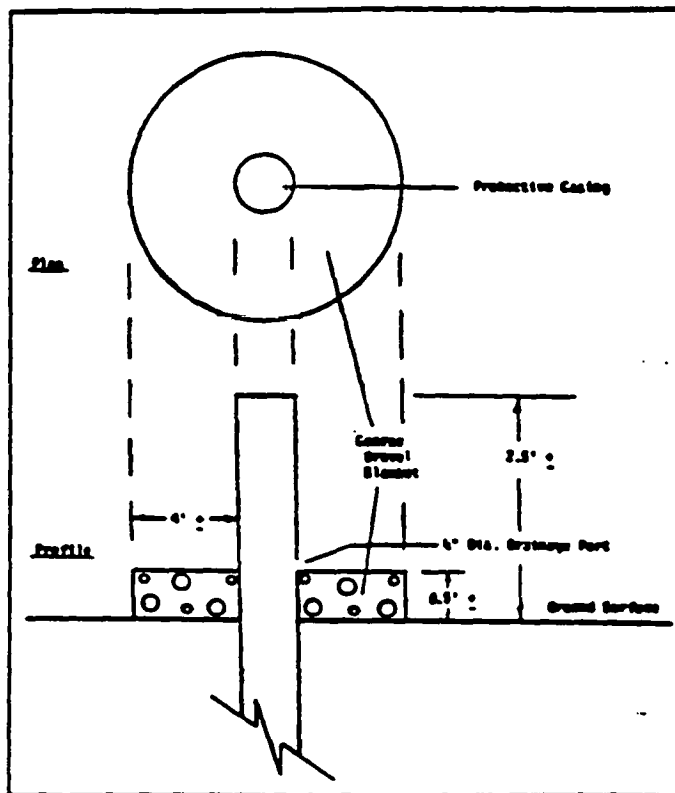


Figure 5-5. Coarse gravel blanket layout

(14) All elements of well protection should be detailed in the drilling plan. In addition, unique well protection requirements for floodplains, frost heaving, heavy traffic areas, parking lots, wells finished at or below grade, and other special circumstances, should also be covered on a case-by-case basis, in the drilling plan. As an example, a suggested well design to minimize the effects of frost heaving is shown in Figure 5-6.

## Chapter 6 Well Development

### 6-1. General

Well development is that procedure which locally improves or restores the aquifer's hydraulic conductivity and removes well drilling fluids, muds, cuttings, mobile particulates, and entrapped gases from within and adjacent a newly installed well. The resulting inflow should be physically and chemically representative of that portion of the aquifer adjacent the screened interval. The appropriate development method/procedure to use will vary according to the hydrologic characteristics of the aquifer, the drilling method used, and the type of well completion.

### 6-2. Timing and Record Submittal

The development of monitor wells should be initiated not sooner than 48 hours after nor longer than 7 days beyond internal mortar collar placement or the final grouting of the well. The record of well development should be submitted to the FA.

### 6-3. Pump and Bailor Usage

Development should be accomplished with a pump and may be supplemented with a bottom discharge/filling bailer (for sediment removal) and surge block. Pumps may be replaced by bottom filling bailers where well size or slow recharge rates restrict pump usage. Bailers should not be left inside the wells after development is completed. Such storage promotes accidental bailer release or loss down the well and inhibits convenient and accurate water-level measurements. The use of a surge block or periodically stopping the pump can agitate and mobilize particulates around the well screen. By pumping the well at a higher rate than that expected during sampling, the mobilized particulates may be removed, thereby providing a cleaner well for sampling. However, a disadvantage of only pumping (especially overpumping) a well is that the smaller fraction of the filter pack and/or aquifer may bridge in or near the screen. To lessen this potential, pumping may be coupled with backwashing or surging and the pumping rate may be reduced. (See USEPA EPA/600/4-89-034 and ASTM D 5092-90 for a discussion of additional development methods.)

### 6-4. Development Criteria

a. Development should proceed until the following criteria are met:

(1) The well water is clear to the unaided eye.

(2) The sediment thickness remaining within the well is less than 1 percent of the screen length or less than 30 mm (0.1 ft) for screens equal to or less than 3 m (10 ft) long.

(3) A minimum removal of five times the standing water volume in the well (to include the well screen and casing plus saturated annulus, assuming 30 percent annular porosity). **IN ADDITION** to the "five times the standing water volume" criteria, further volumetric removal should be considered as follows:

(a) For those wells where the boring was made without the use of drilling fluid (mud and/or water), but water was added to the well during well installation, then five times the amount of any water unrecovered from the well during installation should be removed (in addition to five times the standing volume).

(b) For those wells where the boring was made or enlarged (totally or partially) with the use of drilling fluid (mud and/or water), remove five times the measured (or estimated) amount of total fluids lost while drilling, plus five times that used for well installation (in addition to five times the standing volume).

(4) Applicable Federal, state, and local regulatory requirements are satisfied. Some of these requirements may specify that development continue until the readings for some parameters like pH, conductivity, temperature, or turbidity have stabilized; i.e., vary within a specified range.

b. Water should not be added to a well as part of development once the initial bentonite seal atop the filter pack is placed.

c. The use of air to develop a well **SHOULD NOT** be allowed. The introduction of air into a well enhances the occurrence of chemical, physical, and biological changes to the local aquifer system monitored by the well.

Furthermore, procedures involving compressed air at HTW sites increase potential exposure/health risks to site personnel from the volatilization and misting of the aerated water. If air development is deemed the most appropriate method for a site, the above factors should be evaluated and mitigation procedures documented in the drilling plan.

d. If any of the following circumstances occur, the FA should be contacted for guidance:

(1) Well recharge so slow that the required volume of water cannot be removed during 48 consecutive hours of development.

(2) Persistent water discoloration after the required volumetric development.

(3) Excessive sediment remaining after the required volumetric removal.

#### 6-5. Development-Sampling Break

Well development should be completed at least 14 days before well sampling. The intent of this hiatus is to provide time for the newly installed well and backfill materials to superficially equilibrate to their new environment and for that environment to re-stabilize after the disturbance of drilling. Though a significant volume of water may be pulled through the well during development, the well and granular backfill surfaces over which this water passes are not likely to be at chemical equilibrium with the aquifer. Intuitively, the hiatus allows time for that equilibrium to be created, thereby enhancing the probability of the resulting sample to be more representative of the local aquifer. The 14-day hiatus is a "rule-of-thumb," unsubstantiated by rigorous scientific analysis. If a different value is proposed based upon technical data or overall project considerations, such a change should be evaluated and, if deemed appropriate, implemented.

#### 6-6. Pump/Bailer Movement

During development, water should be removed throughout the entire water column in the well by periodically lowering and raising the pump intake (or bailer stopping point).

#### 6-7. Development Water Sample

For each well, a 500-cm<sup>3</sup> (1-pint) sample of the last water to be removed during development should be placed in a clear glass jar and labeled with well number and date.

No preservation of these samples is required. Each sample should be individually agitated and immediately photographed close-up by the FDO with a 35-mm camera and color print film, using a back-lit setup to show water clarity. These photos, minimally 125 mm x 175 mm (5 in. x 7 in.), individually identified with project name, well number, and photo date, should be provided to the FA after all wells are developed. The film negatives should be provided to the FA after the FA has received the prints. The FDO should dispose of these water samples in the same manner as the rest of the water removed during development.

#### 6-8. Well Washing

Part of well development should include the washing of the entire well cap and the interior of the well casing above the water table using only water from that well. The result of this operation will be a well casing free of extraneous materials (grout, bentonite, sand, etc.) inside the well cap and blank casing, between the top of the well and the water table. This washing should be conducted before and/or during development, not after development.

#### 6-9. Problems

If problems are encountered during development, contact the FA for guidance.

#### 6-10. Well Development Record

The following data should be recorded as part of development and submitted to the FA:

- a. Project name, location.
- b. Well designation, location.
- c. Date(s) and time(s) of well installation.
- d. Date(s) and time(s) of well development.
- e. Static water level from top of well casing before and 24 hours after development.
- f. Quantity of mud/water:
  - (1) Lost during drilling.
  - (2) Removed prior to well insertion.
  - (3) Lost during thick fluid displacement.

(4) Added during granular filter placement.

g. Quantity of fluid in well prior to development:

(1) Standing in well.

(2) Contained in saturated annulus (assume 30 percent porosity).

h. Field measurement of pH, conductivity, and temperature before, twice during, and after development using an appropriate device and method according to EPA 600/4-79-020.

i. Depth from top of well casing to bottom of well.

j. Screen length.

k. Depth from top of well casing to top of sediment inside well, before and after development (from actual measurements at time of development).

l. Physical character of removed water, to include changes during development in clarity, color, particulates, and any noted odor.

m. Type and size/capacity of pump and/or bailer used.

n. Description of surge technique, if used.

o. Height of well casing above ground surface (from actual measurement at time of development).

p. Typical pumping rate.

q. Estimated recharge rate.

r. Quantity of fluid/water removed and time for removal (present both incremental and total values).

## 6-11. Potential Difficulties

Many difficulties may arise during development and presample purging. Some are readily apparent but troublesome to resolve; e.g., a well that is easily pumped dry but slow to recharge or one that will not produce clear, particulate-free water. Other difficulties are not easily observed but may bias the analytical results; e.g., pulling-in distant parts of the aquifer in an effort to achieve a repetitively consistent field reading or aerating the aquifer adjacent the well in a hurried attempt at well development. In addition, the unanticipated presence of dense (or light) nonaqueous phase liquids in the screened interval would affect the chemical homogeneity of that interval and hydrologic parameters derived from that well. The anticipation, evaluation, and tentative solution for these problems should begin early in the formulation of each drilling plan.

## Chapter 7

### Well and Boring Acceptance Criteria

#### 7-1. Well Criteria

Wells should be acceptable to the FA. Well acceptance should be on a case-by-case basis. The following criteria should be used along with individual circumstances in the evaluation process.

*a.* The well and material placement should meet the construction and placement specifications of the drilling and well installation plan unless modified by any amendments.

*b.* Wells should not contain portions of drill casing or augers unless they are specified in the drilling plan as permanent casing.

*c.* All well casing and screen materials should be free of any unsecured couplings, ruptures, or other physical breakage/defects before and after installation.

*d.* The annular material (filter pack, bentonite, and grout) of the installed well should form a continuous and uniform structure, free of any detectable fractures, cracks, or voids.

*e.* Any casing or screen deformation or bending should be minimal to the point of allowing the insertion and retrieval of the pump and/or bailer optimally designed for that size casing (e.g., a 75-mm (3-in.) pump in a 100-mm (4-in.) schedule 80, PVC casing is optimal; a 50-mm (2-in.) pump in a 100-mm (4-in.) casing is not optimal).

*f.* All joints should be constructed to provide a straight, nonconstricting, and watertight fit.

*g.* Completed wells should be free of extraneous objects or materials; e.g., tools, pumps, bailers, pack, excessive sediment thickness, grout, etc. This prohibition should not apply to intentionally installed equipment per drilling plan.

*h.* For those monitor wells where the screen depth was determined by the FDO, the well should have sufficient free water at the time of the water-level measurement to obtain a representative groundwater level for that well. These same wells should have sufficient free water, at the time of initial sampling, which is representative of the desired portion of the aquifer for the intended chemical analyses.

*i.* All boring logs, well diagrams, development records, topographic survey data, and related photographs and negatives should have been completed per drilling plan and received by the FA.

*j.* Keys to the padlocks securing the well covers should be in the possession of the FA and the FA project representative prior to well acceptance.

#### 7-2. Abandoned/Decommissioned Borings and Wells

Borings not completed as wells should be abandoned/decommissioned per paragraph 3-14 of this manual.

#### 7-3. Well and Boring Rejection

Wells and borings not meeting drilling plan criteria are subject to rejection by the FA.

## Chapter 8 Water Levels

### 8-1. Measurement Frequency and Coverage

The frequency of water-level measurement is project related. At a minimum, for those projects involving the installation of any monitor wells, at least one complete set of *static* water-level measurements should be made over a single, consecutive 10- to 12-hour period for all project-related wells, both newly installed and specified existing wells. These measurements should be taken at least 24 hours after development or sampling. Static levels in borings not converted to wells should be included if practical and technically appropriate. This set of measurements should include a notation for the presence of any streams, lakes, and/or open water bodies (natural and man-made) within proximity, i.e., about 90 m (300 ft), of these wells. Elevation measurements of any surface water bodies should be a consideration within the drilling and well installation plan.

### 8-2. Vertical Control

The depth to groundwater should be measured and reported to the nearest 3 mm (0.01 ft). Measurement should be made from the highest point on the rim of the well casing or riser (not protective casing). This same point on the well casing should be surveyed for vertical control. Surface water levels should be measured at least to the nearest 30 mm (0.1 ft) using an adjacent temporary or permanent survey marker as a datum for current and future reference.

### 8-3. Reporting and Usage

All water level data should be presented as elevations in tabular form. Where sufficient data points exist, the elevations should be contoured to denote flow directions, gradients, and any hydrological interconnections between aquifers and surface water bodies.

## Chapter 9 Topographic Survey

### 9-1. Licensing

All topographic survey efforts conducted under contract should be certified by a surveyor with a current surveyor's license in the project state. Any licensing requirements within the project state for contract or Corps of Engineers surveyors should be determined by the FA.

### 9-2. Horizontal Control

Each boring and/or well installation should be topographically surveyed to determine its map coordinates referenced to either a Universal Transverse Mercator (UTM) grid or the State Plane Coordinate System (SPCS). These surveys should be connected to the UTM or SPCS by third order, Class II control surveys in accordance with the Standards and Specifications for Geodetic Control Networks (Federal Geodetic Control Committee 1984). If the project is in an area remote from UTM or SPCS benchmarks and such horizontal control is not warranted, then locations measured from an alternate system depicted on project plans may suffice, at least on a temporary basis. All borings, wells, temporary and/or permanent markers should have an accuracy of  $\pm 300$  mm ( $\pm 1$  ft) within the chosen system.

### 9-3. Vertical Control

Elevations for the natural ground surface (not the top of the coarse gravel blanket) and a designated point on the

rim of the uncapped well casing (not protective casing) for each bore/well site should be surveyed to within 3 ( $\pm 0.01$  ft) and referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929). These surveys should be connected by third order leveling to the NGVD of 1929 in accordance with the Standards and Specifications for Geodetic Control Networks. If the project is in an area remote from NGVD benchmarks and such vertical control is not warranted, then elevations measured from a project datum may suffice, at least on a temporary basis.

### 9-4. Field Data

The topographic survey should be completed as near to the time of last well completion as possible. Survey field data (as corrected), to include loop closures and other statistical data in accordance with the Standards and Specifications referenced above, should be provided to the FA. Closure should be within the horizontal and vertical limits given above. These data should clearly be listed in tabular form: the coordinates (and system) and elevation (ground surface and top of well) as appropriate, for all borings, wells, and reference marks. All permanent and semipermanent reference marks used for horizontal and vertical control (benchmarks, caps, plates, chiseled cuts, rail spikes, etc.) should be described in terms of their name, character, physical location, and reference value. These field data should become part of the project record maintained by the FA.



## **Chapter 10 Geophysics**

### **10-1. Usage and Reporting**

The use of geophysical techniques, if required, should be specified in the drilling plan. In the absence of this specification, the FDO should consider these techniques for site-specific applicability to enhance the technical acuity and cost-effectiveness of its efforts. Special applications may be useful in unexploded ordnance detection, disturbed area delineation, contaminant detection, depth to bedrock determination, buried drum detection, borehole and well logging, etc. When approved for use, geophysical techniques should be discussed in the drilling plan,

to include the purpose, particular method(s) and equipment, selection rationale, physical and procedural assumptions, limitations (theoretical and site specific), resolution, accuracy, and quality control. Safety aspects of geophysical applications should be included in the safety plan, especially for those areas where induced electrical currents or seismic waves could detonate unexploded ordnance or other explosive materials.

### **10-2. Methods**

General geophysical methodology is covered in EM 1110-1-1802. Geophysical techniques applied to HTW studies are found in USEPA EPA 600/2-87/078 and in Benson, Glaccum, and Noel (1982).

## **Chapter 11**

### **Vadose Zone Monitoring**

#### **11-1. Usage and Reporting**

Data acquisition from the vadose (unsaturated) zone should be addressed on a case-by-case basis. The use of lysimeters in a silica flour matrix, soil-gas monitors, and analysis of bulk soil samples are mechanisms which may be employed. When vadose zone monitoring is proposed,

the drilling plan should include the purpose, particular method(s) and equipment, selection rationale, physical procedural assumptions, limitations (theoretical and specific), quality control, and any analytical variances from the current USACE protocol.

#### **11-2. Methods**

A general discussion of vadose monitoring is found in Everett, Wilson, and Hoylman (1984).

## **Chapter 12 Background Sampling**

### **12-1. Physical and Chemical Aspects**

Within the areal boundaries of a project, "background" samples should be comparable to "downgradient" samples in terms of current environmental setting, depositional environment, and physical composition. This means, for example, that if a potentially contaminated soil is an outcropping lacustrine clay, then the background sample should be acquired from a similar lacustrine clay outcrop

(ideally an extension of same clay unit) that is chemically, hydrologically, topographically, and meteorologically upgradient of the suspect contaminated area. This same logic of environmental comparability and direction also applies to the background sampling of surface water and groundwater.

### **12.2. Importance**

The evaluation of physically comparable environmental data is of the utmost importance if trace level variations within the chemical environment are to be determined.

## **Chapter 13 Data Management System**

### **13-1. Benefits**

The use of a computerized system will enhance reporting procedures by means of intra-report consistency, reduction of editorial review, broadening of graphical capabilities, and ease of data retrieval for project review and

inter-project comparisons. Each FA is encouraged to utilize a computerized data management system for technical data.

### **13-2. Assistance Sources**

Several existing systems are available for utilization by individual FAs. Assistance can be obtained from the HTRW MCX, CEMRD-ED-TG.

## Appendix A References

### A-1. Required Publications

Code of Federal Regulations, 29 CFR 1910.120,  
Hazardous Waste Operations and Emergency Response

Code of Federal Regulations, 29 CFR 1926, Safety and  
Health Regulations for Construction

ER 385-1-92

Safety and Occupational Health Document Requirements  
for Hazardous, Toxic, and Radioactive Waste (HTRW)  
Activities

ER 1110-1-263

Chemical Data Quality Management for Hazardous Waste  
Remedial Activities

ER 1110-1-1803

Care, Storage, Retention, and Ultimate Disposal of  
Exploratory and Other Cores

ER 1110-2-1807

Use of Air Drilling in Embankments and Their  
Foundations

EM 385-1-1

Safety and Health Requirements Manual

EM 1110-1-1804

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works," National Oceanic and Atmospheric Administra-  
tion, Rockville, MD.

American Society For Testing and Materials

American Society for Testing and Materials, *Annual Book  
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Gypsum." 1916 Race St., Philadelphia, PA 19103.

American Society For Testing and Materials

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Building Stones; Geotextiles," 1916 Race St., Philadel-  
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American Society for Testing and Materials

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American Society For Testing and Materials

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The Munsell Soil Color Chart, MacBeth, 405 Little  
Britain Rd., New Windsor, NY 12553.

Geological Society of America

Geological Society of America, GSA Rock Color Chart,  
Geological Society of America, 3300 Penrose Place,  
Boulder, CO 80301.

National Sanitation Foundation

National Sanitation Foundation, NSF Standard 14:  
"Plastics Piping System Components and Related Materi-  
als," 3475 Plymouth Rd., P.O. Box 130140, Ann Arbor,  
MI 48105.

USEPA, EPA/540/G-91/009

Management of Investigation-Derived Wastes During Site  
Inspections," 401 M St., SW, Washington, DC 20460.

USEPA, EPA 600/4-79-020

"Methods for Chemical Analysis of Water and Wastes,"  
401 M St., SW, Washington, DC 20460.

USEPA, OSWER Publication 9345.3-03FS  
"Guide to Management of Investigation-Derived Wastes,"  
401 M St., SW, Washington, DC 20460.

USEPA, SW-846  
"Test Methods for Evaluating Solid Waste,  
Physical/Chemical Methods," 401 M St., SW, Washing-  
ton, DC 20460.

## A-2. Related Publications

ER 1165-2-132  
Hazardous, Toxic, and Radioactive Waste (HTRW)  
Guidance for Civil Works Projects

EM 1110-1-1802  
Geophysical Exploration

EM 1110-2-1907  
Soil Sampling

EM 1110-2-3506  
Grouting Technology

USEPA, EPA 600/2-87/078  
"Nondestructive Testing Techniques to Detect Contained  
Subsurface Hazardous Waste," 401 M St., SW, Washing-  
ton, DC 20460.

USEPA, EPA/540/G-88/003, OSWER Directive  
9283.1-2  
"Guidance on Remedial Actions for Contaminated Ground  
Water at Superfund Sites," 401 M St., SW, Washington,  
DC 20460.

USEPA, OSWER-9950.1  
"RCRA Ground-Water Monitoring Technical Enforcement  
Guidance Document," 401 M St., SW, Washington, DC  
20460.

USEPA, EPA/600/4-89-034  
"Handbook of Suggested Practices for the Design and  
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St., SW, Washington, DC 20460.

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Benson, R.C., Glaccum, R.A., and Noel, M.R. 1982.  
"Geophysical Techniques for Sensing Buried Wastes and  
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Laboratory, USEPA, Las Vegas, NV.

Everett, Wilson, and Hoytman 1984  
Everett, L.G., Wilson, L.G., and Hoytman, E. W. 1984.  
"Vadose Zone Monitoring for Hazardous Waste Sites."  
Noyes Data Corporation, Park Ridge, NJ.

Hsai-Wong Fang 1991  
Hsai-Wong Fang. 1991.  
"Foundation Engineering Handbook"

## Appendix B Abbreviations

AE	Architect-Engineer	HTW	Hazardous and/or Toxic Waste
ASTM	American Society for Testing and Materials	ID	Inside Diameter
CECW-EG	Geotechnical and Materials Branch, Engineering Division, Directorate of Civil Works, Headquarters, U.S. Army Corps of Engineers	IDW	Investigation-Derived Waste
CEMP-RT	Environmental and Chemical Engineering Branch, Environmental Restoration Division, Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers	MCX	Mandatory Center of Expertise
CEMRD-ED-TG	Missouri River Division, HTRW and Engineering Directorate, Geotechnical and Technical Engineering Division, Geotechnical Branch	MRD	Missouri River Division
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act	N	Normal
CFR	Code of Federal Regulations	NGVD	National Geodetic Vertical Datum
DERP	Defense Environmental Restoration Program	NSF	National Sanitation Foundation
ENG	Engineer	OD	Outside Diameter
FA	Field Activity	OSHA	Occupational Safety and Health Administration
FDO	Field Drilling Organization	pH	The negative logarithm of the effective hydrogen ion concentration in gram equivalents per liter
GDQM	Geotechnical Data Quality Management	PCBs	Polychlorinated biphenyls
GSA	Geological Society of America	PTFE	Polytetrafluoroethylene
HQUSACE	Headquarters, United States Army Corps of Engineers	PVC	Polyvinyl chloride
HTRW	Hazardous, Toxic, and Radioactive Waste	RCRA	Resource Conservation and Recovery Act
		SARA	Superfund Amendments and Reauthorization Act
		SPCS	State Plane Coordinate System
		TSCA	Toxic Substance Control Act
		USACE	United States Army Corps of Engineers
		USEPA	United States Environmental Protection Agency
		UTM	Universal Transverse Mercator

HTRW DRILLING LOG		DISTRICT		MOLE NUMBER	
1. COMPANY NAME BEST ENGINEERING		NASHVILLE DIST		MW-3	
2. DRILL SUBCONTRACTOR DEEP DRILLING INC				SHEET SHEETS 1 OF 3	
3. PROJECT DIRTY SITE		4. LOCATION SOME TOWN USA			
5. NAME OF DRILLER A. DRILLER		6. MANUFACTURER'S DESIGNATION OF DRILL DIETRICH D-120			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT 4 1/2" Hollow stem 1 1/8" ss split spoon NO CORE		8. MOLE LOCATION SEE SKETCH.			
		9. SURFACE ELEVATION 450.0			
		10. DATE STARTED 10 OCT 1994		11. DATE COMPLETED 14 OCT 1994	
12. OVERBURDEN THICKNESS 4.5 (445.5)		15. DEPTH GROUNDWATER ENCOUNTERED 6.8'			
13. DEPTH DRILLED INTO ROCK 15.0		16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED 15.2' / 16 OCT 1994			
14. TOTAL DEPTH OF HOLE 19.5 (430.5)		17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)			
18. GEOTECHNICAL SAMPLES		19. TOTAL NUMBER OF CORE BOXES			
DISTURBED 2		UNDISTURBED		2	
20. SAMPLES FOR CHEMICAL ANALYSIS		VOC		METALS	
1		1		OTHER (SPECIFY) Nitroaromat	
22. DISPOSITION OF HOLE		BACKFILLED		MONITORING WELL	
		X		21. SIGNATURE OF INSPECTOR John Q Geologist	
LOCATION SKETCH/COMMENTS					
PROJECT DIRTY SITE				HOLE NO. MW-3	



# HTRW DRILLING LOG

(CONTINUATION SHEET)

HOLE NUMBER  
MW-3

PROJECT  
DIRTY SITE

INSPECTOR  
John Q Geologist

SHEET  
3 of 3

ELEV. (10)	DEPTH (10)	DESCRIPTION OF MATERIALS (10)	FIELD SCREENING RESULTS (10)	GEOTECH SAMPLE OR CORE BOX NO. (10)	ANALYTICAL SAMPLE NO. (10)	REMARKS (10)
		WEA SHALE				Set 12.0' of 4" PVC CSJ to 11.5'. Grouted in CSJ
438.5	11	Auger refusal 11.5		11.5		
	12	SHALE, lt grist wear, fs1, mod hd, calc				14 Oct 1994 Begin coring @ 11.5' using 13.5' (10.3') NQ core bbl & clear water
		spin		Box 1		
	13	ti break				P-1
						End 1130 Start 1100 Time 30min Ran 5.0 Rec 4.8 Loss 0.2 L.C. 0.0 W.P. 50 psi W.L. 14.2' @ 1145 RQD 100%
	14	spin				
	15	spin				
434.1	15.9					
	16	LIMESTONE, gr, cgr, fos, hd, sh ptgs		16.3		CD 16.3
		op bdd break				16.5
	17	ti bdd breaks		Box 2		P-2
						End :220 Start 1200 Time 20min Ran 3.0 Rec 3.2 Gain 0.2 L.C. 0.0 W.P. 50 psi W.L. 18.5' @ 1300 RQD 75%
	18	h/a ≈ 60° frac, op, fe st				
		op bdd break, fe st				
		op break				
	19	1/a ≈ 30° frac, ti				
430.5	19.5	B.O.H. 19.5		19.5		B.O.H. 19.5
	20					Well set in boring. See installation diagram

PROJECT  
DIRTY SITE

HOLE NO.  
MW-3

# HTRW DRILLING LOG

(CONTINUATION SHEET)

HOLE NUMBER  
MW-3

PROJECT  
DIRTY SITE

INSPECTOR  
John O. Gendron

SHEET  
2 of 3

ELEV. (ft)	DEPTH (ft)	DESCRIPTION OF MATERIALS (ft)	FIELD SCREENING RESULTS (ppm)	GEOTECH SAMPLE OR CORE BOX NO.	ANALYTICAL SAMPLE NO.	REMARKS
	1	CLAY lean sdy br mst stiff	HNU 0 ppm	1.0 MW-3-1		Sample thru 4 1/4" I.D. augers using 1 3/8" I.D. SS split spoon  Ran 2.0 Rec 1.8 Loss 0.2
	2	SAND, br f to med gr, wet		1.5		
447.2	2.8					Auger to 2.0' 2.0
	3	CLAY lean sl sdy gr dmp hd	HNU 2 ppm		MW-3-3 Metals Nitro- aromatics	Ran 2.0 Rec 2.0 Loss 0.0
	4			4.0	4.0	Auger to 4.0' 4.0
445.5	4.5	TOP OF WEA ROCK				
	5	SHALE highly wea (cl) br gr bdd visible med dmp	HNU 0 ppm			Ran 2.0 Rec 1.5 Loss 0.5
	6					Auger to 6.0' 6.0
	7		HNU 0 ppm			Ran 1.7 Rec 0.8 Loss 0.9
442.3	7.7	TOP OF ROCK				
	8	Refusal on shale				7.7
	9					Rock too wea to core. Continued augering to 11.5' - auger refusal
	10					

PROJECT  
DIRTY SITE

HOLE NO.  
MW-3

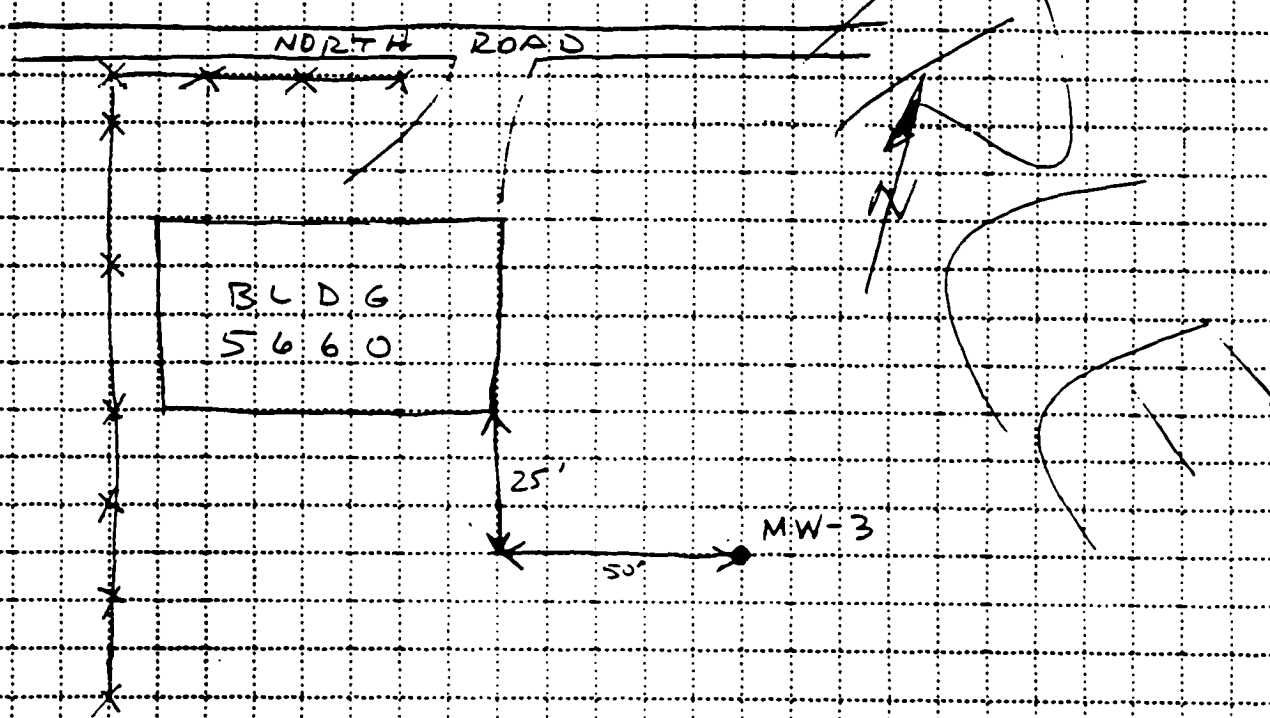
## Appendix B Abbreviations

AE	Architect-Engineer	HTW	Hazardous and/or Toxic Waste
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CEMP-RT	Environmental and Chemical Engineering Branch, Environmental Restoration Division, Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers	MCX	Mandatory Center of Expertise
CEMRD-ED-TG	Missouri River Division, HTRW and Engineering Directorate, Geotechnical and Technical Engineering Division, Geotechnical Branch	MRD	Missouri River Division
CERCLA	Comprehensive Environmental Resource, Compensation, and Liability Act	N	Normal
CFR	Code of Federal Regulations	NGVD	National Geodetic Vertical Datum
DERP	Defense Environmental Restoration Program	NSF	National Sanitation Foundation
ENG	Engineer	OD	Outside Diameter
FA	Field Activity	OSHA	Occupational Safety and Health Administration
FDO	Field Drilling Organization	pH	The negative logarithm of the effective hydrogen ion concentration in gram equivalents per liter
GDQM	Geotechnical Data Quality Management	PCBs	Polychlorinated biphenyls
GSA	Geological Society of America	PTFE	Polytetrafluoroethylene
HQUSACE	Headquarters, United States Army Corps of Engineers	PVC	Polyvinyl chloride
HTRW	Hazardous, Toxic, and Radioactive Waste	RCRA	Resource Conservation and Recovery Act
		SARA	Superfund Amendments and Reauthorization Act
		SPCS	State Plane Coordinate System
		TSCA	Toxic Substance Control Act
		USACE	United States Army Corps of Engineers
		USEPA	United States Environmental Protection Agency
		UTM	Universal Transverse Mercator

<b>HTRW DRILLING LOG</b>		DISTRICT <b>NASHVILLE DIST</b>		HOLE NUMBER <b>MW-3</b>	
1. COMPANY NAME <b>BEST ENGINEERING</b>		2. DRILL SUBCONTRACTOR <b>DEEP DRILLING INC</b>		SHEET SHEETS <b>1 OF 3</b>	
3. PROJECT <b>DIRTY SITE</b>			4. LOCATION <b>SOME TOWN USA</b>		
5. NAME OF DRILLER <b>A. DRILZ</b>			6. MANUFACTURER'S DESIGNATION OF DRILL <b>DIETRICH D-120</b>		
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		4 1/4" Hollow stem 1 1/2" ss split spoon NO CORE		8. HOLE LOCATION <b>SEE SKETCH.</b>	
		9. SURFACE ELEVATION <b>450.0</b>		10. DATE STARTED <b>10 Oct 1994</b>	
				11. DATE COMPLETED <b>14 Oct 1994</b>	
12. OVERBURDEN THICKNESS <b>4.5 (445.5)</b>		15. DEPTH GROUNDWATER ENCOUNTERED <b>6.8'</b>			
13. DEPTH DRILLED INTO ROCK <b>15.0</b>		16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED <b>15.2' / 16 Oct 1994</b>			
14. TOTAL DEPTH OF HOLE <b>19.5 (430.5)</b>		17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)			
18. GEOTECHNICAL SAMPLES		DISTURBED <b>2</b>	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES <b>2</b>	
20. SAMPLES FOR CHEMICAL ANALYSIS		VOC <b>1</b>	METALS <b>1</b>	OTHER (SPECIFY) <b>Nitroaromat</b>	OTHER (SPECIFY)
22. DISPOSITION OF HOLE		BACKFILLED	MONITORING WELL <b>X</b>	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY 100%
				23. SIGNATURE OF INSPECTOR <b>Jon Q Geologist</b>	

LOCATION SKETCH/COMMENTS

SCALE:



PROJECT <b>DIRTY SITE</b>	HOLE NO. <b>MW-3</b>
------------------------------	-------------------------

# HTRW DRILLING LOG

CONTINUATION SHEET

HOLE NUMBER  
MW-3

PROJECT  
DIRTY SITE

INSPECTOR  
John Q Geologist

SHEET  
3 of 3

ELEV. (ft)	DEPTH (ft)	DESCRIPTION OF MATERIALS (ft)	FIELD SCREENING RESULTS (ft)	GEOTECH SAMPLE OR CORE BOX NO. (ft)	ANALYTICAL SAMPLE NO. (ft)	REMARKS (ft)
		WFA SHALE				Set 12.0' of 4" PVC CSG to 11.5'. Grouted in CSG
438.5	11	Auger refusal 11.5		11.5		
	12	SHALE, lt grist wear, fsl, mod hd, calc				14 Oct 1994 Begin coring @ 11.5' using 13.5' (10.3') NQ core bbl & clear water
		spin		Box 1		
	13	ti break				P-1 End 1130 Start 1100 Time 30min Ran 5.0 Rec 4.8 Loss 0.2 L.C. 0.0 W.P. 50 psi W.L. 14.2' @ 1145 RRD 100%
	14	spin				
	15	spin				
434.1	15.9					
	16	LIMESTONE, gr, c gra, fos, hd, sh ptgs		16.3		CD 16.3
		op bdd break		Box 2		
	17	ti bdd breaks				P-2 End 1220 Start 1200 Time 20min Ran 3.0 Rec 3.2 Gain 0.2 L.C. 0.0 W.P. 50 psi W.L. 18.5' @ 1300 RRD 75%
	18	1/2 ≈ 60° frac, op, fe st				
		op bdd break, fe st				
		op break				
	19	1/2 ≈ 30° frac, ti				
430.5	19.5	B.O.H. 19.5		19.5		B.O.H. 19.5
	20					Well set in boring. See installation diagram
PROJECT DIRTY SITE						HOLE NO. MW-3

# HTRW DRILLING LOG

(CONTINUATION SHEET)

HOLE NUMBER  
MW-3

PROJECT  
DIRTY SITE

INSPECTOR  
John Q. Gooden

SHEET 2 of 3 SHEETS

ELEV. (1)	DEPTH (1)	DESCRIPTION OF MATERIALS (1)	FIELD SCREENING RESULTS (1)	GEO TECH SAMPLE OR CORE BOX NO. (1)	ANALYTICAL SAMPLE NO. (1)	REMARKS (1)
	1	CLAY lean sdy br mst stiff	HNU 0 ppm	1.0 MW-3-1		Sample thru 4 1/8" I.D. augers using 1 3/8" I.D. ss split spoon Ran 2.0 Rec 1.8 Loss 0.2
	2	SAND, br f to med gr, wet		1.5		
447.2					2.0 MW-3-2	Auger to 2.0' 2.0
	3	CLAY lean sl sdy gr dmp hd	HNU 2 ppm		2.1	Ran 2.0 Rec 2.0 Loss 0.0
	4			4.0 MW-3-4	4.0	Auger to 4.0' 4.0
445.5		TOP OF WEA ROCK 4.5		4.5		
	5	SHALE highly wea (cl) br gr bdd visible med dmp	HNU 0 ppm			Ran 2.0 Rec 1.5 Loss 0.5
	6					Auger to 6.0' 6.0
	7		HNU 0 ppm			Ran 1.7 Rec 0.8 Loss 0.9
442.3		TOP OF ROCK 7.7				
	8	Refusal on shale				7.7
	9					Rock too wea to core. Continued augering to 11.5' - auger refusal
	10					

PROJECT  
DIRTY SITE

HOLE NO.  
MW-3

## **APPENDIX H**

### **Background Soil Sampling and Analysis Plan for the St. Louis Downtown Site**

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## 1.0 INTRODUCTION

This document is a sampling and analysis plan (SAP) for the collection of background soil samples from the St. Louis Downtown Site (SLDS). The site is the former location of a facility operated by the Mallinckrodt Chemical Works for the separation of uranium from ores by chemical processing and was operated for the Atomic Energy Commission of the United States (U.S.) Government under contract with the Manhattan Engineer District (MED) during the years from 1942 to 1957. Due to these operations, portions of SLDS are contaminated with radium, thorium, uranium, and possibly other chemical contaminants. The focus of this SAP will be the collection of representative soil samples indicative of background chemical concentrations so that future (and past) data can be evaluated relative to pre-existing chemical levels.

Responsibility for the cleanup of radioactive and commingled chemical contamination identified at the site is divided between the U.S. Army Corps of Engineers (ACE) and the U.S. Environmental Protection Agency (EPA). The radiological contamination of the SLDS site has been characterized during several sampling activities completed from 1977 to 1992 and these results are documented in the *Remedial Investigation Report for the St. Louis Site, St. Louis, Missouri* (DOE 1994) with a remedial action proposed in the draft *Focused Feasibility Study for the St. Louis Downtown Site* (USACE 1998).

This document is organized as an appendix to the SAP prepared for the St. Louis Airport Site (SLAPS) due to the overlap of planned activities for SLAPS and SLDS and the anticipated concurrent sampling at both locations. Elements of the SLAPS SAP will be incorporated into this document by referencing the appropriate section. This document includes a brief review of the site history and contaminants, a review of previous sampling results, the objectives of the planned sampling, and descriptions of the specific field activities to be completed. A Health and Safety Plan specific to the SLDS is included as an attachment to this appendix.

Science Applications International Corporation (SAIC) is the delivery order manager for the Kansas City Division of the USACE and is tasked with writing this plan, collecting the soil samples, and interpreting the results.

### 1.1 SITE HISTORY AND CONTAMINANTS

The sampling and analysis of background soils for the St. Louis Downtown Site (SLDS) is being conducted as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was instituted in 1974 by the Atomic Energy Commission (AEC), a predecessor of the United States Department of Energy (DOE), and is now managed by the United States Army Corps of Engineers (USACE). The goal of FUSRAP is to identify and clean up, or otherwise control, sites where residual radioactive contamination (exceeding prevailing guidelines) remains from activities carried out under contract to the Manhattan Engineer District (MED) and AEC during the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has now authorized USACE to remedy. The SLDS was among the first properties to be designated for remediation under FUSRAP.

1  
2 SLDS is located in an industrial area on the eastern border of St. Louis, immediately west  
3 of the Mississippi River and south of the McKinley Bridge (Figure 1-1). SLDS consists of the  
4 Mallinckrodt property and adjacent commercial and city owned properties, collectively referred  
5 to as the vicinity properties. The Mallinckrodt property covers approximately 45 acres (18.2 ha)  
6 and contains many buildings that house Mallinckrodt offices and chemical processing operations  
7 (Figure 1-2). The vicinity properties surrounding the Mallinckrodt facility include a large metals  
8 recycling company (McKinley Iron Works) to the north; the Mississippi River, a defunct food  
9 processing company (PVO Foods), and City of St. Louis property to the east; a lumber yard  
10 (Thomas and Proetz Lumber) and a large salt producer/distributor (?) (Gunther Salt) to the south;  
11 and North Broadway and small businesses to the west. Additionally, the Norfolk and Western  
12 Railroad; the Chicago, Burlington, and Quincy Railroad; and the St. Louis Terminal Railroad  
13 Association have active rail lines, and rail spurs, throughout the Mallinckrodt facility. A levee  
14 which protects the area from flood waters is also located to the east of the SLDS.  
15

16 An extensive network of utility lines across the site includes underground sewer,  
17 sprinkler, water, and natural gas lines; overhead electricity and telephone lines; and plant process  
18 pipes. Before the Bissell Point Sewage Treatment Plant (located approximately 1 mile north of  
19 the SLDS) went online on December 17, 1970, most process, storm, and sanitary effluent for St.  
20 Louis was collected in a combined sewer system (i.e. process, sanitary, and storm effluent all  
21 flowed in the same conduit) for discharge directly to the river through one of approximately 90  
22 municipal outfalls. St. Louis has always had a combined sewer system. The Clean Water Act  
23 has generally brought about separate sewer designs. After the Bissell Point Sewage Treatment  
24 Plant went online, all dry weather sewer flow was collected for treatment prior to release to the  
25 Mississippi River. Mallinckrodt's discharge permit states that discharge of the wastewater shall  
26 not be at a rate that would cause the influent at Bissell Point to exceed the 1 curie per year limit.  
27 In times of heavy stormwater flow, when the capacity of the interceptor tunnel under SLDS is  
28 exceeded, excess flow is discharged directly into the Mississippi River. High stormwater flows  
29 also result in diluted sewage being treated at Bissell Point.  
30

31 At least three operations that dealt with radiologically contaminated materials could lead  
32 to contamination in the sewers and drains: the MED/AEC contract work, the columbium-  
33 tantalum processing (C-T) work, and the euxenite processing performed under a separate NRC  
34 source material license number 226. Much of the superstructure used for MED/AEC operations  
35 has been demolished and the underground utilities abandoned or plugged.  
36

37 The primary radiological contaminants at SLDS are radium, thorium, and uranium. Many  
38 of the chemicals at SLDS cannot be attributed to one source, industry, or event due to the history  
39 and diverse nature of the industries located at the downtown site. Mallinckrodt has used, blended,  
40 and/or manufactured chemicals at this facility including organics (e.g., 1,2-dichloropropane,  
41 dichloromethane, phenol, zinc phenolsulfonate, toluene, hexane, dimethylaniline, chloroform,  
42 alcohols, propanediols, nitrobenzene, nitrophenols, xylenes, trichloroethylene,  
43 hexachlorobutadiene, oxydianilinetars, stearates, biphenyls, and acetonitrile) and inorganics  
44 (e.g., aluminum chloride, hydroxide salts, zinc, sulfuric acid, nitric acid, hydrochloric acid,  
45 chromium, sodium iodide, magnesium salts, palladium, and bismuth oxychloride).  
46

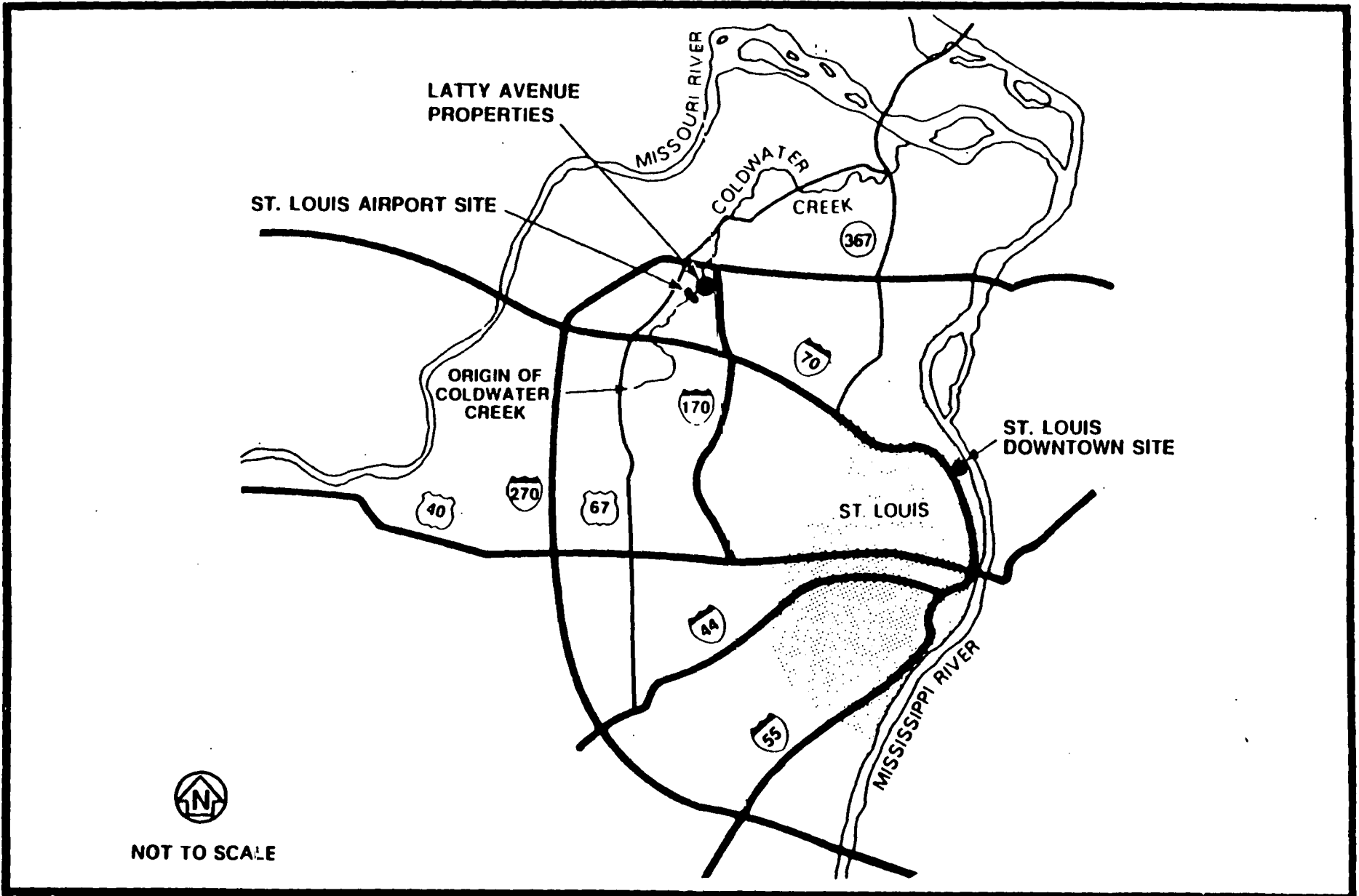


Figure 1-1. Locations of FUSRAP Properties in the St. Louis, Missouri Area

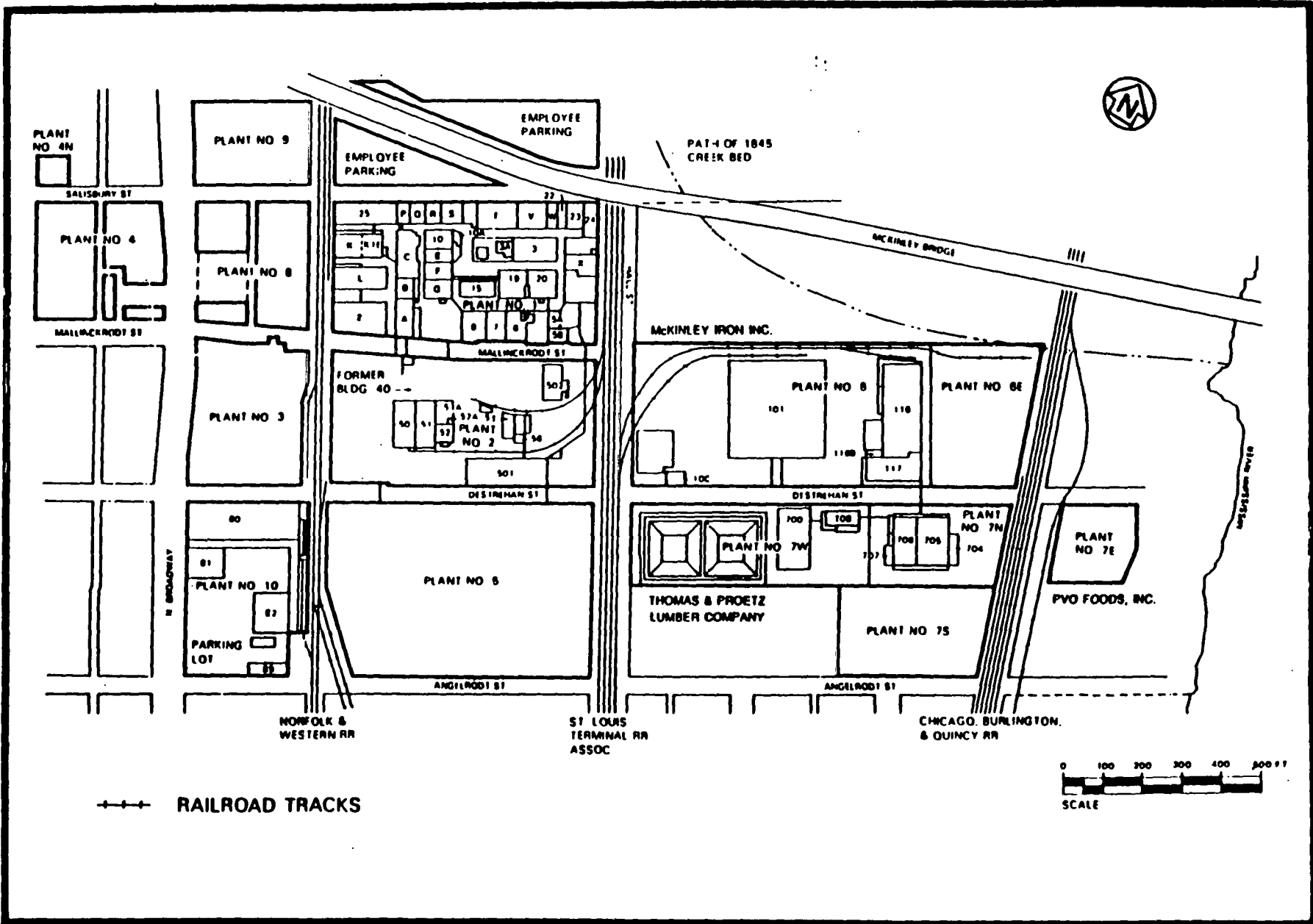


Figure 1-2. St. Louis Downtown Site

1 From 1942 to 1957, the former Mallinckrodt Chemical Works (now known as  
2 Mallinckrodt, Inc.) performed work at the SLDS under contract with the MED and AEC. The  
3 work included development of uranium-processing techniques, production of forms of uranium  
4 compounds and metal, and recovery of uranium metal from residues and scrap.  
5

6 From 1942 to 1945, work was performed in Plants 1, 2, and 4 (now Plant 10). In 1946,  
7 manufacturing of uranium dioxide from pitchblende ore began at the newly constructed Plant 6.  
8 During the processing, uranium ore was digested in acid and filtered to form uranyl nitrate; then a  
9 solvent extraction procedure and denitration were conducted to create uranium oxide.  
10 Hydrofluoric acid was then used to fluorinate the uranium oxide to create uranium tetrafluoride  
11 (green salt), which was subsequently reduced with heat and magnesium to produce uranium metal.  
12

13 Mallinckrodt personnel conducted decontamination activities at Plants 1 and 2 from 1948  
14 through 1950. These decontamination efforts were focused to meet the AEC criteria in effect at  
15 that time, and the plants were released for use without radiological restrictions in 1951; however,  
16 no documentation of the results of these activities has been found.  
17

18 During 1950 and 1951, operations began at Plant 6E and 7, and Plant 4 was modified and  
19 used as a metallurgical pilot plant for processing uranium metal until it was closed in 1956. AEC  
20 operations in Plant 6E ended in 1957; AEC managed decontamination efforts (removal of  
21 contaminated buildings, equipment, and soil) in Plants 4 and 6E to meet AEC criteria in effect at  
22 that time and returned the plants to Mallinckrodt in 1962 for use without radiological restrictions.  
23 Since 1962, some buildings have been demolished, and new buildings have been constructed at  
24 Plants 4 and 6.  
25

26 Plant 7 was designed to produce green salt and was also used for storing reactor cores and  
27 for removing metallic uranium from slag by a wet grinding/mill flotation process (Mason 1977).  
28 Plant 7 was released for use with no radiological restrictions in 1962 following decontamination  
29 that met AEC criteria in effect at that time and is now used primarily for storage.  
30

31 Because of the highly industrialized nature of SLDS and the industrial history of the area  
32 near the site, a decision was made to seek representative soil samples in the area near SLDS.  
33  
34

## 35 1.2 SUMMARY OF PREVIOUS SAMPLING

36

37 Sampling of soil, sediment air, ground water, and buildings during past investigative  
38 activities at SLDS has focused on the collection of samples and measurements to characterize the  
39 radiochemical contamination in excess of DOE guidelines. Table 1-1 is a listing of the date of  
40 previous sampling events and details for SLDS. In the course of these investigations,  
41 characterization of the site geology, hydrogeology, and contaminant migration potential has been  
42 completed (SAIC 1994).  
43

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**Table 1-1. Previous sampling activities at SLDS**

Date of sampling/survey	Type of survey	Purpose of sampling	Activities completed	Analysis completed
1977	Screening survey	Radiological survey to identify areas of concern	Walkover radiation survey, drilling and sediment sampling.	Field survey for elevated radiation
1987	Phase I	Determine the horizontal and vertical extent of contamination, identifying other areas of contamination	Utilities survey, walkover gamma scan, surface soil samples from 297 locations, subsurface soil sampling and gamma logging of 109 boreholes.	Radiochemicals, metals, VOCs, semivolatiles, and RCRA hazardous wastes characteristics.
1988-1989	Phase II	Focus on completing data collection for new areas identified during Phase I.	Drilling, sampling, and gamma logging of an additional 109 boreholes, installation and sampling of ground-water monitoring wells. Survey for residual radioactivity in 84 manholes with sludge or sediment samples collected when possible.	Samples from 51 of the boreholes analyzed for chemical constituents.

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Previous sampling during the drilling of Phase I and Phase II borings samples at SLDS identified a suite of eighteen metals that exceeded maximum expected background concentrations. In addition to metals, these borings detected low levels of volatile organic compounds (VOCs) and twenty-seven base/neutral and acid extractable (BNAE) organics. BNAE distribution did not follow a discernible distribution pattern but occurred in most boreholes (BNI 1994). A limitation to this data interpretation is the background screening levels used. Background concentration ranges for metals were derived from soils collected at various locations in the United States and other parts of the world (BNI 1994) and therefore are likely not representative of SLDS background levels. The focus on radiochemical parameters and the use of DOE guideline criteria has resulted in limited background information on the chemicals present within the SLDS soils.

Sampling of soil for background levels of chemicals was completed during the Phase II activities with the drilling of four boreholes to the west of SLDS at Hyde Park during September 1992. These borings, designated B16C88, 89, 90, and 91 were sampled at multiple depths up to 12 below ground surface over two foot intervals. Soil sample analysis included volatile organics, semivolatile organics, and metals and are summarized in Table 1-2. The data from these borings will be used in conjunction with other boreholes drilled as per the details of this SAP. Note volatile and semi-volatile organics were detected at these locations.



1  
2  
Table 1-2. Summary of analytes detected for 1992 background borings for SLDS

Analyte	Results >Detection Limit	Minimum Detect <sup>a</sup>	Maximum Detect	Average Result	Minimum Variance
<b>Metals (mg/kg)</b>					
Aluminum	11/11	6050	10600	7580	7570
Arsenic	11/11	4.40	7.70	5.70	5.70
Barium	11/11	108	288	173	173
Beryllium	11/11	0.47	1.10	0.61	0.61
Boron	11/11	21.90	51.20	29.90	34.20
Cadmium	4/11	1.60	3	1.35	1.79
Calcium	11/11	1890	11300	4170	4170
Chromium	11/11	9.50	21.20	13.30	13.30
Cobalt	11/11	6.20	13.70	9.75	10.80
Copper	11/11	15.20	26.80	20	22.50
Iron	11/11	12900	22100	17100	17100
Lead	11/11	11.30	225	45.40	81.60
Magnesium	11/11	1080	5630	2660	2660
Manganese	11/11	337	1230	813	813
Mercury	3/11	0.08	0.15	0.05	0.08
Molybdenum	4/11	1.20	8.40	1.58	1.58
Nickel	11/11	12.60	24.40	20.30	22.40
Potassium	11/11	578	1060	732	732
Selenium	1/10	0.56	0.56	0.26	0.32
Sodium	11/11	120	232	155	155
Vanadium	11/11	18.60	25.80	21.90	21.90
Zinc	11/11	45.20	133	69.60	87
<b>Semivolatile Organics (ug/kg)</b>					
Acenaphthalene	2/11	18	22	165	165
Anthracene	2/11	47	68	172	172
Benzo(a)anthracene	4/11	19	310	171	171
Benzo(a)pyrene	4/11	14	290	166	166
Benzo(b)fluoranthene	4/11	15	320	169	169
Benzo(g,h,i)perylene	2/11	71	190	186	186
Benzo(k)fluoranthene	3/11	21	220	158	158
Carbazole	2/11	24	35	167	167
Chrysene	4/11	24	350	177	177
Di-n-butylphthalate	11/11	88	190	110	110
Dibenz(a, h)anthracene	2/11	36	86	173	173
Fluoranthene	4/11	42	590	222	222
Fluorene	1/11	19	19	180	180
Indeno(1, 2, 3-c, d) pyrene	2/11	83	230	190	190
Pentachlorophenol	1/11	34	34	440	440
Phenanthrene	4/11	21	370	188	188
Pyrene	4/11	39	690	223	223
bis(2-Ethylhexyl)phthalate	10/11	31	98	57.90	57.90
<b>Volatile Organics (ug/kg)</b>					
Acetone	2/11	11	120	30.50	30.5
Ethylbenzene	1/11	1	1	7.73	7.73
Toluene	10/10	6	980	131	88.4

3<sup>a</sup> Results less than detection limit were set to 1/2 the reported detection limit.

1                   **2. PROJECT ORGANIZATION AND RESPONSIBILITIES**

2

3

4                   The organization chart shown in Figure 2-1 outlines the management structure that will  
5 be used to implement the project. The functional responsibilities of key personnel are described  
6 in the following parts of this section. The assignment of personnel to each project position will  
7 be based on a combination of (1) experience in the type of work to be performed, (2) experience  
8 working with United States Army Corps of Engineers (USACE) personnel and procedures, (3) a  
9 demonstrated commitment to high quality and timely job performance, and (4) staff availability.

10

11

12                   **2.1 SAIC DELIVERY ORDER MANAGER**

13

14                   The Science Applications International Corporation (SAIC) Project Manager ensures the  
15 overall management and quality of all SAIC Formerly Utilized Sites Remedial Action Program  
16 (FUSRAP) projects performed under USACE contracts. This individual will ensure that all  
17 project goals and objectives are met in a high-quality and timely manner. Quality assurance  
18 (QA) and nonconformance issues will be addressed by this individual, in coordination with the  
19 SAIC Project Manager, for corrective action.

20

21

22                   **2.2 SAIC QUALITY ASSURANCE/QUALITY CONTROL OFFICER**

23

24                   The SAIC Quality Assurance/Quality Control (QA/QC) Officer is responsible for the  
25 project QA/QC in accordance with the requirements of the project Quality Assurance Project  
26 Plan (QAPP), other work plan documentation, and appropriate management guidance. This  
27 individual, in coordination with the SAIC Chemical Quality Control (CQC) Representative, will  
28 be responsible for participating in the project field activity readiness review; approving variances  
29 during field activities before work continues; approving, evaluating, and documenting the  
30 disposition of Nonconformance Reports (NCRs); overseeing and approving any required project  
31 training; and designing audit/surveillance plans followed by supervision of these activities. The  
32 SAIC QA/QC Officer reports directly to the SAIC FUSRAP Program Manager.

33

34

35                   **2.3 SAIC HEALTH AND SAFETY OFFICER**

36

37                   The SAIC Health and Safety Officer is responsible for ensuring that health and safety  
38 procedures designed to protect personnel are maintained throughout the field activities. This will  
39 be accomplished by strict adherence to the project Site Safety and Health Plan (SSHP), which  
40 has been prepared as a separate document for this project. This individual, in coordination with  
41 the SAIC Site Safety and Health Officer (SSHO), will have the authority to halt field work if  
42 health and/or safety issues arise that are not immediately resolvable in accordance with the  
43 project SSHP. The SAIC Health and Safety Officer and SSHO report directly to the SAIC  
44 FUSRAP Program Manager.

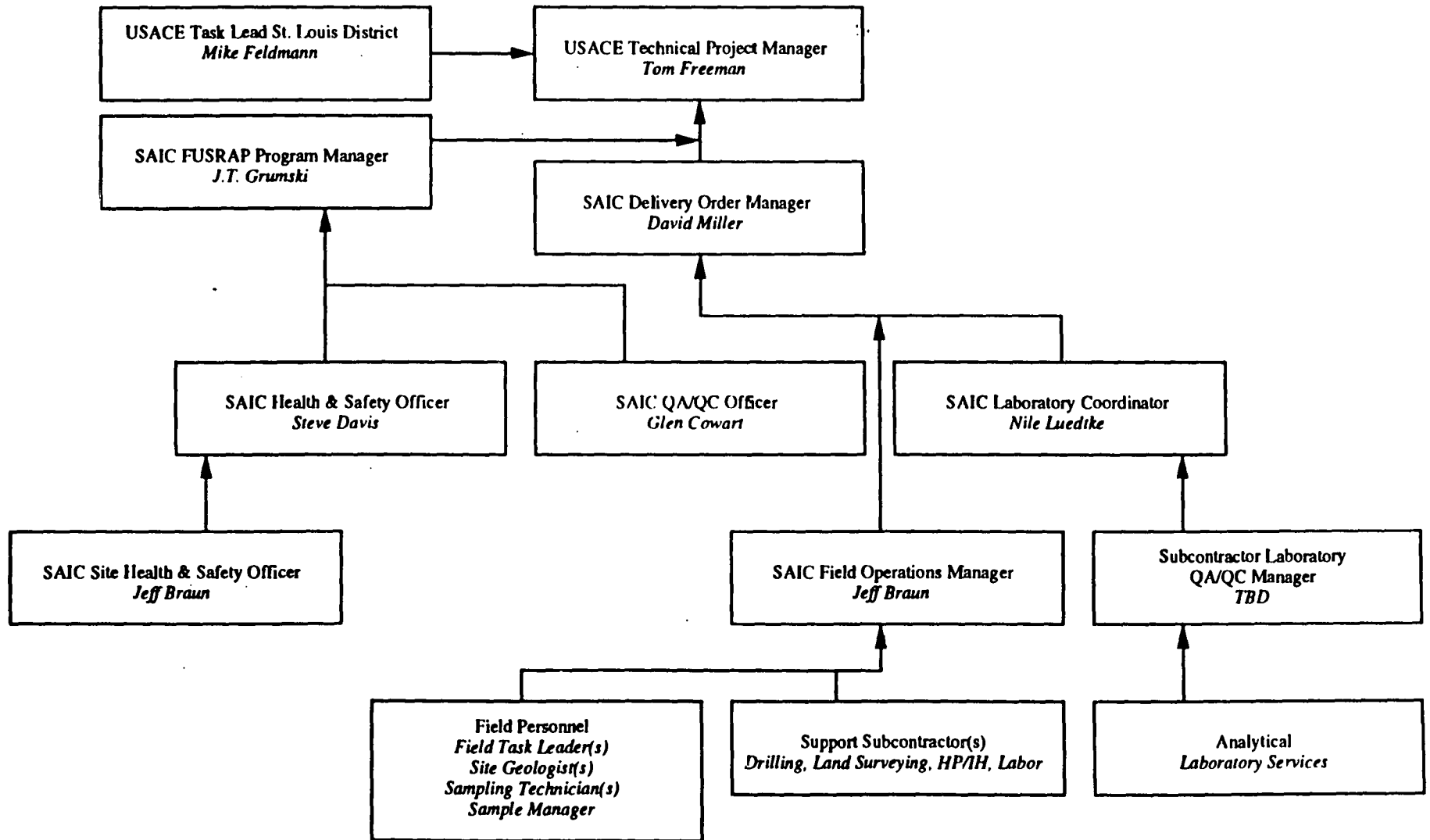


Figure 2-1. Project Organization Chart for St. Louis Downtown Site Background Soil SAP Investigation

1 **2.4 SAIC LABORATORY COORDINATOR**

2  
3 The SAIC Laboratory Coordinator is responsible for coordination of sample collection,  
4 and subsequent chemical analysis and data reporting performed by the subcontract laboratories,  
5 in accordance with the requirements defined in the QAPP. This individual will also coordinate  
6 the shipment of QA samples to the USACE QA Laboratory, which has been designated as the  
7 government QA laboratory for the project. This individual will be responsible for obtaining  
8 required sample containers from the laboratory for use during field sample collection, resolving  
9 questions the laboratory may have regarding QAPP requirements and deliverables, and  
10 coordination of reduction, validation, and documentation activities related to sample data package  
11 deliverables received from the laboratory. The SAIC Laboratory Coordinator reports directly to  
12 the SAIC Delivery Order Manager.  
13

14  
15 **2.5 SAIC FIELD OPERATIONS MANAGER**

16  
17 The SAIC Field Operations Manager (FOM) is responsible for implementing all field  
18 activities in accordance with the FSP and the QAPP. This individual is responsible for ensuring  
19 proper technical performance of drilling operations and field sampling activities, adherence to  
20 required sample custody and other related QA/QC field procedures, coordination of field personnel  
21 activities, management of investigation-derived wastes, checks of all field documentation, and  
22 preparation of Field Change Orders if required. The SAIC FOM reports directly to the SAIC  
23 Delivery Order Manager except with regard to QA/QC matters that are reported directly to the  
24 SAIC QA/QC Officer.  
25

26  
27 **2.6 SAIC FIELD PERSONNEL**

28  
29 In addition to the SAIC FOM, other SAIC field personnel participating in the  
30 implementation of field activities are anticipated to be a site geologist and a sampling technician.  
31 These individuals, in coordination with field subcontractor personnel, will be responsible for  
32 performance of drilling operations, collection of soil and ground-water samples, and preparation  
33 of field logbooks and other required documentation. These individuals will be responsible for  
34 performing all field activities in accordance with this FSP, and report directly to the SAIC FOM.  
35

36  
37 **2.7 SUBCONTRACTOR FIELD PERSONNEL**

38  
39 Companies that have been, or will be, subcontracted by SAIC to perform various field  
40 services during the project were previously identified at the beginning of this FSP section.  
41 Subcontractor field personnel, under the supervision of the SAIC FOM, will be responsible for  
42 performing their specific scopes of work that have been incorporated into the FSP. These  
43 individuals will be required to review applicable sections of the FSP, and the entire SSHP, prior  
44 to field mobilization. All subcontractor field personnel report directly to the SAIC FOM who  
45 will be responsible for ensuring that all subcontractor activities comply with project requirements.

### 3.0 SCOPE AND OBJECTIVE

The primary objective of the activities presented in this SAP is to collect and analyze soil samples for chemical and radiological concentrations with the resulting data to be used as representative of background concentrations at the SLDS site. This background analytical data set will be the relative baseline against which past and future sample analyses will be compared and screened (i.e., concentrations exceeding background values are related to operations at the site). To be representative, the number of sample locations must be statistically valid and the locations chosen must be representative of the soils found on the SLDS site.

#### 3.1 SELECTION OF NUMBER OF SAMPLE LOCATIONS

The sample design for collection of background samples at SLDS falls within the statistical realm of nonparametric statistics. Nonparametric testing assumes no knowledge whatsoever about the distribution of the population to be tested (i.e., the distribution of chemical concentrations at the selected background locations). A key element of this test type are the tolerance limits; defined as the amount of error acceptable in a data set. Tolerance limits are defined in terms of degrees of confidence and are selected by the sampler. The degree of confidence is a function of the sample size (n). As the background data set will be used as a relative maximum concentration, the concern is with the highest levels of chemical concentrations, therefore tolerance limits are one sided. The rule for one sided tolerance limits states:

*For any distribution of measurements, a one-sided tolerance limit is given by the largest observation in a sample of size n, where n is determined so that one can assert with  $100\gamma\%$  confidence that at least the proportion  $1-\alpha$  of the distribution will exceed the largest observation in the sample (Walpole and Myers 1978).*

{For this discussion, (n) will be the number of sample locations, but could be applied to the number of samples per interval (e.g., 5 to 10 ft)}.

For example, when  $\gamma=0.95$  and  $1-\alpha=0.90$ , a sample size of  $n=29$  in order to be 95% confident that only 10% of the soil contaminant concentration values will exceed the largest value of the entire population of samples collected from the sample area (Table XXII, Walpole and Myers 1978). If it is necessary to be confident that only 5% of the samples will exceed the largest concentration, then the number of samples goes up to 59.

For this background sampling event, a sample size of 15 (i.e., 15 boring locations) has been chosen. This size will allow 90% confidence that only 15% of the soil concentration values will exceed the largest value of the collected data set.

1 **3.2 SELECTION OF SAMPLE LOCATIONS**  
2

3 Due to present activities, the placement of utilities, the past history of the area near  
4 SLDS, and possible difficulties in obtaining permission to sample, the locating of sample sites  
5 will be a challenge. It is intended that all sample sites will be selected with bias and located in  
6 the area surrounding SLDS. In this regard, the data collected will be relative to the SLDS site  
7 (i.e., indicative of levels expected in this setting). [The previous sampling of the SLDS site has  
8 collected chemical data from soils primarily within areas known to be contaminated with  
9 radiochemicals and this information is useful in selecting sites at which not to locate a  
10 background boring].  
11  
12

13 **3.3 SAMPLE INTERVAL**  
14

15 The collection of soil samples will be performed during the drilling of each boring using  
16 a compositing method to ensure representative sampling. Sampling will commence at a minimum  
17 of 2 ft below ground surface and continue until native nondisturbed soil is encountered, as  
18 determined by the onsite geologist. The sample interval will be 5 ft, the length of a standard  
19 length of a large volume split sampling spoon. Samples will be from a composited mixture  
20 consisting of soil removed from the entire interval. VOC samples will be collected prior to  
21 compositing the interval. Field screens for VOCs will be performed upon initial opening of the  
22 sample spoon.

## 4.0 FIELD SAMPLING

### 4.1 SOIL SAMPLING

#### 4.1.1 Location

Soil samples will be taken from approximately 15 of 20 proposed locations (Figure 4-1) near the SLDS. Some of these sample locations may be deleted or relocated due to inaccessibility or if the property is determined to have been environmentally impacted by past activities. The area is considered representative of the soils found at the SLDS because of soil origin and historical use of the area. The area to be sampled for background soil is bounded by Broadway to the west, the Mississippi River to the east, Grand Avenue to the north, and North Market Street to the south. Soil collection and QA procedures for field sampling will be consistent with those discussed for the SLAPS SAP.

#### 4.1.2 Analyte List, Detection Limits, and Methods

A full suite of organic and inorganic chemicals and radiological constituents will be analyzed. The list of analytes, the detection limits for each analyte, and the proposed analytical methods are outlined in Table 4-1.

## 4.2 CIVIL SURVEY

### 4.2.1 Background Soil Boring Locations

A civil survey will be conducted at the completion of all drilling and sampling to provide as-built coordinates and elevations of all background soil boring locations.

#### 4.2.1 Existing Monitoring Wells

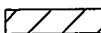

A civil survey will also be conducted of all existing FUSRAP monitoring wells at SLDS. The coordinates will be determined for each well location, as well as the elevations for: 1) the top of riser casing, 2) ground surface, and 3) top of protective surface casing.

**Horizontal Control.** Each background soil boring location and monitoring well location will be surveyed to determine its map coordinates referenced to the Missouri State Plane (NAD 83). The horizontal survey will have an accuracy of 1 foot (third order, Class II control surveys in accordance with the Standards and Specifications for Geodetic Control Networks Federal Geodetic Control Committee 1984). Locations of wells will be measured at the rim of the uncapped well casing.

**Vertical Control.** Each background soil boring location and monitoring well location will be topographically surveyed. For the monitoring wells, the riser casing elevation will be surveyed at a V-notch cut into the top of the riser casing. The ground surface elevation adjacent



**LEGEND:**

-  St. Louis Downtown Site Location
-  Proposed Background Soil Sample Location



Science Applications  
International Corporation

St. Louis Downtown Site Proposed  
Background Soil Sample Location  
St. Louis, Missouri

Source: Granite City Quadrangle, Illinois-Missouri USGS/USACE 7.5 Min. Series

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**Figure 4-1. Proposed Background Soil Sample Locations**



**Table 4-1. Analytical/Methods, Parameters, and Project Quantitation Limits  
for St. Louis Site Investigations**

Parameters	Analytical Methods		Project Quantitation Levels <sup>a</sup>	
	Water	Soil/Sediment	Water	Soil/Sediment
<b>Volatile Organic Compounds (VOC)</b>	SW 846-8260B	SW 846-8260B	(µg/L)	(µg/Kg)
Chloromethane			10	10
Bromomethane			10	10
Vinyl Chloride			2	2
Chloroethane			10	10
Methylene Chloride			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
1,1,-Trichloroethane			5	5
Carbon tetrachloride			5	5
Bromodichloromethane			5	5
1,2-Dichloropropane			5	5
cis-1,3-Dichloropropene			5	5
Trichloroethene			5	5
Dibromochloromethane			5	5
1,1,2-Trichloroethane			5	5
Benzene			5	5
trans-1,3-Dichloropropene			5	5
Tribromomethane			5	5
4-Methyl-2-pentanone			10	10
2-Hexanone			10	10
Tetrachloroethene			5	5
Toluene			2	2
1,1,2,2-Tetrachloroethane			5	5
Chlorobenzene			5	5
Ethylbenzenc			5	5
Styrene			5	5
Xylenes (total)			5	5
<b>Semivolatile Organic Compounds (SVOCs)</b>	SW 846-3520/8270C <sup>b</sup>	SW 846-3550/8270C <sup>b</sup>		Low Soil/Sediment <sup>a</sup>
Phenol			10	330
bis(2-Chloroethyl) ether			10	330

**Table 4-1. Analytical/Methods, Parameters, and Project Quantitation Limits  
for St. Louis Site Investigations (continued)**

Parameters	Analytical Methods		Project Quantitation Levels <sup>a</sup>	
	Water	Soil/Sediment	Water	Soil/Sediment
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
4-Chlorophenyl-phenyl ether			10	330
Fluorene			10	330
4-Nitroaniline			25	800

**Table 4-1. Analytical/Methods, Parameters, and Project Quantitation Limits  
for St. Louis Site Investigations (continued)**

Parameters	Analytical Methods		Project Quantitation Levels <sup>a</sup>	
	Water	Soil/Sediment	Water	Soil/Sediment
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
<b>Pesticides/PCBs</b>	<b>SW 846-8080C</b>	<b>SW 846-8080C</b>		
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

**Table 4-1. Analytical/Methods, Parameters, and Project Quantitation Limits  
for St. Louis Site Investigations (continued)**

Parameters	Analytical Methods		Project Quantitation Levels <sup>a</sup>	
	Water	Soil/Sediment	Water	Soil/Sediment
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
<b>PCBs</b>	SW 846-8080	SW 846-8080	(µg/L)	(µg/Kg)
Toxaphene			5.0	170
Arochlor-1016			0.5	33
Arochlor-1221			0.5	67
Arochlor-1232			0.5	33
Arochlor-1242			0.5	33
Arochlor-1248			0.5	33
Arochlor-1254			0.5	33
Arochlor-1260			0.5	33
<b>Herbicides</b>	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
MCPA			1	20
MCPP			1	20
2,4,5-TP (Silvex)			0.5	10
2,4,5-T			0.5	10
<b>Metals (Target Analyte List) plus Uranium</b>	SW 846-3010A/ 6010A, 6020A, or 7000 series <sup>b</sup>	SW 846-3050A/ 6010A, 6020A, or 7000 series <sup>b</sup>		(mg/Kg) <sup>c</sup>
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

**Table 4-1. Analytical/Methods, Parameters, and Project Quantitation Limits  
for St. Louis Site Investigations (continued)**

Parameters	Analytical Methods		Project Quantitation Levels <sup>a</sup>	
	Water	Soil/Sediment	Water	Soil/Sediment
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			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
Uranium			50	5
<b>Metals, Selected Rare Earths</b>	SW 846-3010A/ 6010A or 6020A	SW 846-3050A/ 6010A or 6020A		
Cerium			10	1.0
Erbium			10	1.0
Gadolinium			10	1.0
Lanthanum			10	1.0
Neodymium			10	1.0
Praseodymium			10	1.0
Samarium			10	1.0
Thulium			10	1.0
Yttrium			10	1.0
<b>Cyanide</b>	SW 846-9010 or 9012	SW 846-9011/ 9010 or 9012	(mg/L) 10	0.5
<b>pH</b>	SW 846-9045	SW 846-9045	NA	NA
<b>Radiochemical Parameters</b>			pCi/L	pCi/g
Gamma Spectral Scan	Gamma Spec. <sup>c</sup>	Gamma Spec. <sup>c</sup>	Gamma Spec. <sup>c</sup>	NA
Iso-Uranium 234, 235, 238	Alpha Spec. <sup>c</sup>	Alpha Spec. <sup>c</sup>	1 ea.	1 ea.
Iso-Thorium 228, 230, 232	Alpha Spec. <sup>c</sup>	Alpha Spec. <sup>c</sup>	1 ea.	1 ea.
Radium 226, 228	Rn Emination or Alpha Spec. <sup>c</sup>	Alpha or Gamma Spec. <sup>c</sup>	1 ea.	1 ea.
Protactinium-231	Alpha Spec. <sup>c</sup>	Alpha Spec. <sup>c</sup>	1	1

**Table 4-1. Analytical/Methods, Parameters, and Project Quantitation Limits  
for St. Louis Site Investigations (continued)**

Parameters	Analytical Methods		Project Quantitation Levels <sup>a</sup>	
	Water	Soil/Sediment	Water	Soil/Sediment
Actinium-227	Alpha Spec. <sup>c</sup>	Alpha Spec. <sup>c</sup>	1	1
<b>Geophysical Analysis</b>				
Grain Size (sieve and pipette)	—	ASTM D422	—	NA
Atterberg Limits	—	ASTM D4318	—	NA
Moisture Content	—	ASTM D2216	—	NA

- 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. 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 DOE Environmental Measurements Laboratory Procedure Manual (HASL-300), will be submitted for the project files.

1 to each well will also be measured. The protective surface casing will be surveyed from the rim  
2 of the casing with the cover removed. The survey will be connected by third order leveling to  
3 the National Geodetic Vertical Datum of 1929 in accordance with the Standards and  
4 Specifications for Geodetic Control Networks (Federal Geodetic Control Committee 1984). All  
5 vertical survey data will have an accuracy of at least 0.01 foot.  
6

7 **Field Data Report.** The topographic survey will be performed as soon as possible after  
8 completion background drilling and sampling activities at the site. Survey field data (as  
9 corrected), to include loop closures and other statistical data in accordance with the standards  
10 and specifications referenced above, will be provided to the SAIC Project Manager. Closure will  
11 be within the horizontal and vertical limits referenced above. The following data will be clearly  
12 listed in tabular form: coordinates (and system) and elevations (ground surface, top of riser  
13 casing, and top of protective surface casing), as appropriate, for all borehole and well locations,  
14 and reference marks. All permanent and semipermanent reference marks used for horizontal and  
15 vertical control (i.e., benchmarks, caps, plates, chiseled cuts, rail spikes, etc.) will be described in  
16 terms of their name, character, physical location, and reference value.  
17

18 The topographic survey will be led/conducted by an individual licensed in an appropriate  
19 classification with the state of Missouri for the specific work anticipated to be conducted. This  
20 license will be current and active throughout the term of performance during the project.

## 5. SAMPLE CHAIN OF CUSTODY/DOCUMENTATION

### 5.1 FIELD LOGBOOK

All information pertinent to drilling and sampling activities, including field instrument calibration data, will be recorded in field logbooks as outlined in the SAP and QAPP for the SLAPS and Contiguous Properties. Field documentation will follow the methodology described in detail in Section 3 of the SAP and Sections 4 and 5 of the QAPP.

Sufficient information will be recorded in the logbooks to permit reconstruction of all drilling and sampling activities conducted. Information recorded on other project documents (e.g., boring logs, etc.) will not be repeated in the logbooks except in summary form where determined necessary. Possession of all field logbooks will follow the suggested practices outlined in Section 3 of the SLAPS and Contiguous Properties.

### 5.2 SAMPLE NUMBERING SYSTEM

A unique sample numbering scheme will be used to identify each sample designated for laboratory analysis. 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 and/or logbooks, COC records, and all other applicable documentation used during the site-specific investigation. A listing of all sample identification numbers will be maintained in the field logbook.

The sample number used for field samples will also be used for QA split duplicate samples. However, other types of field QC samples (i.e., equipment rinsate, trip blank, etc.) will be numbered so that they can be readily identified from other sample types. The location/sample identification naming conventions to be used for this background soil investigation are presented in Figure 5-1.

### 5.3 SAMPLE DOCUMENTATION

#### 5.3.1 Sample Labels and/or Tags

The use of sample labels and/or tags will follow the methodology outlined in Section 3 of the SAP and Sections 4 and 5 of the QAPP for the SLAPS and the Contiguous Properties. All sample containers provided by the contracted analytical laboratory for use during the site-specific investigation will be shipped with sample labels pre-affixed to the containers, or the labels will be affixed to the bottles upon delivery to the investigation site. Information will be recorded on each sample container label at the time of sample collection. However, if preprinted labels are used, only field-specific information not already on the labels will be recorded at the time of sample collection.



1

XXX-AAmmNNNNn-#### – to be used for data base reporting

XXX#### – to be used for sample collection and delivery to lab

XXX = Site Designator

St. Louis Downtown Site = SLD

St. Louis Airport Site = SLA

Hazelwood Interim Storage Site = HIS

Coldwater Creek Watershed = CCW

AAA = Area Designator

Investigation Area 1 = IA1 (for IA1–IA9, then A10–A99, or others as identified)

Background = BKG

etc. (can include designators for Site vicinity properties)

mm = Media

Surface Soil = SS

Subsurface Soil Boring = SB

Sediment = SD

Ground Water = GW

Surface Water = SW

Storm Water = ST

Aquatic Biota = AB

Terrestrial Biota = TB

Air Filter = AF

Radon Detector = RD

TLDs = TD

Quality Control = QC

etc. (as new media types are identified)

NNNN = Station Number

Unique station identifier

n = Sample Type

Regular = 0

Trip Blank = 3

Duplicate = 1

Equipment Rinsate = 4

Split = 2

Site Source Water Blank = 5

#### = Sequential Sample Number

Unique to each site

2

3

**Figure 5-1. Location/Sample Identification Naming Conventions**

1 An example of sample label type used for this investigation is illustrated in Section 3 of  
2 the SAP for the SLAPS and Contiguous Properties.

### 3 4 **5.3.2 Chain-of-Custody Records** 5

6 The chain-of-custody (COC) record documentation will follow the methodology  
7 described in detail in Section 3 of the SAP and Sections 4 and 5 of the QAPP. SAIC will utilize  
8 EPA Region VII COC protocols for this investigation, as described in EPA Procedure 330/9-  
9 78DDI-R "NEIC Policies and Procedures" (EPA 1985). COC procedures implemented for the  
10 investigations will provide documentation of the handling of each sample from the time of  
11 collection until completion of laboratory analysis. The field copy of the form will be appropriately  
12 filed and kept at the site for the duration of the site activities.

13  
14 An example of the COC form that will be used for this investigation is illustrated in  
15 Section 3 of the SAP for the SLAPS and Contiguous Properties.

### 16 17 **5.3.3 Receipt of Sample Forms** 18

19 The contracted laboratory will document the receipt of environmental samples by accepting  
20 custody of the samples from the approved shipping company. In addition, the contracted  
21 laboratory will document the condition of the environmental samples upon receipt as outlined in  
22 Section 3 of the SAP for the SLAPS and the Contiguous Properties. For samples sent to a  
23 USACE QA laboratory that are suspected or known to be hazardous, a sample characterization  
24 form will be included with other required laboratory paperwork.

## 25 26 27 **5.4 DOCUMENTATION PROCEDURES** 28

29 The tracking procedure to be utilized for documentation of all samples collected during  
30 this investigation will following the steps outlined in Section 3 of the SAP and Sections 4 and 5  
31 of the QAPP for the SLAPS and the Contiguous Properties.

## 32 33 34 **5.5 CORRECTIONS TO DOCUMENTATION** 35

36 All original information and data in field logbooks, on sample labels, on COC forms, and  
37 on any other project-related documentation will be recorded in black waterproof ink and in a  
38 completely legible manner. Errors made on any accountable document will be corrected by  
39 crossing out the error and entering the correct information or data as outlined in Section 3 of the  
40 SAP and Sections 4 and 5 of the QAPP for the SLAPS and the Contiguous Properties. Any error  
41 discovered on a document will be corrected by the individual responsible for the entry. Erroneous  
42 information or data will be corrected in a manner which will not obliterate the original entry, and  
43 all corrections will be initialed and dated by the individual responsible for the entry.  
44  
45

1 **5.6 MONTHLY REPORTS**  
2

3 Monthly Reports will be submitted during implementation of the field investigations.  
4 The Monthly Reports will focus on the progress to date of this investigation and will be  
5 submitted directly to the USACE-Kansas City District Project Manager by the 10th day of the  
6 month following the reporting period. The Monthly Reports will contain the following  
7 information: (1) site identification and activities; (2) status, (3) percent complete; (4) data  
8 collected to date (excluding analytical results); (5) difficulties encountered; (6) corrective actions;  
9 and (7) planned activities. Due to the short field duration ( $\approx 1$  month), it is expected that no more  
10 than 2 monthly reports will be provided.



## 7.0 INVESTIGATION DERIVED WASTE

Investigation Derived Waste (IDW) includes all materials generated during performance of an investigation that cannot be effectively reused, recycled, or decontaminated in the field. IDW consists of materials that could potentially pose a risk to human health and the environment (e.g., sampling and decontamination wastes) and materials that pose no risk to human health and the environment (e.g., sanitary solid wastes). The types of IDW anticipated to be generated during field activities are (1) soil cuttings, (2) residual soil samples, (3) decontamination solids and fluids, and (4) noncontaminated compactible and miscellaneous trash. Procedures to be used for management of project IDW are described below. A discussion of IDW generation and disposition is included in this SAP, however, off-site disposition of IDW is not included in the current Delivery Order.

All solid IDW generated from drilling the boreholes will be collected initially on plastic sheeting during drilling and temporarily stockpiled until completion of drilling activities. Field screening will be performed to determine the appropriate disposition of the soil IDW (i.e. drill cuttings and residual soil samples). Should field screening indicate no evidence of contamination in the soil, the soil will be returned to the borehole as backfill upon completion of drilling. The soil will be collected in lined, 55-gallon drums should the field screening indicate the presence of contamination. After completion of drilling activities, the drummed IDW will be placed in a satellite storage area and will be managed in accordance with the final remedy for the site. Uncontaminated compactible and miscellaneous trash (e.g. uncontaminated PPE) will be collected in trash bags and disposed of at an approved refuse collection point, or will be transported off site for proper disposal.

All liquid IDW will be stored in closed-top A1A/X1.8/300 steel drums or other type of container that will facilitate handling. Liquid IDW will include water generated from decontamination of the sampling equipment. All liquid IDW will be stored in a designated field staging area. IDW will be segregated so that all solid and liquid wastes generated at a given borehole location will be containerized in a designated set of drums assigned to that location.

Waste storage containers will be labeled to ensure proper management of the contained wastes. The following procedure will be used to label waste storage drums:

- Two labels will be placed opposite of each other on the upper one-third of each container.
- Each label will be placed on a smooth part of the container and will not be affixed across drum bungs, seams, ridges, or dents.
- Information to be recorded on each label will include the following:
  - contents
  - source of waste
  - source location

- 1           – project name and site identification
- 2           – physical characteristics of the waste
- 3           – generation date(s), and
- 4           – responsible USACE district.

5

6           An example of the waste storage drum labels to be used for the project is illustrated in  
7 Figure 7-1.

8

9           IDW suspected to be contaminated will be sampled and analyzed for all potential COCs.  
10 Immediately upon receiving information that hazardous waste is present, SAIC will contact the  
11 USACE Project Manager and inform him of this situation. SAIC will implement additional  
12 sampling and analysis of this hazardous waste only upon receiving a modification to the existing  
13 delivery order, or receiving a new delivery order specifically addressing management of this  
14 waste. If the material is determined not to be a hazardous waste, it will be dispositioned to a  
15 local publicly owned treatment works (POTW).

16

17           SAIC will prepare and submit an IDW Disposal Report to the USACE Project Manager  
18 that will present an inventory of the wastes generated during the project and recommended  
19 disposal means, including estimated costs. Disposal of hazardous wastes will not be conducted  
20 until approval of the method(s) and cost, if applicable, for the disposal is received from the  
21 USACE Project Manager.

22

**WASTE CONTAINER LABEL**

DRUM NUMBER \_\_\_\_\_

CONTENTS \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

SOURCE OF WASTE \_\_\_\_\_

SOURCE LOCATION \_\_\_\_\_

COMMENTS \_\_\_\_\_  
\_\_\_\_\_

WASTE TYPE:    ( ) LIQUID   ( ) SOLID  
GENERATION DATE(S) \_\_\_\_\_

U.S. Army Corps of Engineers – St. Louis District

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**Figure 7-1. Example of Waste Storage Drum Label**

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## 8. CONTRACTOR CHEMICAL QUALITY CONTROL

The Contractor Chemical Quality Control (CCQC) program to be utilized for this investigation will follow procedures outlined in Section 3 of the SAP and Sections 4 and 5 of the QAPP for the SLAPS and the Contiguous Properties. The site-specific investigation will consist of three phases. The three CCQC phases will be the preparatory phase, the initial phase, and the follow-up phase, all of which will be performed by SAIC whether or not a USACE-Kansas City District representative is present. The SAIC CQC representative responsible for implementation and documentation of the CCQC program and definable features of work that will comprise the CCQC program will be identified in the SAP.

The preparatory phase of the CCQC program will be conducted by the SAIC CQC representative before beginning each definable feature of work. A summary of all activities performed during each preparatory phase meeting will be documented by the SAIC CQC representative in a meeting minutes record. Each preparatory phase meeting will address the following:

- Review of all pertinent sections of the SAP in order to ensure that all field personnel are cognizant of the overall project DQOs, specific project activities to be accomplished, and specific sampling and analysis requirements.
- Actual calibration of all instruments to be used for measurement of field parameters using certified calibration standards, gases, etc.
- Physical examination of all materials and equipment required to accomplish the specific project activities.
- Demonstration of equipment decontamination procedures in accordance with the SAP.
- Demonstration of how each sample type is to be collected, containerized, documented, and packaged.
- Demonstration of proper IDW management and documentation.
- Demonstration of the procedure for completing all required information to be recorded on sample custody forms and discussion of the project sample numbering system. Completed examples of a COC form, sample container label, and IDW drum label will be provided to the field personnel for reference.
- Demonstration/discussion of any other activities to be performed as deemed necessary by the SAIC CQC representative.
- Examination of the work area(s) to ascertain if all preliminary work is complete.



- 1           • Review of preparatory phase field equipment and support materials checklists. The  
2 contents of the field equipment checklist and supporting materials checklist will be  
3 presented in the site-specific investigation addenda. An example of the QA table that  
4 will be used to match up primary and QC samples is presented in Figure 8-1.  
5

6           In addition to the activities noted above, the SAIC CQC representative will ensure that  
7 the USACE QA laboratory has been contacted to schedule receipt and analysis of the government  
8 QA samples. This will be accomplished by review of the telephone log used to document the  
9 laboratory contact.  
10

11           The initial phase of the CCQC program will be conducted by the SAIC CQC representative  
12 and will include the following:  
13

- 14           • oversight of drilling, well installation construction and development, and/or sampling  
15 activities and review of this work to ensure compliance with delivery order  
16 requirements;  
17
- 18           • inspection of individual sample labels and COC forms for accuracy, completeness, and  
19 consistency;  
20
- 21           • inspection of sample packaging and shipping activities;  
22
- 23           • observation, verification, and documentation of initial and ongoing field instrument  
24 calibration;  
25
- 26           • inspection of field logbooks and other field records/sketches to ensure that all pertinent  
27 data are recorded in accordance with delivery order requirements; and  
28
- 29           • inspection of the QA sample match-up table to ensure that all samples collected  
30 during each day are documented properly.  
31

32           The follow-up phase of the CCQC program will be conducted by the SAIC CQC  
33 representative and will involve performing the various activities noted for the initial phase on a  
34 daily basis until completion of the particular definable feature of work.

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## 9. DAILY CHEMICAL QUALITY CONTROL REPORTS

During the field activities performed for this investigation, Daily Chemical Quality Control Reports (DCQCRs) will be prepared, signed, and dated by the SAIC Sample Manager. An example of the DCQCR format to be used is illustrated in Section 3 of the SAP for the SLAPS and the contiguous properties. These reports will be submitted to the USACE-Kansas City District Project Manager at the end of each 10-day working cycle. The contents of each DCQCR will include a summary of activities performed at the project site, weather information at the time of sampling, results of measurements made with field instruments, results of CCQC activities performed including field instrument calibrations, departures from the approved SAP, problems encountered during field activities, and any instructions received from government personnel. Any deviations that may affect the project DQOs will be immediately conveyed to the USACE-Kansas City District Project Manager.

## 10. PROJECT SCHEDULE

The project schedule for the various tasks defined in this FSP is presented in Figure 10-1.

## SLDS Background Soil Characterization Activities

ID	Task Name	Duration	4/12/98	4/19/98	4/26/98	5/3/98	5/10/98	5/17/98	5/24/98	5/31/98	6/7/98	6/14/98	6/21/98	6/28/98	7/5/98	7/12/98	7/19/98	7/26/98
1	Issue Draft SLDS Sap (SLAPS SAP Appendix)	1 day	4/17															
2	Review Period	10 days	4/20		5/1													
3	Incorporate Comments	9 days		5/4		5/14												
4	Issue Final SAP (SLAPS SAP Appendix)	1 day					5/15											
5	Mobilize to Field	5 days				5/18		5/22										
6	Sampling	10 days					5/25		6/5									
7	Receive Sample Data from Laboratories (5-day TAT)	1 day																
8	Issue Draft SLDS Background Sampling Report	1 day												6/26				
9	Review Period	10 days											6/29					
10	Incorporate Comments	10 days														7/10		
11	Issue Final SLDS Background Sampling Rept	1 day															7/13	7/24

H-40

Project: SLDS Background Soil Chara Date: Tue 4/14/98	Task  Milestone Split  Summary Progress  Rolled Up Task	Rolled Up Split Rolled Up Milestone Rolled Up Progress	External Tasks Project Summary
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## 11. CORRECTIVE ACTIONS

### 11.1 SAMPLE COLLECTION AND FIELD MEASUREMENTS

The corrective actions that may be implemented during this investigation will follow guidelines set forth in Sections 4 and 10 of the QAPP for the SLAPS and Contiguous Properties. Corrective actions will be implemented in the event that a discrepancy is discovered by field personnel, laboratory personnel, and/or during a field or desk audit. The initial responsibility for monitoring the quality of field activities and measurements lies with the field personnel. These personnel are responsible for following QA procedures, while the SAIC Sample Manager is responsible for verifying that these procedures are being followed. This verification requires that the SAIC Sample Manager assess the correctness of the field methods and the ability of the field team to meet the QA objectives and to make a subjective assessment of the impact that a procedure has on the field objective and resulting data quality. The field variance system is discussed in detail in Section 4 of the QAPP. Examples and discussions of the use of a field change order and a nonconformance report are present in Sections 4 and 10, respectively in the QAPP.

### 11.2 LABORATORY ANALYSES

In the event that a laboratory problem occurs that might jeopardize the integrity of the project analytical results, cause a QA objective not to be met, or affect data quality, the first action taken will be an assessment of the severity of the problem by the SAIC Laboratory Coordinator. If the problem is determined to be minor, the SAIC Laboratory Coordinator will initiate an appropriate corrective action, which will be recorded in a memorandum submitted to the SAIC Project Manager. The SAIC Project Manager will then relate the corrective action to be implemented to the SAIC Sample Manager and/or SAIC QA/QC Officer if the problem is associated with activities being performed in the field. If the problem is determined to be significant, the SAIC Laboratory Coordinator will initiate an Analytical Data Package Nonconformance Report, illustrated in Section 10 of the QAPP, which will be submitted to the SAIC QA/QC Officer and addressed in the same manner as described in Section 11.1 of this FSP. Analytical nonconformance reports will be copied to the USACE-Kansas City District Project Manager. The determination of corrective actions are discussed in detail in Section 10 of the QAPP.

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**ATTACHMENT TO APPENDIX H**

**SITE SAFETY AND HEALTH PLAN  
FOR  
SAMPLING AND ANALYSIS OF BACKGROUND SOILS AT AND NEAR THE  
ST. LOUIS DOWNTOWN SITE  
AT  
ST. LOUIS, MISSOURI**

Prepared for:

U.S. Army Corps of Engineers  
Omaha District

Prepared by:

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April 1998

**SCIENCE APPLICATIONS INTERNATIONAL  
CORPORATION**

contributed to the preparation of this document and should not  
be considered an eligible contractor for its review.



COMMITMENT TO IMPLEMENT THE ABOVE SITE  
SAFETY AND HEALTH PLAN

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## LIST OF ACRONYMS

ACGIH	American Council of Government Industrial Hygienists
AST	above-ground storage tank
ASTM	American Society of Testing and Materials
CB	chemical/biological
CPR	cardiopulmonary resuscitation
EC&HS	Environmental Compliance and Health and Safety (program)
EEMG	Engineering and Environmental Management Group
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
FP	flash point
GFCI	ground fault circuit interrupter
HTRW	hazardous, toxic, and radioactive waste
IDLH	immediately dangerous to life and health
IP	ionization potential
IWTP	Industrial Wastewater Treatment Plant
LEL	lower explosive limit
MCL	maximum contaminant level
MSDSs	Material Safety Data Sheets
NIOSH	National Institute of Occupational Safety and Health
OEW	Ordnance and Explosive Waste
OJT	on-the-job training
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Agreement
RFI	RCRA Facility Investigation
SAIC	Science Applications International Corporation
SMCL	secondary maximum contaminant level
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
STEL	short-term exposure limit
SWMU	Solid Waste Management Unit
TCLP	toxicity characteristic leaching procedure
TLV	threshold limit value
TPH	total petroleum hydrocarbons
TWA	time-weighted average
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
UST	underground storage tank

## 1.0 INTRODUCTION

### 1.1 GENERAL

SAIC maintains a corporate Environmental Compliance and Health and Safety (EC&HS) program intended to ensure safe operation and regulatory compliance. The company's corporate policy states "It is the policy of SAIC to take every reasonable precaution to protect the health and safety of our employees, the public, and the environment." This policy statement further says that "Any employee found to have intentionally or negligently violated this policy shall be subject to disciplinary action up to and including dismissal." As a result of this program and policy, SAIC maintains a favorable insurance modifier rate or EMR (1994 - 0.52, 1995 - 0.59, 1996 - 0.65).

SAIC's EC&HS program document, together with site safety and health plans, present the requirements for safely performing field work. This SSHP sets forth the basic procedures required to protect SAIC and subcontractor personnel involved in the field phase of this project. It also establishes practices to protect the public and the immediate environment from hazards caused by this work. SAIC personnel and subcontractors are required to review this plan prior to onsite project participation. SAIC subcontractors are further required to verify that the hazard controls contained in this plan are sufficient to protect their employees, and if not, to supplement this plan with additional and sufficient controls. Standard procedures will be used to minimize the potential for personnel injury or illness. These will include site-specific training, routine inspections, visual and instrument surveillance for hazards, and enforcement of the health and safety requirements by project management.

This document is designed to satisfy the requirements of Appendix B to ER 385-1-92, "Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) and Ordnance and Explosive Waste (OEW) Activities," the requirements of EM 385-1-1, "U.S. Army Corps of Engineers Safety and Health Requirements Manual," relevant Occupational Safety and Health Administration regulations, and the SAIC EC&HS Manual. All work conducted during this project is required to be conducted in compliance with relevant OSHA regulations, USACE requirements (specifically EM 385-1-1), SAIC's EC&HS program and this SSHP.

This SSHP is included as an attachment to the project Work Plan. In cases where required information is contained in the work plan or in one of the other attachments, this information will be referenced rather than repeated in this SSHP. See the Work Plan for site maps and detailed site information. Both the Work Plan and this SSHP must be on site during field work and accessible to employees and subcontractors.

The general scope of this project is to collect subsurface soil samples from neighboring properties (approximately 12 locations) to establish ambient conditions in locations that have not been influenced by the processing of radioactive materials by Mallinckrodt. Field work will also



include locating and surveying existing groundwater wells in the area. Field tasks to be performed by SAIC and its subcontractor include:

- drilling of soil boreholes with hollow-stem auger.
- collection of soil samples from boreholes.
- equipment decontamination, and
- visual and civil surveying

The primary hazards posed by the planned tasks are physical hazards associated with drill rigs and potential exposure to radioactive and chemical contaminants. It appears that the probability of encountering dangerous concentrations of chemical or radiological contamination is remote. Standard procedures (gloves, hand washing) will be utilized to prevent unacceptable exposure to contaminants. Real time monitoring will also be conducted.

This project will be performed in Level D and Level D+ personal protective equipment (PPE) unless one of several action levels specified in the plan are exceeded or the potential for increased risk becomes apparent during the field activities. If the work scope changes to include intentional sampling in areas of known chemical or radiological contamination, or if monitoring instruments indicate contamination, these hazard controls must be reassessed and modified as needed. The Site Safety and Health Officer (SSHO) will perform and document a daily safety inspection and will observe all work tasks to verify that hazard controls are appropriate and sufficient. Protective procedures, including protective clothing, will be upgraded as necessary by the SSHO based on established action levels or judgment. Changes in hazard controls that result in a decrease in protective measures must have prior approval of the EEMG Project Manager and H&S Manager. Upgrades in protective measures work stoppages necessitated by an on-site determination that controls are insufficient will be made as necessary, with subsequent notification of the Project Manager and H&S Manager.

EM 385-1-1 requires specific items of information to be included in a Project Accident Prevention Plan. Table 1-1 gives the locations of these specific items within SAIC's program documents and this SSHP.

## 1.2 SITE DESCRIPTION

The St. Louis Downtown Site (SLDS) is located in St. Louis, Missouri, in an industrial area immediately west of the Mississippi river and south of the McKinley Bridge. SLDS consists of the Mallinckrodt property and adjacent commercial and city owned properties, collectively referred to as the vicinity properties. The Mallinckrodt property covers approximately 45 acres (18.2ha) and contains many buildings that house Mallinckrodt offices and chemical processing operations. The vicinity properties surrounding the Mallinckrodt facility include a large metals recycling company (McKinley Iron Works) to the north; the Mississippi River (behind a levee), a defunct food processing company (PVO Foods), and City of St. Louis property to the east; a lumber yard (Thomas and Proetz Lumber) and a large salt producer/distributor (Gunther Salt) to the south; and North Broadway and small businesses to the west. Several active rail lines cross the property. The entire

area is heavily industrialized and is crossed by overhead process piping and electrical lines as well as buried utilities including sewer, sprinkler, water, and natural gas.

From 1942 to 1957, the former Mallinckrodt Chemical Works performed work at the SLDS under contract with the MED and AEC. The work included development of uranium-processing techniques, production of forms of uranium compounds and metal, and recovery of uranium metal from residues and scrap. This work included the processing of uranium ore to produce uranium metal. The process including digestion of uranium ore in acid, solvent extraction, treatment with hydrofluoric acid, and treatment with magnesium. Following completion of these contracts, the site grounds and buildings were remediated to meet the AEC requirements in effect at that time. Many of the buildings used during the 1942 to 1957 activities have since been removed and replaced by other buildings. Mallinckrodt Inc. has continued to operate a chemical processing businesses at this facility. The Mallinckrodt property and some of the surrounding properties are known to be contaminated with radium, thorium, and uranium. In addition, various chemical components are also known or suspected to be present. These include arsenic, cadmium, copper, nickel, trichloroethene, toluene, hexane, etc. Previous site investigation reports and the feasibility study published in 1998 concluded that the contaminants resulting from uranium processing (1942-1957) posed a minimal hazard under current conditions but might pose an unacceptable hazard under some potential future use.

**Table 1-1. SSHP Accident Prevention Plan Information**

Requirement	Location of Information
Signature sheet	SSHP, inside front cover
Background information	SSHP front cover and introduction
Statement of safety and health policy	EC&HS Program Document
Responsibilities and lines of authority	SSHP Section 3
Subcontractors and suppliers	SSHP Section 3
Training	EC&HS Proc. 20, SSHP Section 4
Safety and health inspections	SSHP Section 3.5
Safety and health expectations, incentive programs, and Compliance	EC&HS Policy Statement, EC&HS Program Implementation Guide C.2 - Discipline
Accident reporting	EC&HS Proc. 4 & 6, SSHP Sections 3.3, 3.4, 3.5, and 11
Medical support	SSHP Section 11
Personal protective equipment	SSHP Section 5
Emergency response	SSHP Section 11
Contingency plans	SSHP Section 11
Job cleanup and safe access	SSHP Section 8.1
Public safety requirements	SSHP Sections Introduction, 8, and 11
Local requirements	None
Prevention of alcohol/drug abuse on the job	Policy A 18, Drug and Substance Abuse
Hazard Communication	EC&HS Procedure 8 and SSHP Sections 4 and 8.11

## 2.0 HAZARD/RISK ANALYSIS

The purpose of this site task hazard analysis is to identify and assess potential hazards that may be encountered by site personnel and to prescribe required controls. Table 2-1 is a checklist of common hazards that may be posed by this type of project. It includes negative declarations for hazards that will not be encountered. If additional tasks or significant hazards are encountered during the work, this document will be modified by addendum or field change order to include the additional information. Downgrades in protective measures require prior approval of the EEMG H&S Manager and Project Manager. Upgrades will be made as needed, with subsequent notification of Project Manager and H&S Manager. Changes to this plan will be documented with addenda, field change orders, hazardous work permits or similar documents.

**Table 2-1. Hazards Inventory**

Yes	No	Hazard
	X	Biological hazards
	X	Confined space entry
	X	Drowning
X		Electrical shock
	X	Excavation entry
X		Exposure to chemicals
X		Fire
	X	Unexploded ordnance
X		Heavy equipment
X		Noise
X		Traffic
X		Contact with overhead or buried utilities
X		Radiation or radioactive contamination
X		Temperature extremes
X		Lifting

### 2.1 TASK-SPECIFIC HAZARD ANALYSIS

A number of intrusive and non-intrusive tasks are planned for this project. These major tasks include:

- civil surveying.
- soil boring and subsurface soil sampling using hollow stem auger rigs, and
- equipment decontamination.

The non-intrusive tasks (visual and civil surveying) pose a very limited potential for exposure to radiological and chemical contamination. These tasks also pose limited physical hazards as well.

since these tasks will not involve heavy equipment, loud noises, power tools, working at heights or other physical hazards.

Intrusive tasks utilizing heavy equipment (soil boring with hollow stem auger rigs) pose more significant physical hazards. Contact with moving equipment, being struck by falling equipment, and noise, are all hazards associated with heavy equipment use. Equipment decontamination poses significantly lesser physical hazards but contact with steam or hot water and noise overexposure is possible. These tasks also pose a greater probability of radiological and chemical contamination because potentially contaminated soils will be uncovered and handled. The intrusive sampling locations will be selected to avoid contamination associated with Mallinckrodt's previous uranium processing work. The sampling locations may be contaminated with materials from Mallinckrodt's other activities or material from the activities of other firms. The extent of contamination from the activities of other firms is not known but it can be assumed that there will be at least some contamination because the area has been heavily industrialized for many years.

Table 2-2 presents task-specific hazards, task-specific hazard analyses, relevant hazard controls, and required monitoring, if appropriate, for all of the planned site tasks. The hazard analyses are derived through a qualitative risk assessment process using a matrix of probability codes and severity codes. The probability codes are high = likely to occur immediately, moderate = probably will occur in time, low = possible to occur in time, and very low = unlikely to occur. The severity codes are high = injuries/illnesses involving permanent total disability or death, moderate = injuries/illnesses with permanent partial disability or temporary total disability, low = injuries/illnesses resulting in temporary, reversible conditions with period of disability of less than 3 months, and very low = injuries/illnesses with reversible adverse effects requiring only minor treatment.

## 2.2 POTENTIAL EXPOSURES

The locations to be sampled during this field work will be selected to avoid contamination associated with Mallinckrodt's prior processing of uranium ore. The intent of the sampling is to assess ambient levels of contamination on nearby industrialized properties. For this reason, existing information concerning contamination on the Mallinckrodt property can only be used as a guide. It is probable that the selected sites will be contaminated with heavy metals and industrial solvents. It is also probable that none of these sites will be sufficiently contaminated to pose a significant short term or long term hazard to site personnel as long as reasonable standard procedures are followed. To be prudent, SAIC and subcontractor personnel will operate with the assumption that these sites may be contaminated and will apply procedures such as using gloves to handle potentially contaminated material, washing faces and hands before eating and drinking, etc.

Information on the significant suspected contaminants and chemical tools that will be used for the project is contained in Tables 2-3 and 2-4. Note that this list does not include all the contaminants that have been detected. Only those contaminants with relatively low exposure limits and that are present in relatively great concentrations have been listed in Table 2-3. Other contaminants, including arsenic, beryllium, chromium, lead, tetrachloroethene, polynucleararomatic,

and polychlorinated biphenyls have been detected at concentrations greater than background. If additional contaminants or chemical tools that pose new or significantly greater hazards are identified prior to, or during, site activities, they will be provided as an addendum to this document.

Table 2-2. Hazards Analysis

Safety and Health Hazards	Probability/ Severity	Controls	Monitoring
<b>Visual surveying, topographic surveying, other non-intrusive tasks</b>			
General safety hazards	Very low/ very low	Level D PPE (see Section 5.0). Buddy system. Site-specific training, HAZWOPER 40-hour training	Daily safety inspections
Biological hazards (bees, ticks, wasps, poison ivy)	Very low/low	PPE: (boots, work clothes, taped pant legs if necessary) Insect repellent if necessary	Visual survey
Exposure to chemicals (see Table 2.3 and 2.4)	Very low/ Very low	Level D PPE including nitrile or PVC gloves for contact with potentially contaminated materials Medical clearance for HAZWOPER work Wash face and hands prior to taking anything by mouth	Daily site safety inspections
Radiological contamination (See Table 2.3 and 2.4)	Very low/ Very low	PPE (Level D) including nitrile or PVC gloves for contact with potentially contaminated material  Medical clearance for HAZWOPER work	TLDs Personnel and eqpt. surveyed following contact with potentially contaminated material
Temperature extremes	Low/ Low	Administrative controls (see Section 8.0).	Temperature measurements as appropriate; heart rate monitoring as appropriate
<b>Soil boring and sampling using hollow stem auger drill rig</b>			
General safety hazards (rotating machinery, suspended loads, moving equipment, lifting, slips, falls)	Low/low	Level D PPE (see Section 5.0), buddy system No employees under lifted loads. Exclusion zone around rig. Only necessary and experienced personnel within exclusion zone, two functional kill switches, functional back-up alarm, drill rig operating manual on-site, lifts of >75 lbs will be performed by two or more personnel or using mechanical assistance, extensive heavy lifting will require additional lifting training. HAZWOPER 40-hour training, standard procedures (see Section 8.14)	Daily site safety inspections Daily drill rig inspections
Noise	High/moderate	Hearing protection within 25 feet of rig, unless site-specific monitoring indicates noise <85 dBA	Daily safety inspections

**Table 2-2. Hazards Analysis (continued)**

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Safety and Health Hazards	Probability/ Severity	Controls	Monitoring
Fire (fuels)	Low/low	Fuel stored in safety cans with flame arresters Fire extinguisher rated ≥20B 25 to 75 feet from flammables storage Flammables cabinet for indoor storage of ≥25 gallons No ignition sources in fuel storage areas Fuel storage areas marked with "No Smoking or Open Flame" signs Bonding (metal to metal contact) during pouring Gasoline powered equipment shut down during fueling	Daily safety inspections
Exposure to chemicals (see Table 2.3 and 2.4)	Very low/low	PPE (Level D) including nitrile or PVC gloves for contact with potentially contaminated material. Medical clearance for HAZWOPER work Minimal contact, wash face and hands prior to taking anything by mouth	PID or equivalent and other sampling as appropriate
Radiological hazards (See Table 2.3 and 2.4)	Low/Low	PPE (Level D) including nitrile or PVC gloves for contact with potentially contaminated material. Exclusion zone around drilling sites. If cuttings and soil are dry apply water spray to suppress dust Medical clearance for HAZWOPER work Minimal contact, radiological frisk, wash face and hands prior to taking anything by mouth. Seats of vehicles & equipment used in exclusion zone must be non-porous free of holes or cracks	Daily site safety inspection  Contamination surveys conducted in exclusions zone and at exit from zone
Temperature extremes	Moderate/ moderate	Administrative controls (see Section 8.16)	Temperature measurements as appropriate; heart rate monitoring as appropriate
Biological hazards (bees, ticks, wasps, poison ivy)	Very low/Low	PPE (boots, work clothes, tape pant legs if needed) Insect repellent, if necessary	Visual survey
Electric shock and other utility related hazards	Low /High	Identification and clearance of overhead and underground utilities (See Section 8.0)	Visual of all work areas Digging clearance from local utilities and/or one-call system
<b>Equipment decontamination (hot water washing, soap and water washing, isopropyl alcohol washing)</b>			
General equipment decontamination hazards (hot water, slips, falls, equipment handling)	Very low/ very low	Level D PPE (see Section 5.0)	Daily site safety inspections

**Table 2-2. Hazards Analysis (continued)**

Safety and Health Hazards	Probability/ Severity	Controls	Monitoring
Steam/hot water	Low/low	Level D+ PPE including Face shield, heavy duty PVC or similar gloves Saranax suit, rain suit, or splash apron optional (when operating steam washer)	Daily site safety inspections
Noise (spray washer and generator)	Moderate/ moderate	Hearing protection within 25 feet when washer is operating unless equipment-specific sound level measurements indicate noise <85 dBA	Daily site safety inspections
Fire (isopropanol and gasoline)	Very low/low	Fuel stored in safety cans with flame arresters Fire extinguisher rated ≥20B 25 to 75 feet from flammables storage Flammables cabinet for indoor storage of ≥25 gallons No ignition sources in fuel storage areas Fuel storage areas marked with "No Smoking or Open Flame" signs Bonding (metal to metal contact) during pouring Gasoline powered equipment shut down during fueling	None
Exposure to chemicals (see Table 2.3 and 2.4)	Very low/low	Level D PPE including nitrile or PVC gloves for contact with potentially contaminated materials Medical clearance for HAZWOPER work Wash face and hands prior to taking anything by mouth	Daily site safety inspections
Radiological hazards (See Table 2.3 and 2.4)	Low/low	PPE (Level D) including nitrile or PVC gloves and face shield. Medical clearance for HAZWOPER work Minimal contact, radiological frisk if monitoring at drill sites indicated contamination, wash face and hands prior to taking anything by mouth.	Daily site safety inspection
Temperature extremes	Moderate/ moderate	Administrative controls (see Section 8.16)	Temperature measurements as appropriate; heart rate monitoring as appropriate
Electrical shock	Low/moderate	GFCI for electrical equipment	Daily site safety inspections as appropriate

- GFCI = ground fault circuit interrupter
- PID = photoionization detector
- PPE = personal protective equipment
- PVC = polyvinyl chloride



**Table 2-3. Site Contaminants**

Contaminant	Reported Concentration			Medium
	Minimum	Maximum	Average	
Radium 226	0.4 pCi/g	5,400 pCi/g	11 - 87 pCi/g depending on plant	Soil at Mallinckrodt site
Thorium 230	0.3 pCi/g	14,000 pCi/g	14 - 270 pCi/g depending on plant	
Thorium 232	0.4 pCi/g	440 pCi/g	2.2 - 7.0 pCi/g depending on plant	
Uranium 238	1/0 pCi/g	20,000 pCi/g	21 - 1300 pCi/g depending on plant	Soil at Mallinckrodt site

**Table 2-4. Potential Exposures**

Chemical	TLV, PEL, STEL, IDLH or DAC <sup>a</sup>	Health Effects/ Potential Hazards <sup>b</sup>	Chemical and Physical Properties <sup>b</sup>	Exposure Route(s) <sup>b</sup>
Arsenic	PEL/TWA: 0.01 mg/m <sup>3</sup> ; IDLH: Ca [5 mg/m <sup>3</sup> ]	Dermatitis, nasal tissue damage, stomach upset, potential cancer	Solid; VP: 0 mm; FP: NA	Inhalation, Ingestion, Absorption, Contact
Gasoline (fuel)	TLV/TWA: 300 ppm IDLH: NA	Dizziness, eye irritation, dermatitis; flammable liquid	Liquid with aromatic odor; FP: -45°F	Inhalation, Ingestion, Contact
Isopropyl alcohol (used for equipment decontamination)	TLV/TWA: 400 ppm STEL: 500 ppm	Irritation of eyes, skin, respiratory system; headache, drowsiness; flammable liquid	Colorless liquid; VP: 33 mm; IP: 10.10 eV; FP: 53°F	Inhalation, Ingestion
Lead	TLV/TWA: 0.05 mg/m <sup>3</sup> , A3 PEL/TWA: 0.05 mg/m <sup>3</sup> IDLH: 100 mg/m <sup>3</sup>	Weakness, anorexia, abdominal pain, anemia	Solid metal; VP: 0 mm; FP: NA; IP: NA	Inhalation, Ingestion, Contact
Liquinox (used for decontamination)	TLV/TWA: NA	May cause local irritation to mucus membranes	Aqueous liquid, odorless, nonflammable	Ingestion, Contact
Radium 226	2mR/hr 3 × 10 <sup>-10</sup> uCi/mL	Cancer	Solid; VP: NA; FP: NA	Inhalation, Ingestion, Contact
Thorium 232	2mR/hr 5 × 10 <sup>-11</sup> uCi/mL	Cancer	Solid; VP: NA; FP: NA	Inhalation, Ingestion, Contact
Thorium 230	3 × 10 <sup>-12</sup> uCi/mL 2mR/hr	Cancer	Solid; VP: 0 FP: NA	Inhalation, Ingestion, Contact
Tetrachloroethene	TLV: 25 ppm, A3; Skin notation PEL: 100 ppm IDLH: Ca [150 ppm]	Irritation of eyes and nose, vomiting, dizziness, liver cancer	Liquid with chloroform odor; VP: 14 mm; FP: NA; IP: 9.32 eV	Inhalation, Ingestion, Absorption, Contact
Uranium 238	2mR/hr 3 × 10 <sup>-10</sup> uCi/mL	Cancer	Solid; VP: NA; FP: NA	Inhalation, Ingestion, Contact

<sup>a</sup> From 1997 Threshold Limit Values, NIOSH Pocket Guide to Chemical Hazards, or 10 CFR 20.

<sup>b</sup> From NIOSH Pocket Guide to Chemical Hazards.

- |       |   |  |      |   |                            |
|-------|---|--|------|---|----------------------------|
| FP    | = | flash point  | PEL  | = | permissible exposure limit |
| IDLH  | = | immediately dangerous to life or health              | STEL | = | short-term exposure limit  |
| IP    | = | ionization potential                                 | TLV  | = | threshold limit value      |
| NA    | = | not available  | TWA  | = | time-weighted average      |
| NIOSH | = | National Institute of Occupational Safety and Health | VP   | = | vapor pressure             |

### 3.0 STAFF ORGANIZATION, QUALIFICATIONS, AND RESPONSIBILITIES

This section presents the lines of authority, responsibilities, and communication procedures concerning site safety and health and emergency response. It includes key SAIC and subcontractor personnel. All field work will be under the supervision of the SAIC Field Manager. The SAIC Field Manager will oversee normal and emergency work and will perform any required emergency notification. Table 3-1 identifies the individuals who will fill key roles for the project field activities.

**Table 3.1. Staff Organization**

Position	Name	Phone
Program Manager	David Miller	314-209-2955
Health and Safety Manager	Steve Davis CIH, CSP	423-481-4755
Project Health Physicist	George Stephens, CHP	423-481-4720
Project Manager	Wayne Tolbert	423-481-8703
Field Manager	Jeff Braun	423-481-4600
Site Safety and Health Officer	Jeff Braun	423-481-4600

#### 3.1 SAIC PROGRAM MANAGER

The SAIC Program Manager is responsible for ensuring conformance with SAIC Corporate, SAIC Engineering and Environmental Management Group (EEMG), and the United States Army Corps of Engineers (USACE) policies and procedures. Specific responsibilities of the Program Manager include:

- coordinating with USACE personnel;
- ensuring that project managers satisfy SAIC and USACE health and safety requirements;
- ensuring that project staff implement the project SSHPs; and
- ensuring that projects have the necessary resources to operate safely.

#### 3.2 SAIC HEALTH AND SAFETY MANAGER

The SAIC Health and Safety Manager manages the EEMG health and safety program. This includes establishing health and safety policies and procedures, supporting project and office activities, and verifying safe work practices and conditions. The SAIC Health and Safety Manager is certified in the comprehensive practice of industrial hygiene by the American Board of Industrial Hygiene, is certified as a safety professional by the Board of Certified Safety Professionals, and has more than fifteen years of hazardous waste experience. The specific responsibilities of the Health and Safety Manager include:

- conducting on-site audits during field work;

- coordinating with USACE health and safety personnel;
- reviewing and approving SSHPs;
- approving downgrades in PPE or protective procedures;
- reviewing monitoring data;
- reviewing accident reports; and
- recommending changes to engineering controls, work practices, and PPE.

### **3.3 SAIC PROJECT MANAGER**

The SAIC Project Manager is responsible for overall project execution. The responsibilities of the Project Manager include:

- coordinating with USACE personnel, including reporting accidents and incidents to the USACE Project Manager immediately and submitting written reports within two working days;
- ensuring implementation of the project SSHP;
- maintaining auditable project documentation of all required records;
- ensuring that a qualified SSHO is designated; and
- maintaining a current copy of the project SSHP.

### **3.4 PROJECT HEALTH PHYSICIST**

The project health physicist will address radiological hazards associated with the project. The project health physicist's qualifications include certification and over 10 years of experience. Specific responsibilities include:

- providing or reviewing radiation portions of SSHP;
- conducting site training and audits as needed; and
- assessing radiological exposure measurements.

### **3.5 SAIC FIELD MANAGER**

The SAIC Field Manager will oversee the field activities associated with the project and will be responsible for site accessibility, safety, and quality assurance. He/she is responsible for enforcing the field requirements of this SSHP. Specific responsibilities of the Field Manager are listed below:

- enforcing compliance with the project SSHP:

- coordinating on-site operations, including subcontractor activities;
- ensuring that subcontractors follow the requirements of this SSHP;
- coordinating and controlling any emergency response actions;
- ensuring that at least two persons currently certified in first aid/cardiopulmonary resuscitation (CPR) are on site during site operations;
- performing (or ensuring) a daily safety inspection and documenting the inspection on the daily safety inspection form attached; and
- maintaining current copies of the project SSHP, and the SAIC EC&HS Manual on site.

### **3.6 SAIC SITE SAFETY AND HEALTH OFFICER**

The SAIC SSHO is responsible for making health and safety decisions, for specific health and safety activities, and for verifying the effectiveness of the health and safety program. The SSHO's qualifications include, at a minimum, current HAZWOPER training, HAZWOPER Supervisor training, experience with similar projects, knowledge of and understanding of the project SSHP, and the ability to use the required monitoring equipment. The SSHO has primary responsibility for the following:

- implementing and verifying compliance with this SSHP and reporting to the Field Manager, Project Manager, and Health and Safety Manager any deviations from anticipated conditions;
- conducting and documenting daily safety inspections;
- completing the health and safety debrief in EC&HS Procedure 20;
- documenting deficiencies identified in the daily inspections and responsible parties, procedures, and timetables for correction;
- stopping work or upgrading protective measures (including protective clothing) if uncontrolled health and safety hazards are encountered. Indications of uncontrolled health and safety hazards include monitoring instrument readings in excess of the established action limits, encountering liquids other than water, soil staining suggestive of unexpectedly high concentrations of nonvolatile contaminants, etc. The SSHO must also authorize resumption of work following correction of the adverse condition(s);
- ensuring that site personnel have access to this plan and are aware of its provisions;

- conducting a site-specific pre-entry health and safety briefing covering potential chemical and physical hazards, safe work practices, and emergency procedures;
- maintaining on-site auditable documentation of
  - Material Safety Data Sheets (MSDSs) for applicable materials utilized at the site,
  - training for site workers and visitors,
  - calibration/maintenance of field instruments such as photoionization detectors (PID), combustible gas indicators, radiation monitoring equipment, etc.,
  - environmental and personal exposure monitoring results,
  - notification of accidents/incidents,
  - reports of any chemical overexposure or excessive levels,
  - notification of employees of chemical exposure data, and
  - medical surveillance;
- confirming that all on-site personnel have received the training listed in the Training Requirements section (Section 4.0) of this SSHP;
- issuing respirators, as necessary, and ensuring that all respirator users have received medical clearance within the last year, have been properly trained, and have been successfully fitted for respiratory protection;
- verifying that the project SSHP's emergency points of contact are correct;
- ensuring that all monitoring equipment is operating according to the manufacturer's specifications and performing field checks of instrument calibration;
- ensuring monitoring for potential on-site exposures is conducted in accordance with this SSHP;
- updating the project SSHP (field changes) to ensure that it adequately identifies all tasks and significant hazards at the site and notifying project personnel and the SAIC Health and Safety Manager of changes;
- investigating accidents and near accidents and reporting (in concert with Field Manager) same to Project Manager and Health and Safety Manager;
- conducting daily "tailgate" safety briefings; and
- controlling visitor access to the exclusion zone.

### **3.7 HEALTH PHYSICS TECHNICIAN**

Health physics technicians are responsible for assessing radiological exposures, verifying that radiological control practices are being implemented and stopping work if controls are insufficient.

HP technicians will be trained to at least the requirements at 385-1-1 Section 6. Specific duties include:

- performing entry and exit surveys of equipment;
- performing or verifying surveys of personnel leaving controlled areas;
- performing air sampling, as needed, and
- observing work in controlled areas to verify compliance with radiological controls.

### **3.8 SUBCONTRACTOR FIELD MANAGER**

The Subcontractor Field Manager will oversee the field activities of his/her employees. He/she is responsible for enforcing the field requirements of this SSHP. Specific responsibilities are listed below:

- ensuring that his/her personnel on site follow the requirements of the project SSHP and any other applicable health and safety requirements [Occupational Safety and Health Administration (OSHA); equipment-specific controls, state requirements];
- verifying that this SSHP adequately addresses the hazards and controls of the subcontracted work, and supplementing the information in the SSHP, if necessary;
- ensuring the safe operation of any subcontractor equipment;
- coordinating on-site operations of his/her personnel; and
- maintaining any required documentation (for example, drill rig manual) specific to his/her operations.

## 4.0 TRAINING

Personnel who participate in field activities associated with this project are subject to the training requirements presented in Table 4-1. Field activities include all the tasks specified in Section 2.0 of this plan as well as any other unspecified tasks that take place within the exclusion zones, contamination reduction zones, or support zone of the RFI site. Examples of such other tasks include conveying sampling equipment to field crews, observing field crews, transporting samples within the confines of the site, etc. Activities such as driving or walking on paved roads that are not within potentially contaminated areas, paperwork or meetings inside routinely occupied (safe) buildings, and paperwork and similar activities inside office trailers are not field activities and are not subject to these training requirements. Casual visitors, such as package deliverers, who access only the office or staging areas of the support zone are not subject to these training requirements.

**Table 4-1. Training Requirements**

Training	Worker	Supervisor	Site visitor
Hazardous Waste Safety (40 hour, 3 day OJT)	✓	✓	✓
Hazardous Waste Safety Annual Refresher (8 hour)	✓	✓	✓
Hazardous Waste Safety Supervisors Training (8 hour)	X	✓	X
General Hazard Communication Training (Contained in 40-hour and 8-hour courses)	✓	✓	✓
Respiratory Protection Training (required only if respirators are worn; contained in 40-hour course)	✓	✓	✓
Hearing Conservation Training (for workers in hearing conservation program; contained in 40-hour and 8-hour courses)	✓	✓	✓
Site Worker Training	✓	✓	X
Site Specific Hazard Communication (contained in pre-entry briefing)	✓	✓	X
Safety Briefing (daily and whenever conditions or tasks change)	✓	✓	X
Site Visitor Training	X	X	✓
First Aid/CPR (Standard Red Cross or Equivalent)	≥2 workers	X	X

- ✓ = Required
- X = Not required
- OJT = on-the-job training

### 4.1 OFF-SITE TRAINING

The 40-hour Hazardous Waste Safety course is required for HTRW activities in the exclusion (contamination) zone, contamination reduction (buffer) zone, and for any activity that poses a potential to encounter hazardous waste associated hazards. Three days of relevant field experience is required in conjunction with this training.



The 8-hour Hazardous Waste Safety Refresher course is required annually to maintain currency in the 40-hour course.

The Hazardous Waste Safety Supervisors Training is required for personnel who directly supervise hazardous waste site workers. This is an 8-hour course that must be taken once. Note that the 40-hour course is a prerequisite.

General Hazard Communication Training is required for all site workers. This training must communicate the risks and protective measures for chemicals that employees may encounter. This requirement is met by taking the 40-hour Hazardous Waste Site Worker course, annual refreshers, and site-specific training.

Respiratory Protection Training is required for all individuals who wear respirators. This requirement is met by taking the 40-hour Hazardous Waste Site Worker course, annual refreshers, and site-specific training.

Hearing Conservation Training is required on an annual basis by 29 CFR 1910.95 for all employees enrolled in a hearing conservation program. This will include all employees exposed to occupational noise in excess of 85 dBA on a time weighted average. This refresher training is provided as part of the Hazardous Waste Refresher course.

## **4.2 SITE WORKER TRAINING**

Personnel on site must have received the site-specific safety training. Two versions of this training will be used. The site worker version will contain full information on site hazards, hazard controls, and emergency procedures. A shortened version will be used for visitors who will be on site for short times and who will not do hands-on work. This shortened version will contain the hazard information that is directly relevant to the purpose of the visit. Signatures of those attending and the type of briefing must be entered in project documentation before site access will be granted. The site-specific training will include the following site-specific information, as appropriate:

- names of site health and safety personnel and alternates;
- contents of the project SSHP.
- hazards and symptoms of contaminant exposure (chemical and radiological):
  - names of contaminants
  - exposure limits
  - monitoring
  - pregnancy concerns
- hazards and symptoms of chemicals used onsite
- physical hazards in the workplace;
- location and availability of written hazard communication program;
- site and task PPE (including purpose, donning, doffing, proper use);
- safe work practices to minimize risks;
- safe use of engineering controls and equipment;

- medical surveillance requirements;
- site control measures;
- reporting requirements for spills and emergencies;
- decontamination procedures to prevent the spread of chemical and radiological contamination;
- contingency plans (communications, phone numbers, emergency exits, assembly point, etc.);
- hearing conservation (for noisy work if worker does not have documented hearing conservation training);
- spill containment procedures (reporting, clean-up methods, etc.); and
- emergency equipment locations and use (fire extinguishers, spill kits, etc.).

Safety briefings will be held daily and when conditions or tasks change. These briefings will be conducted by the SSHO and/or Field Manager and will be attended by all site workers and supervisors. These briefings will address site-specific safety issues and will be used as an opportunity to refresh workers on specific procedures and to address new hazards and controls.

#### **4.3 SITE VISITOR TRAINING**

Site visitors will receive a briefing specific to hazards and controls associated with their intended site duties. A site visitor will be escorted by qualified personnel when in a controlled area to assure that the individual will not be exposed to hazards for which he/she has not received training.

#### **4.4 DOCUMENTATION**

Documentation of the required training will be maintained in the on-site project files. This documentation will include copies of 40-hour, 8-hour refresher, and supervisor training certificates, copies of first aid/CPR certificates, and records showing the topics covered, trainer, and signatures of those attending on-site training.

## 5.0 PERSONAL PROTECTIVE EQUIPMENT

PPE for site tasks is based on potential site-specific physical, radiological, and chemical hazards. In cases where multiple hazards are present, a combination of protective equipment will be selected so that adequate protection is provided for each hazard. This section emphasizes the programmatic requirements for PPE. For task-specific equipment see the Hazard/Risk Analysis section of this SSHP. In accordance with USACE requirements, two complete sets of PPE will be maintained by SAIC on site for use by government personnel during site visits.

### 5.1 PPE PROGRAM

SAIC's PPE program is controlled by EC&HS Procedures 13 and 20 and 29 CFR 1910, Subpart I, Personal Protective Equipment and EM 385-1-1 Section 5. The level of protection and types of materials selected for a particular task are based on the following:

- potential for exposure because of work being done;
- route of exposure;
- measured or anticipated concentration in the medium of concern;
- toxicity, reactivity, or other measure of adverse effect; and
- physical hazards such as falling objects, flying projectiles, etc.

In situations where the type of contaminant, and probability of contact are not known, the appropriate protection is selected based on the professional judgment of the EEMG Health and Safety Manager until the hazards are further evaluated.

The SSHO may raise or lower the level of PPE worn by the teams, depending upon the site-specific hazards encountered in the field. Prior to lowering the level of PPE, the Project Manager, Field Manager and the Health and Safety Manager will be contacted/consulted and the results documented. If site conditions are such that the level of PPE is insufficient or work must be stopped, the SSHO will take appropriate action immediately and the appropriate personnel (see above) will be contacted afterwards. Criteria indicating a possible need for reassessment of the PPE selection include the following:

- commencement of an unplanned (hazard not previously assessed) work phase;
- working in unplanned temperature extremes;
- evidence of contamination such as discolored soil or elevated instrument readings near the soil;
- exceeding the action limits of chemical or radiological hazards; or
- changing the work scope so that the degree of contact with contaminants changes.

Should respiratory protection (Level C) become necessary, SAIC EC&HS procedure 9. Respiratory protection, will be implemented. As a minimum, this will require that respirator users have current fit tests and medical clearance for respirator use. Workers will wear only the type and

size for which they have been fitted. The SHSO will provide site specific respirator training to ensure that workers understand proper respirator use.

## 5.2 TYPES OF EQUIPMENT

This section presents the types of protective clothing that may be used for the project. Requirements for task-specific levels of protective clothing are presented in the Hazards Analysis table (Table 2.2) of this SSHP. Levels of protection that will be used to protect against chemical, radiological and physical hazards at this site include:

- **Level C Protective Equipment**
  - full-face respirator and air purifying cartridges capable of filtering out organic vapors, acid gasses, and radionuclides
  - hooded chemical-resistant clothing (Polyethylene-coated Tyvek® or equivalent) with all openings taped
  - two pair chemical-resistant gloves (nitrile and non-latex exam gloves)
  - safety boots
  - shoe covers
  - hard hat
  
- **Level D+ Protective Equipment**
  - Tyvek® or equivalent coveralls with openings taped closed
  - nitrile or polyvinyl chloride (PVC) gloves
  - safety boots
  - disposable boot covers
  - hard hat
  - safety glasses with side shields
  - splash goggles or face shield (if splash hazard for eye or face/skin is present)
  
- **Level D Protective Equipment**
  - coveralls/field clothes
  - safety boots
  - safety glasses with side shields
  - hard hat
  - nitrile or PVC gloves if contaminated materials are handled
  - leather or similar work gloves if sharp or abrasive materials are handled

## 5.3 CLEANING, STORAGE, AND PROGRAM VERIFICATION

If site tasks require the use of chemical protective clothing, disposable clothing will be used. Used disposable PPE will be damaged to preclude any reuse. Unused chemical protective clothing will be stored in clean staging areas until needed. The SSHP will verify that the PPE in use is appropriate and is being used properly.

## 6.0 MEDICAL SURVEILLANCE

All employees performing on-site work will be enrolled in a medical surveillance program to meet the requirements of 29 CFR 1910.120(f), 1910.134, 1910.20 and SAIC EC&HS Procedures 12 (Medical Surveillance) and 20 (Hazardous Waste) to assess and monitor workers' health and fitness for employment in this field. Medical surveillance of SAIC personnel will be performed by Environmental Medicine Resources, under the supervision of Elayne F. Theriault, M.D. Dr. Theriault is certified in occupational medicine and has been in practice since 1983. Employees are provided with summaries of medical examination results following each examination and are provided more detailed information upon written request. Documentation of medical clearance will be maintained onsite during the project.

The frequency of employee medical exams shall be as follows:

- prior to assignment;
- once every 12 months for each employee covered unless the attending physician believes a shorter or longer interval (not to exceed 2 years) is appropriate;
- at termination of employment or reassignment to an area where the employee would not be covered, if the employee has performed field work since his/her last examination and has not had an examination within the last 6 months; and
- as soon as possible upon notification by an employee that he/she has developed signs or symptoms indicating possible overexposure to hazardous substances or health hazards, or that the employee has been injured or exposed above the permissible exposure limit (PEL) or published exposure levels in an emergency situation.

## 7.0 EXPOSURE MONITORING

Assessment of employee exposures will be performed, as appropriate, to ensure that exposures do not exceed acceptable levels. Action levels, with appropriate actions, have been established for this monitoring. In addition to the specified monitoring, the SSHO may perform, or require, additional monitoring such as organic vapor monitoring in the equipment decontamination area, personnel exposure sampling for specific chemicals, etc. The deployment of monitoring equipment will depend on the activities being conducted and the potential exposures. All personal exposure monitoring records will be maintained in accordance with 29 CFR 1910.20. The minimum project-specific monitoring requirements and action levels are presented in Table 7.1.

Although overexposure to airborne organic contaminants is very unlikely, air monitoring will be conducted using a photoionization detector (10.2 eV) or flame ionization detector, or equivalent instrument. Although not all volatile organic chemicals can be detected in this fashion, many potential site contaminants can be detected and will serve as indicators of contamination. If breathing zone concentrations of total organic vapors exceed 5 ppm for more than 5 minutes, the activity will be stopped and the SSHO will notify the Field Manager, Project Manager, and Health and Safety Manager. Following assessment of the situation, appropriate actions will be taken. These may include identification of the airborne contaminant(s), measures to reduce airborne concentrations, and consideration of the use of respiratory protection. If breathing zone readings decrease to less than the action levels (5 ppm for total organic vapors), the activity will be resumed without respiratory protection. The instrument used to monitor for organic vapors will be calibrated daily, using the technique specified by the manufacturer.

Air monitoring for combustible gasses and oxygen will be conducted using a combination combustible gas indicator if site conditions suggest the potential for flammable concentrations of solvents or other airborne gasses or vapors. Indications of such potential include elevated (>100 ppm) total organic concentration at the source (borehole) or indication that methane may be present such as a landfill or buried organic material. This monitoring will be conducted close to the source (2-12" from borehole or auger) to reflect worst-case conditions. If used, the combustible gas indicator will be calibrated daily using the technique set forth by the manufacturer.

Monitoring for ionizing radiation and radiological contamination will be conducted using radiation survey meters. Personnel, equipment, and any other items leaving radiologically contaminated areas will be surveyed prior to leaving such area. The monitoring instruments will be calibrated at least every six months and will be checked with a check source prior to each day of use. Proof of calibration and documentation of response checks will be kept on site.

Time-integrated air sampling will be conducted to determine the exposures of representative employees if direct-reading monitoring or other indicators suggest the potential for exposures greater than the threshold limit value (TLV), PEL or 25% of a DAC. Exposure assessments will be reported as required at 10 CFR 20 & 29 CFR 1910.

SAIC has conducted noise monitoring of standard types of site equipment at previous projects and has established basic hearing protection requirements. Drill rigs, portable drilling devices, and generators will be assumed to generate sound levels in excess of 85 dBA (requiring hearing protection) unless site-specific sound level measurements are conducted and indicate otherwise. If used, sound level meters will be calibrated daily (each day of use).

**Table 7-1. Monitoring Requirements and Action Limits**

Hazard or Measured Parameter	Area	Interval	Limit	Action	Tasks
Airborne organics with 10.2 eV PID or equivalent	Breathing zone (2-3 feet from source or 14 inches in front of employee's shoulder)	At least once every 30 minutes during intrusive activities; continuously during elevated readings	<5 ppm  >5 ppm	Level D  Withdraw and evaluate - identify contaminants - notify Project Manager and H&S Manager - implement control measures, potentially including Level C PPE	Drilling, other intrusive tasks
Airborne chemical concentrations (detector tubes)	Breathing zone	Screening with detector tubes will be conducted in an attempt to identify airborne contaminants if breathing zone PID readings exceed 5 ppm. The types of tubes to be used will be based on current conditions.	PEL or TLV	Variable, may include engineering, administrative, or personal protective measures	Any indicated by organic vapor instrument readings
External ionizing radiation with TLDs Exposure rate monitoring device for area surveys	Worn between waist and neck of employee	Will not be performed unless contamination checks indicate radiological contamination	2 rem annually (TEDE)	Notify Project Manager, H&S Manager. Additional controls may include engineering or administrative controls	None. Will only be performed if survey meter readings indicate contamination
Radiological contamination with survey instrument. Alpha & Beta sensitive plastic scintillation /count rate system, or equivalent.	Areas of intrusive work, drill cuttings, when personnel leave potentially contaminated areas, when eqpt. is removed from potentially contaminated areas	1. Upon exit from controlled areas 2. At least once an hour during intrusive work in controlled areas	Any indication of radioactivity above background Personnel and Eqpt. Leaving controlled areas must be free of detectable contamination See Section 8	Notify Project Manager, H&S Manager. Additional controls may include changes to PPE, decontamination procedures, or engineering controls	Intrusive tasks



Table 7-1. Monitoring Requirements and Action Limits (continued)

Hazard or Measured Parameter	Area	Interval	Limit	Action	Tasks
Time weighted sampling for airborne radionuclides	Breathing zone in areas of intrusive work	Representative personnel may be monitored if survey readings indicate that airborne contamination is a possibility	DAC	Variable, may include engineering, administrative, or personal protective measures	None planned. Intrusive tasks will be sampled if sampling is initiated
Flammability and oxygen concentration with combustible gas indicator	Near borehole and any area where flammable gases are suspected	Continuously during intrusive activities	<10% LEL >10% LEL <19.5% O <sub>2</sub>	Continue and evaluate source  Withdraw and allow area to ventilate for a minimum of 30 minutes; notify Project Manager and H&S Manager	Drilling
Temperature	In or near work area	At least twice daily to record approximate lowest and highest temperatures	>70°F <40°F	Administrative controls (See Section 8.16)	All tasks
Noise	Exclusion zone around drilling, equipment decontamination zone around generator	Note that this monitoring is optional, if monitoring is not performed, the areas will be assumed to exceed 85 dBA	85 dBA	Require the use of hearing protection	Drilling, generator use

LEL = lower explosive limit  
 PEL = permissible exposure limit  
 TBD = to be determined  
 TLV = threshold limit value

## 8.0 STANDARD OPERATING SAFETY PROCEDURES

This section presents those general safety rules that apply to all operations performed by SAIC and its subcontractors. These requirements are generic in the sense that they apply to all projects. Therefore, there may be portions of this section that do not apply to this specific project. The provisions of the plan are mandatory for all on-site employees and visitors. This includes employees engaged in initial site reconnaissance, preliminary field investigations, mobilization, project operations, and demobilization.

### 8.1 SITE RULES

The following rules apply to all site activities:

- The OSHA poster #2203 will be prominently displayed on site.
- Daily safety briefings (“tailgate”) will be conducted by the Field Manager and/or SSHO to inform personnel of new hazards or procedures.
- The SSHO, project personnel, and management personnel are responsible to suspend/stop work and require all personnel to evacuate the affected area if any of the following situations occur:
  - inadequate health and safety precautions on the part of any on-site personnel and
  - potential significant environmental insult as a result of planned activities.
- Personnel will perform only those tasks that they believe they can do safely.
- Personnel will notify the SSHO of any medical conditions (e.g., allergy to bee stings, diabetes, pregnancy) that require special consideration.
- Personnel will maintain proper workplace housekeeping to minimize the potential for trips and other accidents.
- Contact with potentially contaminated substances will be avoided. Site personnel in the exclusion zone will avoid walking through puddles, pools, mud, kneeling on the ground, and placing equipment on the ground.
- Spills will be prevented to the greatest extent possible. In the event that a spill occurs, the material will be contained.
- Eating, drinking, smoking, chewing gum, or tobacco and other practices that increase the probability of hand-to-mouth transfer are prohibited in contaminated and potentially contaminated areas.

- Workers will wash their hands and faces upon leaving the work area and prior to eating or drinking.
- All injuries and accidents requiring more than first aid will be reported to the SSHO, Field Operations Manager, EEMG Health and Safety Manager, and USACE
- All on-site workers will abide by a buddy system. Members of a buddy team will maintain verbal or visual contact.

## **8.2 PERMIT REQUIREMENTS**

SAIC will obtain or coordinate with USACE to obtain all permits necessary for the safe execution of this project. At a minimum, all activities such as digging or drilling will be preceded by an investigation to preclude encountering sub-surface utilities. This process will be documented by completion of the checklist in Appendix A or equivalent.

## **8.3 DRUM/CONTAINER HANDLING**

No drums of unknown material will be addressed as part of this project. Any drums used for the project will meet Department of Transportation and 10 CFR 20 requirements and will be labeled to comply with applicable U.S. Environmental Protection Agency (EPA) requirements.

## **8.4 CONFINED SPACE ENTRY**

Any confined space entry will be performed in conformance with the requirements of SAIC EC&HS Procedure 10 and 29 CFR 1910.146 and EM 385-1-1, Section 06I.

## **8.5 HOT WORK, SOURCES OF IGNITION, FIRE PROTECTION**

This work will be performed in conformance with EM 385-1-1, Section 9.

- Hot work (oxyfuel cutting) will be conducted using welder's helmet or shaded goggles, leather gloves, and a long-sleeved shirt.
- A fire extinguisher rated not less than 10-ABC will be immediately available in the vicinity of hot work.
- Sources of ignition will be kept at least 15 meters from flammables storage areas.
- Flammables storage areas will be posted with signs indicating "No smoking or open flame."

- At least one fire extinguisher with a rating of not less than 20-B will be kept 8 to 23 meters from all flammables storage areas.
- An approved flammables cabinet will be used to store 25 or more gallons of flammable liquid.
- Flammable liquids (other than decontamination solvents) will be kept in safety containers with flame arresters.

## 8.6 ELECTRICAL SAFETY

This work will be conducted in conformance with 29 CFR 1910, Subpart S and 385-1-1, Section 11.

- All portable electrical equipment will be double insulated or grounded and connected through a ground fault circuit interrupter.
- Conductive materials (drill rigs) will be kept clear of energized power lines. The following minimum distances will be observed; 0-50 kV - 10 feet; 51-100 kV - 12 feet; 101-200 kV - 15 feet; 201-300 kV - 20 feet; 301-500 kV - 25 feet; 501-750 kV - 35 feet; 750-1000 kV - 45 feet.

## 8.7 EXCAVATION AND TRENCH SAFETY

Trench excavation will be conducted in conformance with 29 CFR 1926, Subpart P-Excavations and 385-1-1, Section 25. Trench excavation potentially poses the following hazards: contact with buried utilities, trench cave-in and engulfment, confined space hazards such as hazardous airborne concentrations of toxic chemicals, flammable concentrations of vapors or gases, and oxygen deficiency. The depth of the excavation and the nature of the excavated material significantly impact the potential hazard—the greater the depth, the greater the hazard.

Prior to opening an excavation, the site will be verified free of underground utilities by contacting the local one-call system, local utility companies and/or appropriate base personnel. If underground utilities are present, they will be located and protected from damage or movement. Other location-specific hazards, such as the potential for unexploded ordnance, building foundations, unstable rocks, etc., will also be controlled.

Cave-in hazards will be controlled by excluding personnel from trenches deeper than 1.2 meters. Personnel will be kept at least 0.9 meters away from trenches deeper than 1.2 meters. Visual examination of excavation will be done from the trench ends, rather than the sides. All excavation shall be performed from a stable ground position. All spoil will be located at least 0.9 meters from the edge of the excavation to prevent it from falling back into the excavation.

If it becomes necessary for personnel to enter trenches deeper than 4 feet, the requirements of 29 CFR 1926.651 will be applied. This will include daily inspections of the excavation and shoring or sloping the trench sides. Shoring will be accomplished using a trench box with rigid sides to prevent engulfment. If a trench box is not utilized, the trench sides will be sloped at a 34° angle (one and one-half horizontal to one vertical). Such entry will also be treated as confined space entry and procedures will comply with 29 CFR 1910.146, OSHA's confined space standard and SAIC EC&HS Procedure 10, Confined Space Entry. The basic requirements include testing the atmosphere in the trench for flammable gases, toxic gases, and oxygen. Prior to entering the trench(es), flammable gas concentrations must be less than 10 percent lower explosive limit (LEL), toxic gases must be less than 5 ppm (or respiratory protection will be worn), and oxygen must be greater than 19.5 percent.

## **8.8 MACHINE GUARDING**

All equipment will be operated with all guards provided by the manufacturer and in compliance with 29 CFR 1910, Subpart O and EM 385-1-1 Section 16.B. If any guarding must be removed for servicing, the equipment will be disabled to preclude movement or release of energy.

## **8.9 LOCKOUT/TAGOUT**

All potentially hazardous servicing or equipment repair will be governed by the SAIC EC&HS Procedure 11, Lock Out/Tag Out, and 29 CFR 1910.147.

## **8.10 FALL PROTECTION**

Work areas with the potential for a fall of 4 feet or more will be provided with fall protection in compliance with EM 385-1-1 Section 21.A.15. This fall protection will consist of guardrails or personal fall protection. Personal fall protection will be used if it is necessary for drilling personnel to climb the upright mast or derrick.

## **8.11 HAZARD COMMUNICATION**

Hazard communication will be governed by SAIC EC&HS Procedure 8, Hazard Communication, 29 CFR 1910.1200, and EM 385-1-1 Section 8. At a minimum, the following steps will be taken.

- All hazardous materials on site will be labeled to comply with the hazard communication standard.
  - clear labeling as to the contents,
  - the appropriate hazard warning, and
  - the name and address of the manufacturer.

- MSDSs will be available on site for all hazardous materials that are present.
- Site-specific training will include the hazards posed by site chemicals, protective measures, and emergency procedures.
- Copies of MSDSs for all hazardous chemicals (chemicals brought on site) will be maintained in the work area. MSDSs will be available to all employees for review during each work shift.

## **8.12 ILLUMINATION**

Most site field work will be conducted during daylight hours (no earlier than 15 minutes after sunrise and no later than 15 minutes before sunset) and natural illumination will be used. Field work to be conducted during non-daylight hours will be specifically identified in the hazard assessment table. Work conducted in buildings will be illuminated to meet the following minimums stated in 29 CFR 1910.120; stairs and ladders 10 foot-candles, offices 50 foot-candles, and first aid areas 30 foot-candles.

## **8.13 SANITATION**

- Means for washing hands and faces prior to eating will be provided at the work site.
- Potable drinking water will be provided in labeled, sanitary dispensers.
- Toilets shall be provided according to the following; ≤20 employees = 2 toilets, 21 to 199 employees = 1 toilet seat and 1 urinal per 40 workers.

## **8.14 DRILL RIG OPERATIONS**

### **8.14.1 General Drilling Practices**

- Operating manuals will be present on site for each type of drill rig in use.
- Drill rigs will have at least two functional kill switches, one for the driller and one for the driller's helper. These switches will be confirmed to be functional each day that the rig is used.
- Drill rigs will have functional backup alarms.
- Drill rigs will be inspected daily by the driller and this inspection will be confirmed by the SSHO. This inspection will address; structural damage, loose bolts and nuts, chain

drive tension, loose or missing guards, fluid leaks, hoses, pressure gauges and pressure relief valves.

- Only the driller, driller's helper, and personnel who have a critical need will be allowed near moving parts of the drill rig.
- Drill sites will be verified free of underground utilities by clearing each site with local utilities or appropriate base personnel prior to beginning drilling.
- Drill-mounted fire fighting equipment will not be tampered with and will not be removed for other than the intended fire-fighting purposes or for servicing.
- Drilling crews and personnel who work near the drilling rig will be trained in the location and use of the kill switches.
- No loose clothing, loose jewelry, loose long hair permitted near drill rig while in operation.
- If lubrication fittings are not accessible with guards in place, machinery will be stopped and disabled (locked out or ignition key removed) for oiling and greasing.
- Work areas and walkways will not be obstructed.
- The derrick (mast) will not be raised unless the area is free of overhead obstructions and far enough from power lines (see Electrical Safety, Section 8.6).
- The derrick will not be raised until the rig has been blocked, leveled, and chocked.
- Prior to drilling the area at the rear of the rig will be cleared of any items as chains, shovels, etc., that might become entangled with the drilling equipment.

#### **8.14.2 Hoisting Operations**

- Rigging equipment for material handling will be checked prior to use on each shift and as often as necessary to ensure it is safe. Defective rigging will be removed from service.
- A hoisting line with a load imposed will not be permitted to be in direct contact with any derrick member or stationary equipment, unless it has been specifically designed for line contact.
- Workers will stand clear of the well bore when any wire line device is being run.
- Loads will not be lifted over workers.

### **8.14.3 Cat Line Operations**

- The cat head area will be kept free of obstructions and entanglements.
- The operator will not use more wraps than necessary to pick up the load. More than one layer of wrapping is not permitted.
- Personnel will not stand near, step over, or go under a cable or cat line that is under tension.
- Personnel will avoid contact with the cat head during operation due to heat generated by cat head use.

### **8.15 UNEXPLODED ORDNANCE**

SAIC will, at a minimum, follow the UXO procedures listed below.

- All on-site workers will be trained to recognize the types of ordnance that may be present.
- SAIC and its subcontractors will not handle, move, or otherwise disturb ordnance or any items that cannot be identified as not being ordnance.
- If ordnance or potential ordnance is discovered, work will be stopped and the area will be evacuated and cordoned off.
- If ordnance or potential ordnance is discovered, the facility security organization and the USACE project manager will be notified immediately.
- For work in areas where UXO may reasonably be expected (former and active ordnance disposal sites), EOD personnel will survey (visual and magnetometer) prior to intrusive work to preclude disturbing subsurface UXO. No soil boring will be performed where magnetometry detects ferrous material.

### **8.16 HEAT/COLD STRESS**

Important factors in preventing heat stress induced illnesses are acclimatization, consumption of copious quantities of fluids, and appropriate work/rest cycles. General controls will consist of making fluids readily available, use of the buddy system, and taking scheduled and unscheduled



breaks in temperature controlled areas as necessary. The following specific steps will be taken to reduce the potential for heat stress induced illness.

- If ambient temperatures exceed 70°F, site training will include heat stress control, recognition of heat stress induced illness, and first aid for heat stress.
- If ambient temperatures exceed 70°F, cool Gatorade or equivalent drink (mixed at 4 parts water to 1 part concentrate) will be made conveniently available to site workers.
- If ambient temperatures exceed 70°F, workers will be instructed to monitor their own and their buddy's condition relative to heat stress.
- Workers will be allowed to take unscheduled breaks, if needed.
- Workers wearing Tyvek® or other impermeable clothing when ambient temperatures exceed 70°F will be monitored for heat stress by taking their pulses at the beginning of each rest period. If any worker's heart rate exceeds 110 beats per minute, the next work period will be shortened by one third (From NIOSH/OSHA/USCG/EPA; Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities).
- An initial work rest cycle will be established for employees wearing impermeable clothing based on the adjusted air temperature [TAADJ in °F=°F in shade + (13 × %sunshine)]. The length of each work period will be as follows (From NIOSH/OSHA/USCG/EPA; Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities).

<u>TAADJ in °F</u>	<u>work period</u>
72.5 to 77.5°F	120 minutes
77.5 to 82.5°F	90 minutes
82.5 to 87.5°F	60 minutes
87.5 to 90°F	30 minutes
≥90°F	15 minutes.

Critical factors in preventing cold stress disorders are adequate clothing and staying dry. The SSHO and Field Manager will ensure the capability to quickly move individuals who become wet to a sheltered, warm area. The following specific steps will be taken [adapted from American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values booklet].

- If ambient temperatures are less than 40°F, site training will include prevention of cold injury, cold injury symptoms, and cold injury first aid.
- A heated break area will be provided if ambient temperatures are less than 32°F.
- As a minimum, breaks will be taken in a warm area every 120 minutes if ambient temperatures are less than 32°F.

- Workers will be allowed to take unscheduled breaks, if needed, in a warm area.
- No outdoor work will be performed if the equivalent chill temperature (temperature combined with the effect of wind) is less than -29°F.

## 8.17 IONIZING RADIATION

All work involving ionizing radiation will be performed in compliance with SAIC EC&HS Procedure 19, Ionizing Radiation and USACE EM 385-1-1 Section 6. The guiding philosophy will be to keep exposures as low as reasonably achievable (ALARA).

### 8.17.1 Exposure Limits

The following table presents exposure limits as they apply to this project.

**Table 8-1. Radiation Exposure Limits**

Effected Individual	Period	Body Portion (Effected Organ <sup>b</sup> )	rem	
			SAIC Control Levels <sup>c</sup>	Regulatory Limit <sup>d</sup>
Adult Radiation Worker	Annual	TEDE	2	5
Adult Radiation Worker	Annual	DE&CD	30	50
Adult Radiation Worker	Annual	Lens of the Eye	10	15
Adult Radiation Worker	Lifetime	TEDE	100	
Adult Radiation Worker	Annual	SDE	30	50
Declared Pregnant Radiation Worker	Gestation Period (9 Months - uniformly distributed)	Fetus	0.5	0.5
SAIC Employee*Public	Annual	TEDE	0.08	0.1
Public Access Areas	Hour	TEDE	0.001	0.002

\*Applies to all employees not qualified as radiation workers.

<sup>b</sup>The abbreviations are summarized below:

TEDE = Total effective dose equivalent.

DE&CE = The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye.

SDE = Shallow-Dose Equivalent to the skin any extremity.

<sup>c</sup>From SAIC EC&HS Procedure 19

<sup>d</sup>From 29 CFR 1910.1096

## 8.17.2 Surface Radioactivity Limits

Table 8-2. Acceptable Surface Contamination Levels

Nuclide <sup>a</sup>	Average <sup>b,c</sup>	Maximum <sup>b,d</sup>	Removable <sup>b,e</sup>
U-nat, U-235, U-238, and associated decay products	5,000 dpm $\alpha$ /100 cm <sup>2</sup>	15,000 dpm $\alpha$ /100 cm <sup>2</sup>	1,000 dpm $\alpha$ /100 cm <sup>2</sup>
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100cm <sup>2</sup>	300 dpm/100 cm <sup>2</sup>	20 dpm/100 cm <sup>2</sup>
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm <sup>2</sup>	3,000 dpm/100 cm <sup>2</sup>	200 dpm/100 cm <sup>2</sup>
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm $\beta\gamma$ /100 cm <sup>2</sup>	15,000 dpm $\beta\gamma$ /100 cm <sup>2</sup>	1,000 dpm $\beta\gamma$ /100 cm <sup>2</sup>

### Information from Regulatory Guide 1.86

<sup>a</sup> Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

<sup>b</sup> As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

<sup>c</sup> Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

<sup>d</sup> The maximum contamination level applies to an area of not more than 100 cm<sup>2</sup>.

<sup>e</sup> The amount of removable radioactive material per 100 cm<sup>2</sup> of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

## 8.17.3 General Requirements

Personnel who work inside radiological control areas must be trained to be able to perform this work safely. The minimum training will include current HAZWOPER training plus either (1) DOE Radiation Worker 2 training (or equivalent) coupled with the site worker training or (2) standard site worker training plus site specific radiation safety to include at least: health effects of ionizing radiation, exposure limits (including those for pregnant workers), use of dosimetry and instruments, effects of radiation on the embryo/fetus, employee rights and responsibilities, site contaminants and probability of exposure, required monitoring, and exposure control methods.

Employees in radiological controlled areas, contaminated areas, radiation areas, or airborne radioactivity areas will be monitored for contamination periodically and at least before leaving the controlled area. A whole body frisk will be performed upon leaving a contaminated area. In areas where contamination is unlikely, this monitoring may be performed by the employee (self-monitoring). Any detected personnel contamination will immediately be reported to an HPT.

In areas where contamination is probable, this monitoring must be performed by an HP technician. Any detectable contamination will require decontamination to non-detectable levels following established procedures. Removal of contamination on personnel will be attempted with moist paper towels followed by washing with soap and water, if necessary.

The whole body frisk will be conducted using the following process.

1. Verify the instrument has passed a source test.
2. Verify the instrument is on and set to its most sensitive scale.
3. Hold the probe approximately 1/4 inch from the surface being frisked and move the probe at approximately two inches per second.
4. Survey hands.
5. Survey head (pausing around mouth and nose), neck and shoulders (pause at elbows), chest and abdomen, back, seat of pants, legs (pause at each knee), and shoes in that order.

Employees in radiological controlled areas, contaminated areas, radiation areas, or airborne radioactivity areas will wear TLDs analyzed under a program meeting the NVLAP program. TLDs will be issued and controlled using established procedures.

Instruments and equipment used inside controlled areas, contaminated areas, radiation areas, or airborne radioactivity areas will be surveyed prior to release from the area. This survey will be performed by a fully qualified HPT.

In cases where instruments or equipment may be drawn into an area or extracted from some opening (down-hole drilling equipment, soil cuttings) and may bring significant contamination into a less contaminated or uncontaminated area, these materials will be surveyed as they are withdrawn from the well or borehole.

Samples taken in controlled areas, contaminated areas, radiation areas, or airborne activity areas will be surveyed to determine removal and shipping restrictions.

Areas where the potential exists for airborne radioactivity concentrations greater than 5% of a DAC will be considered to be airborne radioactivity areas and sampling for airborne radioactivity will be conducted. The potential for excessive airborne intake will be assessed and a determination will be made regarding the need for respiratory protection. Surface contamination will be evaluated to determine the potential to generate airborne dust.

All radiation meters will be calibrated at least annually and will be checked against a known source prior to each day of use. The results of source checks will be maintained onsite. The following instruments, or equivalent, will be used to assess radiological contamination and exposure; Ludlum 12s, Ludlum L2000, and SPA3.

Radiological control areas will be identified and posted to identify type. Areas will be posted as Radiation Areas, Airborne Radioactivity areas, etc., as required and defined at 385-1-1, Section 6 and 10 CFR 20.

## 9.0 SITE CONTROL MEASURES

The SSHO will be responsible for establishing the site control zones, as necessary, around SAIC controlled areas that present physical and/or chemical hazards. Implementation of the site control zones will help to minimize the number of employees potentially exposed and to minimize the potential for the spread of contamination. The SSHO will monitor the implementation of the required site control work rules and will report any deviations from prescribed practice to the Field Manager or stop work, as appropriate. A log will be kept of all personnel visiting, entering or working on site. The log will include the date, name, agency or company, time in and out, and PPE.

Site control zones will be established in a number of locations over the site. The exact locations will vary depending on site conditions; therefore, it is not possible to predetermine the size or exact locations of site control zones. SAIC will attempt to exclude all unauthorized personnel (members of the public, etc.) from exclusion and contamination reduction zones. If unauthorized personnel enter an SAIC controlled area and refuse to leave, work will be stopped and the USACE technical manager will be notified. Authorized visitors will be required to show proof of current training and medical surveillance.

### 9.1 EXCLUSION ZONE

The exclusion (contamination) zone is the area where the greatest potential exists for exposure to contamination or physical hazards. Personnel access to the exclusion zone will be limited to authorized SAIC and subcontractor individuals. The periphery of the exclusion zone will be identified by barricade tape or rope suspended above the ground. An entry and exit checkpoint will be visually defined to regulate the flow of personnel and equipment. The entry and exit checkpoint will be delineated with barricade tape or ropes. The number of people and equipment in the exclusion zone will be minimized to control physical hazards and the spread of contamination. At a minimum, exclusion zones will be established around tasks or areas that pose a potential for the spread of contamination or injury to personnel. Such areas include each drilling site.

The following standard rules will apply to all entry into the exclusion zone.

- The SSHO or Field Manager must approve (and log) entry into the exclusion zone.
- All personnel entering the exclusion zone will wear the prescribed level of protective clothing.
- All items and related paraphernalia intended to be placed on the face or in the mouth (cigarettes, lighters, matches, chewing tobacco, food, cosmetics, etc.) are prohibited in the exclusion zone.
- All personnel in the exclusion zone will follow the buddy system.

Exclusion zones will be established around drilling sites, areas of heavy equipment use, and all activities where contamination is a potential hazard. At a minimum, the exclusion zone for drilling operations will be at least equal to the mast height in radius so that no part of an overturned drill rig will fall outside the zone. Note that the exclusion zone is intended to protect personnel who are not involved with the task. Objects, such as stored unoccupied vehicles or the walls of buildings may occur within the exclusion zones. Building entrances or windows that occur within the exclusion zone will be locked or, at a minimum, marked to preclude use.

## **9.2 CONTAMINATION REDUCTION ZONE**

A contamination reduction zone or restricted area will be established, as necessary, outside the exclusion zone to provide a transition from and a buffer between the exclusion zone and the support zone. An entry and exit checkpoint will be visually defined at the periphery of the zone to regulate the flow of personnel and equipment. The entry and exit checkpoint and the perimeter of the zone will be delineated with the use of traffic cones, ropes/barricade tape, or signs.

All personnel entering the contamination reduction zone or restricted area will wear the prescribed level of protective clothing required for that zone. All items intended to be placed on the face or in the mouth (e.g., cigarettes, chewing tobacco, food, cosmetics, etc.) are prohibited. Doffing of protective clothing and personnel decontamination will occur in the contamination reduction zones.

## **9.3 SUPPORT ZONE**

The support zone is the clean and relatively safe area surrounding the exclusion and contamination reduction zones. Entry requirements for the support zone consist of the general requirements (training, medical surveillance) for on-site work. Note that the support zone is limited to the areas associated with this project and does not generally include areas such as office trailers, roads and buildings accessible to facility personnel or the public and not directly involved in on-site project activities. Primary functions of the support zone are:

- staging area for clean equipment and supplies, and
- location for support services [e.g., office trailers, laboratory trailers, eating area(s), toilet facilities, parking, visitor area(s), etc.].

## **9.4 SITE COMMUNICATION**

Field personnel will be capable of contacting other field personnel and outside agencies. Communication on site will be assured by hand-held radio, portable air horns, or vehicle horns. Short blasts (less than ½ second) of an air horn or car horn will be used to request assistance.

Prolonged blasts (more than 2 seconds) will be used to signal an evacuation. If phone service is not immediately available on the site, the field project will be equipped with a cellular phone.

## 10.0 PERSONAL HYGIENE AND DECONTAMINATION

A system of procedures will be used to control the spread of contamination from the exclusion (contamination) zone and to ensure that workers are sufficiently free of contamination to preclude adverse health effects. PPE doffing and personnel decontamination are part of this system. The SSHO will ensure the construction of a decontamination station, as necessary, instruct personnel on its proper use, and verify that personnel follow the appropriate steps. This section presents basic requirements for personnel decontamination keyed to the level of protection. These requirements may be modified by the SSHO if improvements are needed. See the Hazards Analysis section for task-specific PPE.

### 10.1 LEVEL D PROTECTION DOFFING/DECONTAMINATION

#### Station 1: Equipment drop

Place potentially contaminated equipment in a designated area.

#### Station 2: Removal of disposable gloves and boot covers (if worn)

Deposit disposable gloves and boot covers in a designated container. Note that this step is necessary only if gloves and boot covers are in use.

#### Station 3: Frisk

Perform radiological survey of hands, shoes, and any other areas that may have become contaminated. Any personal contamination will be removed with tape, moistened towel, or soap and water.

#### Station 4: Field wash

Wash face and hands prior to taking anything by mouth. This may be done with soap and water or disposable disinfectant towels.

### 10.2 LEVEL D+ PROTECTION DOFFING/DECONTAMINATION

#### Station 1: Equipment drop

Place potentially contaminated equipment in a designated area.

#### Station 2: Tape removal

Remove all tape (if used) from outer clothing and place in appropriate waste container.



**Station 3:** Boot covers, outer disposable garment, and gloves removal

Carefully remove boot covers, outer contamination-resistant garment, and gloves.

**Station 4:** Frisk

Perform radiological survey of hands, bottoms of shoes, and any other areas that may have become contaminated. Any personal contamination will be removed with tape, moistened towel, or soap and water.

**Station 5:** Field wash

Wash hands and face prior to eating, drinking, smoking, etc. This step may be accomplished with soap and water or disposable disinfectant wipes.

### **10.3 LEVEL C PROTECTION DOFFING/DECONTAMINATION**

**Station 1:** Equipment drop

Place potentially contaminated equipment in a designated area.

**Station 2:** Segregated equipment drop

Deposit equipment used on site (tools, sampling devices, containers, monitoring instruments, clipboards, etc.) on plastic sheets or in different containers with plastic liners. Segregation of the equipment at the drop site reduces the possibility of cross-contamination.

**Station 3:** Outer boot and glove removal

Remove tape from outer boots and outer gloves. Remove outer boot covers and outer gloves. Deposit gloves and boot covers in plastic trash bags.

**Station 4:** Cartridge change

If a worker has left the exclusion zone for the sole purpose of changing a canister/cartridge of the respirator, this is the last step of the decontamination procedure. Once the worker's canister/cartridge has been replaced, the outer boots and gloves will be replaced and retaped so that all potential pathways to the skin are sealed.

**Station 5:** Disposable outer garment removal

Remove disposable outer garment, deposit in a plastic trash bag, and dispose in accordance with the project Work Plan.

#### **Station 6: Respiratory protection and disposable inner glove removal**

The respirator is the next-to-last item for removal. The cartridges/canisters are placed in a plastic trash bag and disposed of in accordance with the project Work Plan. The respirator is placed in a plastic bag dedicated for used respirators only. Remove disposable inner gloves last and deposit them in a plastic trash bag, in accordance with the project Work Plan.

#### **Station 7: Frisk**

Perform radiological survey of hands, shoes, and any other areas that may have become contaminated. Any personal contamination will be removed with tape, moistened towel, or soap and water.

#### **Station 8: Field wash**

Wash hands and face prior to eating, drinking, smoking, etc. This step may be accomplished with soap and water or disposable disinfectant wipes.

### **10.4 EQUIPMENT DECONTAMINATION**

The equipment decontamination pad will be constructed so that liquids generated during decontamination will be contained. Sampling and related equipment will be decontaminated to a level sufficient to prevent cross-contamination of subsequent samples. This stringent requirement assures that decontaminated sampling equipment is sufficiently clean from a personnel contact perspective. Larger pieces of equipment, such as drill rigs, will be decontaminated with pressurized hot water/steam. The following description of the sampling equipment decontamination process is intended to provide only a general overview.

Steps will be taken to assure that the transporting of sampling equipment does not spread contamination to previously uncontaminated areas. Sampling and related equipment will be screened for contamination prior to being transported to the decontamination pad. Any equipment that is deemed to be heavily contaminated will be decontaminated in the immediate area of the sample collection, or will be wrapped in plastic during transit.

## 11.0 EMERGENCY PROCEDURES AND EQUIPMENT

The Field Manager will remain in charge of all SAIC and subcontractor personnel during emergency activities. The Field Manager will perform emergency notification of emergency medical services, fire department, SAIC Project Manager, SAIC Health and Safety Manager, etc. The field manager will also escort or assign an escort to offsite emergency responders. In order to minimize the potential for accidents and injuries, daily safety and health inspections will be conducted by the Field Manager or SSHO. If an emergency occurs, the Field Manager, the SSHO, and the field team will participate in a briefing to discuss the event, identify the causes, identify corrective measures, and evaluate the responses.

**A hospital map and emergency phone numbers are presented in Appendix B.** This information must be posted on site.

In the event of an accident or incident, the Field Manager or SAIC Project Manager will notify the USACE Project Manager immediately according to the requirements of EM 385-1-1.

All accidents will be investigated and reported within 24 hours as specified in EM 385-1-1. The Accident Report (ENG Form 3394) will be completed and submitted to the USACE Occupational Safety and Health Office at the following address:

U.S. Army Corps of Engineers  
CEMVS-SO (ATTN: Gary Groeneman)  
1222 Spruce St.  
St. Louis, Missouri 63103-2833

All personnel working on site will be trained in the requirements of this section. This will include recognizing emergencies, reporting emergencies to the Field Manager or SSHO, and responding to emergencies. Employees will also be informed of any changes in potential emergencies or response plans.

### 11.1 POTENTIAL EMERGENCIES

Credible potential emergencies for this project include fires, minor chemical spills, and personnel injury.

#### 11.1.1 Fires

Small quantities of flammable solvents (typically less than 5 gallons), gasoline, and diesel fuel will be present on site. In the event of a fire, the local fire department will be notified immediately. If it is safe to do so, on-site personnel will attempt to extinguish the fire with the available fire extinguishers and isolate any nearby flammable materials. If there is any doubt about the safety of extinguishing the fire, site personnel will evacuate the area. The supervisor or

knowledgeable employee will provide the fire department with relevant information when they arrive.

### **11.1.2 Spills**

Potential spills include releases of fuels, lubricants, hydraulic fluids, and decontamination solvents. With the exception of fuels, all of these materials will be used in small quantities. In light of the small quantities of spillable materials, it is not possible for site operations to generate a major spill. In the event of a spill or leak, the employee making the discovery will immediately notify the SSHO and/or the Field Manager. The Field Manager will assess the situation and take appropriate measures as follows.

For small quantities (most likely spill scenario) the field crew will use the project spill control kit to clean up and containerize spilled material and other material such as soil that has become contaminated. Cleanup will be performed wearing nitrile or similar gloves and eye protection.

For larger quantities (more than five gallons of fuel) the field manager will notify the local fire department and initiate cleanup and control if feasible with available equipment. Cleanup will be performed wearing appropriate protective gear and at least nitrile or similar gloves and eye protection. If the spill cannot be resolved without undue danger (fire or similar hazard) to personnel, the area will be evacuated and the response turned over to local emergency response personnel.

All spills will be reported to the USACE Project Manager, SAIC Project Manager, and the SAIC Environmental Compliance Officer.

### **11.1.3 Medical Emergencies**

Field crews will use a variety of equipment that could cause injuries. In the event of a medical emergency, the Field Manager will notify the local emergency medical service immediately. At least two first aid/CPR-trained individuals will be on site at all times and these personnel will provide first aid pending release of the injured person to emergency medical staff. Contaminated injured personnel will be decontaminated to the extent feasible. Personnel with minor injuries will follow normal decontamination procedures. Personnel with serious injuries will be decontaminated, if necessary, by disrobing and wrapping in a blanket. Decontamination may be bypassed in the event of life-threatening injuries or illnesses.

## **11.2 EMERGENCY ALERTING**

Each team will have a means for generating an audible alarm, which will consist of a compressed gas horn or vehicle horn. These devices will be used to signal to other project personnel in the event of accidents or emergencies. Short blasts (less than 1/2 second) of the horn will be used to request assistance, while extended blasts (more than 2 seconds) will signal an evacuation.

### **11.3 EVACUATION**

The SSHO or Field Manager will designate the evacuation routes and an assembly area. All employees will be familiar with the evacuation routes and assembly area. Refer to the project Work Plan for site maps.

### **11.4 EMERGENCY EQUIPMENT**

Several items of emergency equipment will be maintained at the work site. Any incident that is not clearly controllable by personnel wearing standard site clothing plus protective gloves and using the listed equipment will require reevaluation by the SSHO. If the SSHO does not feel that on-site personnel can safely control the emergency with the available equipment, the crew will use alternate approaches such as allowing a small fire to burn out or evacuating the site. The required emergency equipment includes:

- 16-unit first aid kit indoors or in weatherproof container, inspected weekly;
- compressed gas horns or vehicle horn;
- fifteen minute emergency eye wash to meet American National Standards Institute standard;
- fire extinguisher(s) (at least 20-B) 8 to 23 meters (25 feet to 75 feet) from outside flammables storage (or use) area;
- one, 5-pound ABC fire extinguisher in each work vehicle;
- basic spill kit suitable to handle small spills of decontamination fluids, hydraulic fluid, or fuels and containing sorbent pads, tubes, and nitrile or similar gloves; and
- telephone for contact with emergency services and, depending on site conditions, portable radios for on-site communication.

## 12.0 LOGS, REPORTS, AND RECORD KEEPING

A system of reports and logs will be used to document activities related to site Health and Safety. These reports will include injuries, accidents, near accidents, interpretations of the SSHP or regulations, interactions with auditors/regulators/USACE personnel, and any off-normal events.

- Employee/visitor log book.
- Accident and injury reports for all accidents other than first aid cases.
- Training certificates.
- Logbooks detailing site training, topics covered, names and signatures of participants and trainer, general site activities, site workers, H&S problems, and problem resolutions.
- Medical clearance forms.
- Daily safety inspection logs will contain the dates of inspections, identity of the person doing the inspection, the examined areas/activities/equipment, any deficiencies, and any corrective actions taken.
- Related procedures such as equipment and personal decontamination.
- Equipment maintenance logs will contain the dates and types of routine maintenance performed on site equipment.
- Environmental and personal exposure monitoring/sampling results will be maintained in a log that will contain monitoring data, location and time of monitoring, types of work being done, calibration records, and the identities of personnel performing monitoring.
- The health and safety debrief form contained in EC&HS Procedure 20 will be completed by the SSHO at the completion of the project and submitted to the H&S Manager.

Examples of reporting forms to be used for the project are included in Appendix A of this SSHP.

### 13.0 REFERENCES

American Conference of Governmental Industrial Hygienists 1997. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.

National Institute for Occupational Safety and Health 1994. Pocket Guide to Chemical Hazards.

NIOSH/OSHA/USCG/EPA 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, October.

OSHA 29 *CFR* 1910 and 1926

U.S. Army Corps of Engineers 1996. Safety and Health Requirements Manual, EM 385-1-1, September.

U.S. Army Corps of Engineers 1994. Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste and Ordnance and Explosive Waste Activities, Appendix B, ER 385-1-92, March.

U.S. Army Corps of Engineers 1997. Radiation Protection Manual, EM 385-1-80, May.

**APPENDIX A**  
**REPORTING FORMS**









DAILY SAFETY INSPECTION

PROJECT: \_\_\_\_\_

Page 1 of 2

N	Y	NA	Item
			OSHA poster #2203 displayed
			Daily safety briefing conducted
			Emergency numbers and route to hospital posted
			SSHP onsite, available to employees, and complete?
			Required exposure monitoring conducted and documented
			Monitoring instruments (PID, OVA, CGI) calibrated daily against known standard and documented
			16 unit first aid kit available and inspected weekly
			Personnel wearing PPE required by SSHP for field work (at least safety shoes or boots, safety glasses with side shields, and nitrile or similar gloves to handle potentially contaminated material)
			Personnel using buddy system (maintain visual or verbal contact and able to render aid)
			If temperature >70°F: heat stress training conducted, cool fluids available, pulse rates of personnel wearing Tyvek are being monitored, work/rest cycle in SSHP being followed
			If temperature <40°F: cold stress training conducted, controls in SSHP implemented
			Personnel using appropriate biological hazard controls (See SSHP)
			Drill rig operating manual on site
			Drill rigs inspected weekly and documented
			Personnel near drill rig or other overhead hazards wearing hardhats
			Each of two drill rig kill switches tested daily
			Employees excluded from under lifted loads
			Unnecessary personnel excluded from hazardous areas, specifically near drill rigs
			Radius of exclusion zone around drill rig at least equal to mast height
			Personnel wearing hearing protection when within 25' of drill rigs, generators, or other noisy equipment
			Containers of flammable liquids closed and labeled properly
			Fully charged fire extinguisher available 25 to 50 feet from flammables storage area and inspected monthly
			Personnel exiting potentially contaminated areas washing hands and face before eating
			Personnel using steam washer wearing faceshield, hearing protection, heavy duty waterproof gloves, Saranex or rainsuit
			Portable electrical equipment double insulated or plugged to a GFCI
			Electrical wiring covered by insulation or enclosure
			Three wire, UL approved, extension cords used
			Housekeeping adequate (walkways clear of loose, sharp or dangerous objects and trip hazards, work areas clear of objects that might fall on employees)
			Walking/working surfaces safe (not slippery, no unguarded holes, no trip hazards)
			Confined space entry (entry into trenches deeper than -4 feet) performed according to SSHP and EC&HS Procedure 10
			Excavations deeper than 5 feet shored or sloped (if personnel will enter) and in compliance with SSHP

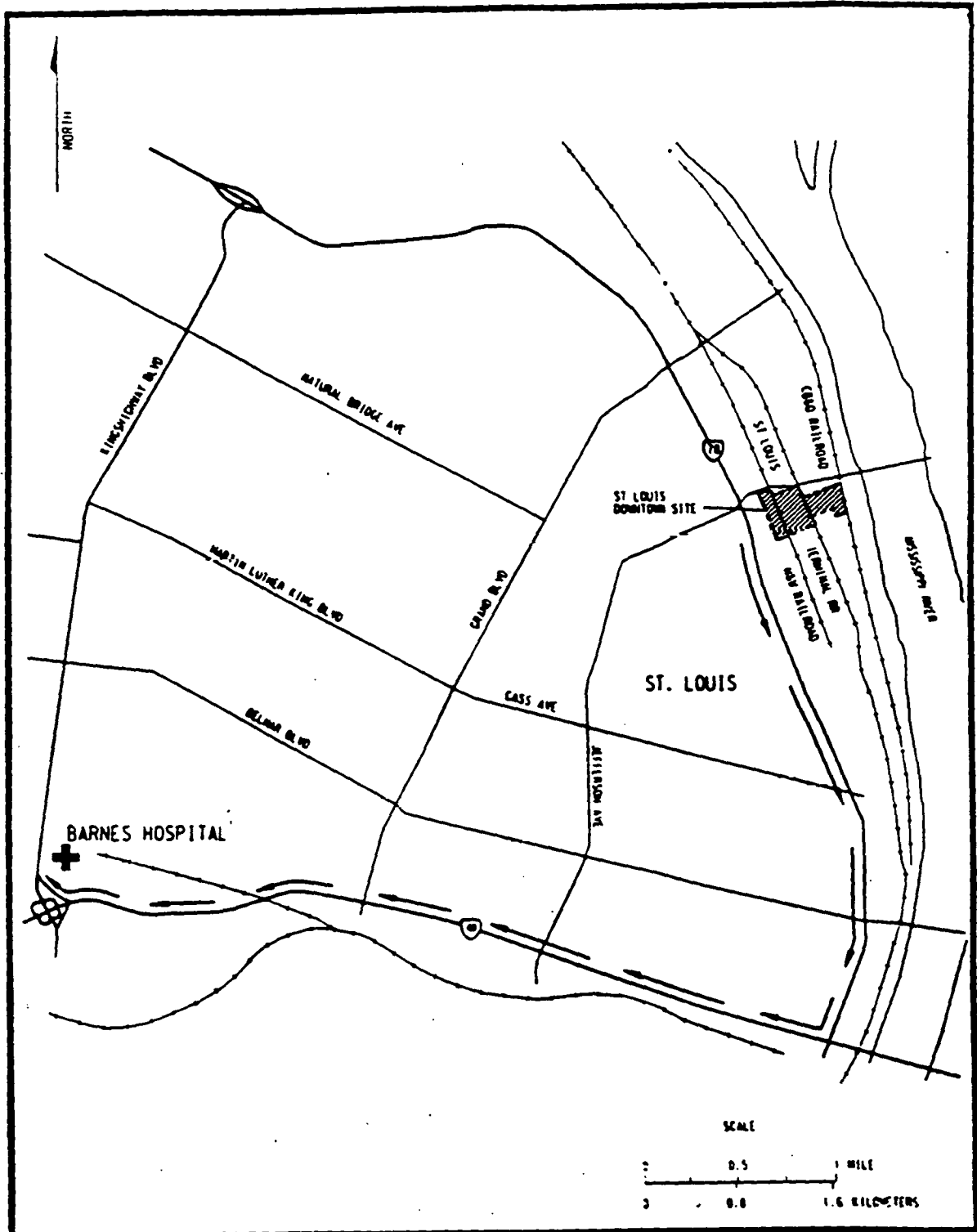
**DAILY SAFETY INSPECTION**

PROJECT: \_\_\_\_\_

Page 2 of 2

		Moving (rotating) machinery guarded to prevent employee contact
		Fall protection provided for work at elevations greater than 4 feet
		All containers of hazardous material labeled to indicate contents and hazards
		MSDSs for hazardous materials on site
		If work is conducted in areas open to hunting (and during season) high visibility vests and other alerting systems such as lights, noise devices (radios) in use
		15 minute eyewash (accessible and full) within 100 feet of areas where corrosive sample preservatives are poured
		Potable and non-potable water labeled
		Chainsaws have anti kick-back protection, personnel wearing cut resistant gloves, protective chaps
		Visitor access controlled
		Site hazards and controls consistent with SSHP
		Site hazard controls appropriate and sufficient
Areas checked, equipment in use, and employees present		
Actions taken to current or control and "N" responses		
Name	Signature	Date

**APPENDIX B**  
**HOSPITAL LOCATIONS MAP**



4907 012 DCA

Figure B-1. Route from SLDS to Barnes Hospital

### EMERGENCY PHONE NUMBERS

Fire department	314-533-3406 or 911
Police	314-444-5555 or 911
Emergency medical service	911
Hospital – Barnes Hospital One Barnes Hospital Plaza St. Louis, MO	314-362-5000
EEMG Health and Safety Manager (Steve Davis)	423-481-4755




## **APPENDIX I**


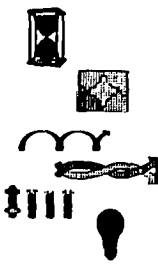
### **Technical Project Planning (TPP) Summaries for SLAPS and SLDS**

SLAPS On-Board TPP Progress (February 25-27, 1998)

Phase	Activity	Resource(s)/Key Concept(s) <sup>1</sup>	On-Board TPP Progress
<p>Phase I Prepare Team Information Package</p> <p><i>Team Information Package = an informal collection of existing site information and preliminary scoping information</i></p>	<p>Gather Existing Site Information</p>	<p>Site Information Checklist (Exhibit 2-1, p 2-7)</p>	<p>Tremendous volume of site data exists. '97 groundwater sampling results have not been reported yet. Detect data is available and stored in SAIC's "earthVision" 3-D system. SAIC does not have below background chemical and metals data from Bechtel (background standard is unknown). Hard copies of SLAPS data is warehoused in Oak Ridge, TN. January 1998 SAP was a menu of Data Collection Items</p> <ul style="list-style-type: none"> <li>- Background Determination</li> <li>- Some additional characterization data collection (fate &amp; transport)</li> <li>- Risk Analysis data collection</li> <li>- Data collection to support RD (treatability, waste mgmt., remedial screening)</li> <li>- Health &amp; Safety data collection (worker protection monitoring while in field)</li> </ul>
	<p>Identify Customer's Goals</p> <ul style="list-style-type: none"> <li>- Customer's concept of site closeout</li> <li>- Customer's desired time frame</li> <li>- Customer's budget for site</li> </ul>	<p>Customer's Concept of Site Closeout (p 2-9)</p>	<p>Site Closeout = walk-away goal = potential for residential development. (Property owners most likely to use portions of site for airport expansion, and some industrial and some recreational uses. Although residential use concern must be evaluated, likelihood is questionable.)</p> <p>Desired Time Frames:</p> <ul style="list-style-type: none"> <li>- Cease characterization activities.</li> <li>- Move dirt this summer.</li> <li>- Continue EE/CAs to mitigate risks.</li> <li>- IROD (Downtown OU) by 7/3/98</li> <li>- ROD (Site-Wide, less Coldwater Creek) by 7/5/99</li> </ul> <p>Budget for Site: Dollars expended on characterization reduce total dollars available for site remediation.</p>
	<p>Determine USACE Acquisition Strategy</p>	<p>(Paragraph 2-6, pp 2-10 to 2-14)</p>	<p>Commitments made to SAIC:</p> <ul style="list-style-type: none"> <li>- Complete SAP</li> <li>- Conduct Field Work</li> <li>- Prepare FS (needs to be contracted)</li> <li>- Several other task elements</li> </ul>
	<p>Identify Technical Planning Team Members</p> <ul style="list-style-type: none"> <li>- Decision Makers</li> <li>- Data Users</li> <li>- Data Implementors</li> <li>- Other Project Specific Specialists</li> </ul>	<p>Technical Planning Team (pp 2-14 to 2-18)</p>	<p>TPP Team Represented During 2/25 Meetings (see attendee list)</p> <ul style="list-style-type: none"> <li>- Decision Makers (USACE-SI, USACE-KC, EPA VII, MDNR, MD011)</li> <li>- Data User Perspectives (Risk, Compliance?, Remedy)</li> <li>- Data Implementor Perspectives (Sampling and Analysis)</li> </ul> <p>TPP Team Members Not Represented During 2/25 Meetings:</p> <p>USGS St. Louis PPM? USACE Legal Counsel Representatives of Suspected Contributors to Site Conditions Stakeholders from Community</p>

**SLAPS On-Board TPP Progress (February 25-27, 1998)**

Phase	Activity	Resource(s)/Key Concept(s) <sup>1</sup>	On-Board TPP Progress
<p>Phase I Identify Site Strategy</p>  <p><i>Site Strategy = an overall approach for managing an HTRW site from its current condition to the desired site closeout condition</i></p>	Identify Primary and Secondary Regulatory Programs	Regulatory Program Flowcharts (Figures 2-4, 2-5, and 2-5, pp 2-21 to 2-24)	<p>Primary Regulatory Program: CERCLA</p> <p>Secondary Regulatory Programs: Many secondary chemical-, action-, and location-specific ARARs.</p>
	Identify Future Use(s) of the Site	(Paragraph 2-10, p 2-30)	<p>Future Use of the Site:</p> <ul style="list-style-type: none"> <li>- Residential (for data collection planning)</li> <li>- Mixed (likely reality of property owners)</li> </ul>
	Define Scope and Meaning of Site Closeout	(Example 2-2, p 2-32)	<p>Scope &amp; Meaning of Site Closeout = risks mitigated to acceptable levels</p> <p>Site (for purposes of on-board TPP meetings, see also SAP Figure 1-9):</p> <ul style="list-style-type: none"> <li>- SLAPS (IA-1 through IA-7)</li> <li>- Contiguous Properties (CPs):                             <ul style="list-style-type: none"> <li>- McDonnell Blvd. (IA-8)</li> <li>- Ballfields (IA-9)</li> <li>- Coldwater Creek Floodplain (IA-10)</li> <li>- Boeing Property (IA-11)</li> <li>- Railroad right-of-way (IA-12)</li> <li>- Airport authority property (IA-13)</li> </ul> </li> <li>- Groundwater (needs to benefit with recent leaching study findings)</li> <li>- Background</li> <li>- Coldwater Creek (baseline conditions wrt verifying no effect from remedies, characterization and contributions of others is outside this SAP and TPP focus)</li> </ul> <p>Excluded portions of FUSRAP Site wrt TPP meetings and SAP revisions:</p> <ul style="list-style-type: none"> <li>- St. Louis Downtown Site (SLDS)</li> <li>- Latty Avenue vicinity properties</li> <li>- Hazelwood Interim Storage Site (IISS)</li> </ul>
	Define All Probable Remedies	Probable Remedies, Typical HTRW Sites (Table 2-1, p 2-35)	<p>Soils &amp; Debris: Excavation and disposal, &amp; possible onsite below criteria borrow</p> <p>Surfacewater &amp; Groundwater: treatment and management during construction</p>
	Identify All Possible Executable Phases to Site Closeout	Project Decision Statements (PDs) (pp 2-34 to 2-47)	<p>PDs 1.31 - 1.38 (Interim Removal Action Objectives)</p> <p>PDs 1.61 and 1.62 (Establish RAOs and Candidate Remedial Alternatives)</p> <p>PDs 1.71, 1.72, 1.73 (Identify and Screen Potentially Suitable Technologies)</p> <p>PDs 1.81, 1.82, 1.83, 1.84, 1.85 (Detailed Analysis of Remedial Alternatives)</p> <p>PD 1.91 (Develop Design of Remedy to Satisfy ROD requirements)</p>

Phase	Activity	Resource(s)/Key Concept(s) <sup>1</sup>	On-Board TPP Progress
	Evaluate Progress to Site Closeout - Have we satisfied PDs for site closeout? - Did previous efforts satisfy previous PDs?	(Paragraph 2-14, pp 2-47 and 2-48)	Regulators agreed that RI (January and September 1994) was adequate for the rad. portion of the site and will be supplemented by the PAM for determination of the PRGs for the full list of MED chemicals. RI is considered adequate because onsite remedy is not being considered. No need for ecological risk assessment, but qualitative evaluation is necessary looking at ecological risks. Individual PRGs appear to be appropriate rather than evaluating cumulative risk. 1994 FS exists w/ formal reviews, but will need to be significantly superseded. EE/CAs ongoing and related Interim Removal Actions planned.
Phase I Determine Project Strategy  <p><i>Project Strategy = the detailed strategy for managing an executable phase of progress (e.g., RI, FS, RD, RA) at an HTRW site condition</i></p>	Identify Site Constraints and Dependencies - HWBS product milestones - level and duration of efforts - availability and timing of funding - technical and regulatory issues	(Paragraph 2-16, pp 2-50 to 2-52)	(See attached schedule prepared during 2/25 meeting, refined during 2/26 meeting, and re-confirmed during 2/27 meeting.)  Constraints and Dependencies were discussed at length in hopes of achieving a site-wide ROD milestone of 7/5/99. Schedule produced as a product of those discussions is only possible with some simultaneous reviews, reduced review cycles, and on-board conference calls to bring major, preliminary comments to surface for proactive resolution. On-board TPP meetings and on-board conference calls are intended to help meet desired project schedule goals, support timely field activities this summer, and ensure problems are proactively averted.  The PAM (Preliminary Assessment Memorandum) needs to provide the risk management process with information that supplements the existing Baseline Risk Assessment. Primary elements of PAM will need to provide PRGs applicable to site based on Uranium and metals findings, and provide an ecological screening for the site. Successful production and acceptance of PAM will ensure that FS is appropriately focused on meaningful alternatives for remaining site conditions that pose unacceptable risk.
	Define Options for Achieving Site Closeout - expedited removals - operable units/ exposure areas - phasing (series and/or parallel) - presumptive remedies - innovative technologies 	Field Screening Opportunities (Figure 2-13, p 2-54)	Interim Removal Actions are being used. Additional Removal Actions may be planned and implemented.  Progress on SLAPS and contiguous properties (CP) will generally be in series.  Progress on other St. Louis portions of FUSRAP site will continue to parallel SLAPS and CP. Some integration of other portions of site may be necessary in the future for public relations purposes, and possibly related to ROD. Similar TPP on-board meetings will be considered for the Downtown site and the Coldwater Creek efforts.


**SLAPS On-Board TPP Progress (February 25-27, 1998)**

Phase	Activity	Resource(s)/Key Concept(s) <sup>1</sup>	On-Board TPP Progress
	Identify Executable Phases and Select PDs for the Project	(Paragraph 2-18, pp 2-55 to 2-56)	Finalize SAP SLAPS field work CPs field work FS and Proposed Plan ROD RD/RA (as appropriate)  (EE/CAs and IRAs are parallel and ongoing across the site as appropriate)
Phase I Complete Phase I Activities	Finalize USACE Acquisition Strategy	(Paragraph 2-19, pp 2-56 to 2-57)	[Action Item for USACE: Contracting and funding wrt SAIC beyond 9/30/97.]
	Initiate Scope of Work Sections	(Paragraph 2-20, p 2-57)	
	Prepare TM Memo	Outline of Typical TM Memo (Exhibit 2-2, pp 2-59 and 2-60)	[Action Item for USACE-KC, with some support from USACE CX.]

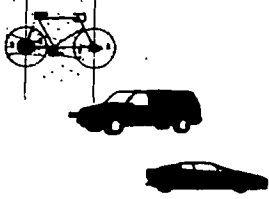
SLAPS On-Board TPP Progress (February 25-27, 1998)

Phase	Activity	Resource(s)/Key Concept(s) <sup>1</sup>	On-Board TPP Progress
<p>Phase II Determine Data Needs</p> <p><i>data need = site information or environmental data that must be obtained to support an evaluation that satisfies a PDs</i></p>	<p>Review Phase I Information - TM Memo - user specific information</p>	<p>(Paragraph 3-4, pp 3-5 to 3-8)</p>	<p>Review of Phase I Information resulted in refining the progress notes captured above and provided foundation for Phase II discussions.</p>
	<p>Assemble PDs and Identify Project Study Elements</p>	<p>Typical Project Study Elements (Figures 3-2, 3-3, and 3-4)</p>	<p>The Project Study Elements, or deliverables, discussed were as follows: 1. PAM 2. FS 3. ROD 4. IRA Designs</p> <p>Re-visited project objectives and outlined them as follows:</p> <p>1 Support Interim RAs 1.1 Design 1.2 Volumes 1.3 Metals &amp; Chemicals @ SLAPS to support HISS RA 1.4 Remedial Screening Tools (1.1-1.4 was first cut at IRAs project objectives. Second cut follows.) 1 Floor confirmatory samples 2 Stop Dig &amp; Haul 3 Boundary Delineation (horiz. &amp; vert., for volumes and to design excavation) 4 Waste Profile materials for disposal 5 "Hot Spot" verification (feeds into 2 above)</p> <p>(Also separate QAPP &amp; DQOs outside this SAP for IRAs planned this summer.)</p> <p>2 Support PAM, FS, and ROD 2.1 Metals 2.2 Chemicals 2.3 Pa/Ac 2.4 Background (soil and groundwater)</p> <p>3 Support Disposal Alternatives 3.1 Subtitle C Landfill (hazardous or non-hazardous) 3.2 Borrow low-criteria soils</p> <p>Some success identifying Data User perspectives who would need data to satisfy individual project objectives. SAP will need improved clarification of project objectives based on TPP discussions.</p>

**SLAPS On-Board TPP Progress (February 25-27, 1998)**

Phase	Activity	Resource(s)/Key Concept(s) <sup>1</sup>	On-Board TPP Progress
	Conceptualize Data Needs to Support Project Study Elements	Data User's Strategy Diagrams and Models (Figures 3-5 through 3-8)	Conceptualized some portions of the following Data Needs: - Risk Perspective data to support the PAM - Compliance Perspective was not discussed in any detail - Remedy Perspective data to support IRA horizontal and vertical boundaries, waste characterization, as well as strategy to discontinue excavations - Responsibility Perspective was discussed and is needed. Legal Counsel input is needed regarding strategy wrt other potential PRPs. If Legal Counsel wants to pursue or evaluate others for some portions of site, the technical team needs to develop fingerprint strategy and sampling to evaluate potential contributions of others to the site. Also Legal Counsel input to decide whether the suspect contaminants should be analyzed.
	Define Data Needs 	(Paragraph 3-7, pp 3-35 to 3-45)	Cyclical discussions occurred between conceptualizing and defining data needs. Limited progress defining data needs, but some progress reviewing data needs as summarized in Table 2-1 of the USACE Review Draft SAP dated January 1998.  Discussed needs to further refine Table 1-5 listing of PCOCs. SAIC is responsible for taking first cut, USACE will review and collaborate (including giving some consideration to obtaining input from Malincot and other stakeholders), following USACE review list will be sent to Regulators as draft, pre-SAP list. The desired PCOC listing will clearly group constituents (e.g., MED/AEC; native & MED/AEC; tracers; risk drivers) and differentiate PCOCs with respect to soil and groundwater where appropriate to ensure analyses meet and don't summarily exceed data needed to support project objectives.  Discussed background data. Discussed number of samples, basis for background locations, limitations due to detection limits and substrates not identified, and all groundwater background was less than bedrock depths. Recognized that several different groups of background results and criteria have been used throughout site progress to date. Consensus was that SAIC will re-visit background determination sampling proposed in SAP and refine based on discussions.  Groundwater background efforts will need greater collaboration with technical working group and phase sampling appropriately.
Phase II Document Data Needs	Document Data Needs	Types of Data Needs Worksheets (Exhibit 3-9, p 3-48)	See attached partially completed Data Needs Worksheets. It appears that they will not be further populated within this SAP or effort.

SLAPS On-Board TPP Progress (February 25-27, 1998)

Phase	Activity	Resource(s)/Key Concept(s) <sup>1</sup>	On-Board TPP Progress
<p>Phase III Identify Data Collection Options</p> <p><i>data collection options = "basic", "optimum", and "comprehensive" data collection options are labels for data collection plans that satisfy minimum data needs of the current executable phase (basic); minimize future costs by collecting data for subsequent executable phases (optimum); and clearly isolate Customer-imposed and Regulator required data needs that are excessive (comprehensive), respectively.</i></p> 	<p>Review Phase I and II Information</p> <ul style="list-style-type: none"> <li>- TM Memo</li> <li>- Data Needs</li> <li>- User specific information</li> </ul>	<p>(Paragraph 4-4, pp 4-4 and 4-5)</p>	<p>Review of TPP efforts to date resulted in some clarification and refinements to progress described above.</p>
	<p>Conceptualize Overall Approach to Identifying Sampling Requirements</p> <ul style="list-style-type: none"> <li>- source location(s) and pathway(s)</li> <li>- physical and chemical characteristics</li> <li>- media to be sampled</li> <li>- interface w/ chemist, geologist, and others</li> </ul>	<p>(Paragraph 4-5, pp 4-5 to 4-12)</p>	<p>Discussed dual use of some sample results and importance of communicating dual use situations to ensure management knows all consequences of eliminating samples from overall program.</p> <p>Tabled detailed discussions on sampling methods and field analytical approaches due to time constraints for finishing all phases of TPP process.</p>
	<p>Develop Approaches for Sampling and Analysis Activities</p> <ul style="list-style-type: none"> <li>- identify and screen sampling overlaps</li> <li>- define sample collection strategy</li> <li>- identify sample and analysis methods</li> </ul>	<p>Identifying Data Need Overlaps (Exhibit 4-1, p 4-14)</p>	<p>Recognize several unique data needs and COCs based on data use and deliverable or project objective. Revisions to Table 2-1 will better reflect these situations.</p>
	<p>Apply Cost, Schedule, and Other Constraints in Developing Data Collection Options</p>	<p>Definition of Data Collection Options (Table 4-3, p 4-28)</p>	<p>Discussed data collection options of basic, optimum, and comprehensive. Discussed all elements of Table 2-1 in USACE Review Draft of SAP. Each element was classified as basic, optimum, and comprehensive. Revisions to Table 2-1 will include adding a column and grouping data collection effort by data collection option. Elements within data collection option will also be in a suggested prioritization to contribute to subsequent management decisions. Table 2-1 will also provide at least a sentence or two clearly linking each element of the table with the applicable project objective(s) supported by obtaining the additional data from the field. Given that no comprehensive data collection elements are currently being advocated by any decision makers, the next version of Table 2-1 will not include any comprehensive (excessive) data collection elements.</p>
<p>Phase III Document Data Collection Options</p>	<p>Document Data Collection Options</p>	<p>Data Collection Program Table (Exhibit 4-2, p 4-31) Summary Table of Data Collection Options (Exhibit 4-3, p 4-32)</p>	<p>A summary table similar to Table 2-1 will be used for this purpose in the Draft SAP due 3/13/98.</p>



**SLAPS On-Board TPP Progress (February 25-27, 1998)**

<b>Phase</b>	<b>Activity</b>	<b>Resource(s)/Key Concept(s)</b>	<b>On-Board TPP Progress</b>
Phase IV Select Data Collection Program  <i>data collection program = describes all the plans for obtaining site information and environmental data needed by Data Users for satisfying PDs and supporting site decision making efforts</i>	Prepare Fact Sheet of Data Collection Options - review data collection options table - summarize sampling and analysis activities - list benefits and limitations of each option	(Paragraph 5-4, p 5-4)	SAIC will be prepared to help USACE management understand specific cost and schedule savings anticipated as a result of including each optimum data collection effort in the current data collection program. The business decision of including an optimum data collection element is not based on the availability of funding to include the sampling, but the anticipated cost and schedule benefits of the efforts as well as the soundness of the business decision to predict and accelerate future data needs.
	Design Data Collection Program - present options to Customer - select data collection options - refine data collection program options	Summary Table of Data Collection Options (Example 5-1, p 5-5)	Draft SAP will enable USACE and all Decision Makers to refine Data Collection Program based on available data collection options.
Phase IV Document Data Collection Program	Prepare DQO for Each Component of the Data Collection Program	(Paragraph 5-7, pp 5-8 and 5-9)	Probabilistic and non-probabilistic types of DQOs were discussed, as well as the products of EPA's 7-Step DQO process relative to USACE's TPP process. The expectation is that the Draft SAP's summary table, similar to Table 2-1 of USACE Review Draft, will provide all the components of a TPP-style DQO statement for each element of the proposed data collection efforts. Each entry in the table will clearly communicate the data needed, the intended use(s) of the data, and the appropriate means to collect the data. Preparation of a series of detailed DQO statements was not fully resolved or committed to during the meetings.
	Prepare Fact Sheet(s) for Presentation	(Paragraph 5-8, pp 5-9 and 5-11)	Not discussed during on-board meetings.
	Finalize Scope of Work Sections	(Paragraph 5-9, pp 5-11 and 5-12)	Not discussed during on-board meetings.
	Prepare Detailed Cost Estimate for Data Collection Program Designed	(Paragraph 5-10, pp 5-12 and 5-13)	Pricing the work by element of the data collection program was discussed to contribute to management decisions regarding the specific data to be collected within the data collection program.

References for resources and key concepts can be used to find additional information within EM 200-1-2 (31 July 1995).

Additional information may be obtained from USACE proponents:

Ms. Heidi Novotny, (402)697-2231

Mr. Larry Becker, (202)761-8882.

heidi.l.novotny@usace.army.mil

larry.becker@usace.army.mil

DATA NEEDS WORKSHEET - REMEDY PERSPECTIVE

SITE NAME: St. Louis Downtown Site (SLDS)  
 PROJECT: SLDS Background Determination

DATA USER NAME(s): This worksheet represents the concurrence reached during 25 March 1998 meeting<sup>1</sup>.

Data Need	Data Use			Number of Samples	Remediation Area(s) / Sample Location(s)	Project Objective(s)
	Remedy Method(s) of Interest	Criteria to be Considered	Medium to be Sampled			
Concentrations of the following chemicals <sup>2</sup> : U-238, Th-232, Th-230, Pa-231, Ac-227, Ra-226, Arsenic (As), Barium (Ba), Cadmium (Cd), Cobalt (Co), Copper (Cu), Fluoride (F), Iron (Fe), Lead (Pb), Magnesium (Mg), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Nitrogen/Nitrate, Palladium (Pd) <sup>3</sup> , Platinum (Pt) <sup>3</sup> , Selenium (Se), Sulfur/Sulfate, Vanadium (V), Zinc (Zn), Trichloroethene (TCE), and PAHs.	not applicable	not applicable	Cinder Fill materials (native alluvial strata need not be sampled) <sup>4</sup> .	To be estimated in SAP Addendum and then verified during field activities <sup>5</sup> .	Sample locations should be within the area bounded by Breman to the North, Broadway to the West, N. Market to the South, and the Mississippi River levee to the East <sup>6</sup> .	Determine background concentrations to support future site decisions and remediation.

## DATA NEEDS WORKSHEET - REMEDY PERSPECTIVE

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<sup>1</sup> Participants in the on-board Technical Project Planning (TPP) meeting included representatives from USACE St. Louis, USACE Kansas City, USACE HTRW CX, USEPA Region VII, MDNR/DGLS, MDNR/HWP, Mallinckrodt, SAIC, and Stone & Webster.

<sup>2</sup> This list of chemicals is the one developed during the meeting. SAIC's Sampling and Analysis Plan (SAP) Addendum will clarify the analytes based on considerations of minimizing analytical costs, and identify the reporting limits required to satisfy the intended use(s) of the background results.

<sup>3</sup> Only 10-20% of the background samples need to be analyzed for Palladium (Pd) and Platinum (Pt), as discussed during the meeting.

<sup>4</sup> The minimum and maximum background sampling depths within the cinder fill materials will be 2 feet and 15 feet below land surface, respectively. The 2 foot minimum was established to minimize the potential effects of surface deposition and the 15 foot maximum was set to be meaningful for site decisions and supportive of both current and future land uses at the site.

<sup>5</sup> The number of discrete samples will be calculated prior to field activities based on an estimate of the standard deviation expected in the strata. The actual number of samples collected will be sufficient to satisfy the statistical values used to initially estimate the sample population. SAIC's SAP Addendum will present the initial estimate and discuss the observational methods that will be used in the field to ensure a sufficient number of background samples are collected based on the actual coefficient of variation within the cinder fill strata at the site. At each background sampling location, the number of discrete samples collected will be restricted to 2, 3, or 4 samples.

<sup>6</sup> Potential background sample locations will be proposed and prioritized based on proximity to site, anticipated ease of access, and suspected likelihood of finding cinder fill materials that have been unaffected by historical activities at each location. USACE, the Regulators, Mallinckrodt, and SAIC will further collaborate on selecting and prioritizing potential background sampling locations and expediting site access agreements.

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North St. Louis County Sites

St. Louis County, Missouri

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