United States
Environmental Protection
Agency

Office of
Solid Waste and
Emergency Response

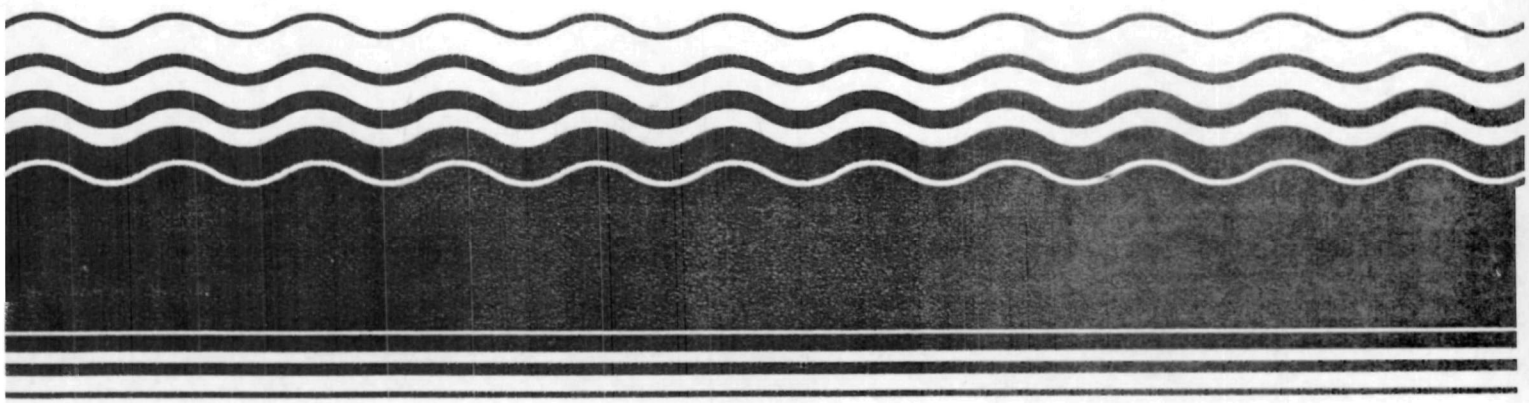
9285.9-17B
EPA/540/R-96/035
PB96-963248
December 1996

Superfund

EPA

Sampling for Hazardous Materials (165.9)

Student Manual



Desireé Moyer

9285.9-17B
EPA540/R-96/035
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FOREWORD

This manual is for reference use of students enrolled in scheduled training courses of the U.S. Environmental Protection Agency (EPA). While it will be useful to anyone who needs information on the subjects covered, it will have its greatest value as an adjunct to classroom presentations involving discussions among the students and the instructional staff.

This manual has been developed to provide the best available current information; however, individual instructors may provide additional material to cover special aspects of their presentations.

Because of the limited availability of the manual, it should not be cited in bibliographies or other publications.

References to products and manufacturers are for illustration only; they do not imply endorsement by EPA.

Constructive suggestions for improvement of the content and format of the Sampling for Hazardous Materials (165.9) manual are welcome.

SAMPLING FOR HAZARDOUS MATERIALS (165.9)
3 Days

This course provides individuals who have little or no sampling experience with practical information for effectively sampling hazardous materials at Superfund sites. The course focuses on sampling plan development, types of equipment suitable for hazardous materials sampling, and procedures for safely collecting samples. It is intended for personnel responsible for inspections, investigations, and remedial actions at Superfund sites. Air sampling is specifically addressed in *Air Monitoring for Hazardous Materials (165.4)* and is not discussed in this course.

The course is designed to be consistent with the EPA protocol and guidance documents entitled *A Compendium of Superfund Field Operations Methods* and *Data Quality Objectives for Remedial Response Activities*.

Topics that are discussed include sample plan development; procedures for sampling containerized materials, surface water/lagoons, sediments/sludges, and soil; soil gas sampling; field screening techniques; documentation; and quality assurance.

Instructional methods include lectures, group discussions, demonstrations, classroom exercises, and outdoor field exercises, emphazing the hands-on use of multimedia sampling equipment.

After completing the course, participants will be able to:

- Select the appropriate field screening method for a given contaminant and geologic environment.
- Select the appropriate sampling container and sample preservation method based on the sample media and analysis required.
- Select the appropriate sampling implements and methods for sampling various containerized wastes.
- Select the appropriate tools and methods for sampling surface water and sediments.
- Describe the basic methods of soil sampling in the unsaturated zone.
- Demonstrate the proper method for obtaining a groundwater sample from a monitoring well.
- Complete the required documentation, including chain of custody and sample labels, for shipment of environmental samples to an analytical laboratory.
- Complete fundamental tasks in a sampling event from initial site investigation through field data collection.

CONTENTS

Section 1	**Orientation and Introduction**
Section 2	**Sample Plan Development**
	• Quality Assurance Sampling Plan for Emergency Response
	• Appendix II of *Guidance for Data Useability in Risk Assessment (Part A)*
Section 3	**Field Screening**
	• Environmental Photographic Interpretation Center (EPIC)
Section 4	**Documentation**
Section 5	**Field Screening Exercise**
Section 6	**Containerized Material Sampling**
	• Hazard Categorization
Section 7	**Groundwater Sampling**
Section 8	**Surface Water and Sediment Sampling**
Section 9	**Soil Sampling**
Section 10	**Field Exercise**
	Problem Session: Sample Plan Development Exercise

ACRONYMS AND ABBREVIATIONS

AMD	Advanced Monitoring Systems Division
AMS	air monitoring system
API	American Petroleum Institute
ARAR	applicable or relevant and appropriate requirements
ASCS	Agricultural Stabilization and Conservation Service
ASTM	American Society for Testing and Materials
BNA	base/neutral and acid extractables
BTEX	benzene, toluene, ethylbenzene, and xylenes
CBI	confidential business information
CDP	common depth point
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CGI	combustible gas indicator
CLP	Contract Laboratory Program
COC	chain of custody
COE	U.S. Army Corps of Engineers
COLIWASA	composite liquid waste sampler
CRDL	contract-required detection limit
CRQL	contract-required quantitation limit
CWA	Clean Water Act
DCO	document control officer
DL	detection limit
DOT	U.S. Department of Transportation
DQO	data quality objectives
EAU	evidence audit unit
Eh	oxidation-reduction potential (redox potential)
EM	electromagnetic
EMSL-LV	Environmental Monitoring and Support Laboratory-Las Vegas
EPA	U.S. Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
ESD	Environmental Services Division (EPA)
FID	flame ionization detector
FIPS	federal information processing standards
FIT	field investigation team
FS	feasibility study
FSP	field sampling plan
FTS	federal telephone system

Acronyms and Abbreviations (continued)

GC	gas chromatograph or gas chromatography
GC/MS	gas chromatography/mass spectroscopy
GIS	geographic information system
GPR	ground-penetrating radar
HAZCAT	hazard categorization
HRS	hazard ranking system
HSL	hazardous substance list
IATA	International Air Transport Association
IDL	instrument detection limit
LEL	lower explosive limit
MDL	method detection limit
NAPL	nonaqueous phase liquid
NAPP	National Aerial Photography Program
ND	nondetect
NEIC	National Enforcement Investigation Center
NHAP	national high altitude photography
NMO	normal movement
n.o.s.	not otherwise specified
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTIS	National Technical Information Service
OD	outside diameter
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	organic vapor analyzer
PAH	polycyclic aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PE	performance evaluation
PID	photoionization detector
POTW	publicly owned treatment works
PPM	parts per million
PPB	parts per billion
PRP	potentially responsible party
PTFE	polytetrafluoroethylene
PVC	polyvinyl chloride

Acronyms and Abbreviations (continued)

QAO	quality assurance officer
QAP	quality assurance plan
QAPjP	quality assurance project plan
QA/QC	quality assurance/quality control
RA	remedial action
RAS	routine analytical services
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RDCO	regional document control officer
REAC	Response Engineering and Analytical Contract
RI	remedial investigation
ROD	record of decision
RPM	remedial project manager
RSCC	Regional Sample Control Center
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
SAS	special analytical services
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SIC	standard industrial classification
SM	site manager
SMO	Sample Management Office
SOP	standard operating procedure
SOW	statement of work
SW-846	*Test Methods for Evaluating Solid Waste (SW-846)* (EPA document)
TAL	Target Analyte List
TCDD	tetrochlorodibenzo-*p*-dioxin
TCL	Target Compound List
TDS	total dissolved solids
TIC	tentatively identified compounds
TOC	total organic carbon
TOX	total organic halogens
TR	traffic report
TSCA	Toxic Substances Control Act
USGS	U.S. Geological Survey
VOA	volatile organic analysis
VOC	volatile organic compound

Section 1

Sampling for Hazardous Materials (165.9)

Orientation and Introduction

Student Guide

SAMPLING FOR HAZARDOUS MATERIALS (165.9)

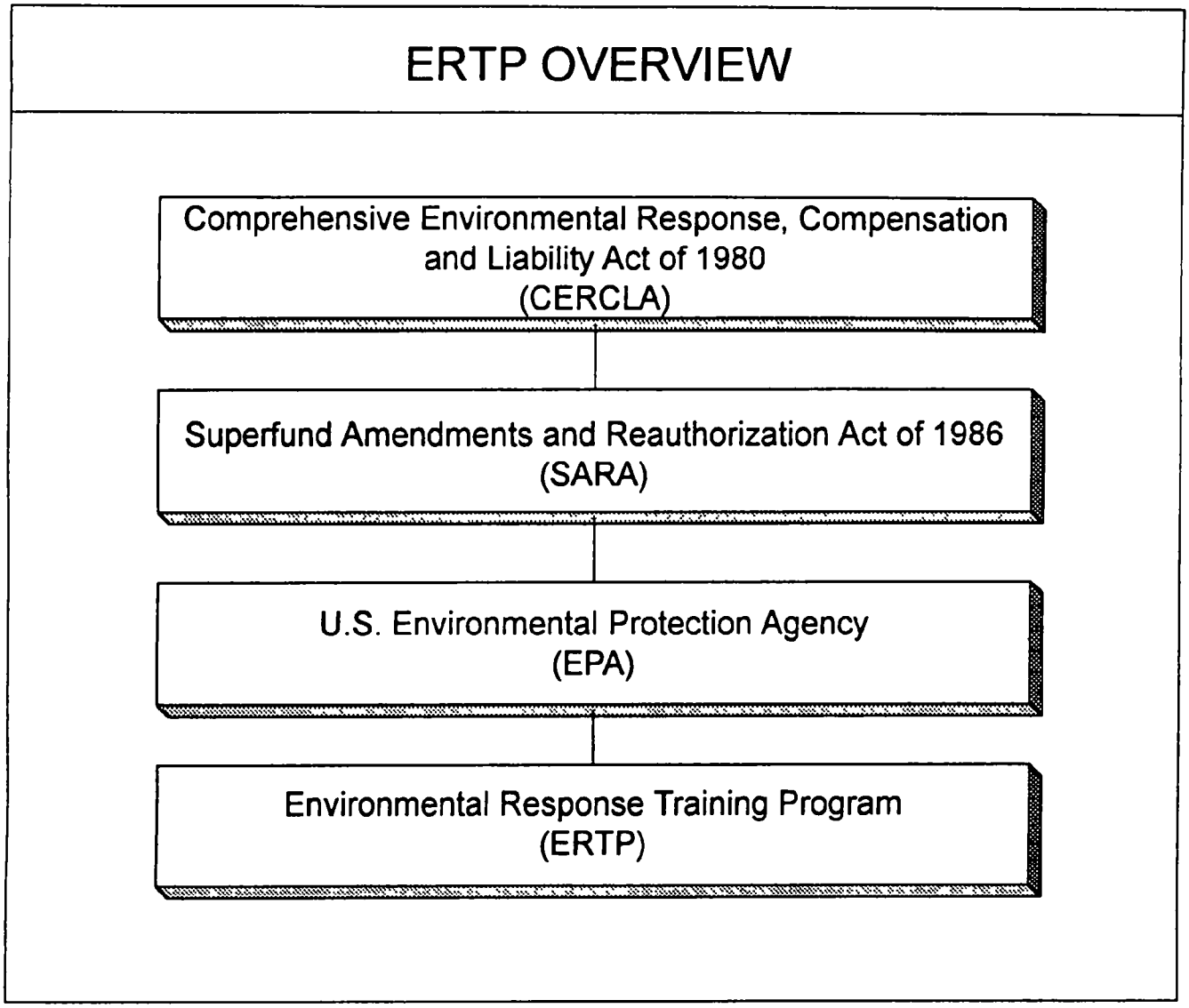
Presented by:
Halliburton NUS Corporation
EPA Contract No. 68-C2-0121

Orientation and Introduction

Agenda:

- Environmental Response Training Program (ERTP) overview
- Synopsis of ERTP courses
- Course layout and agenda
- Course materials
- Facility information

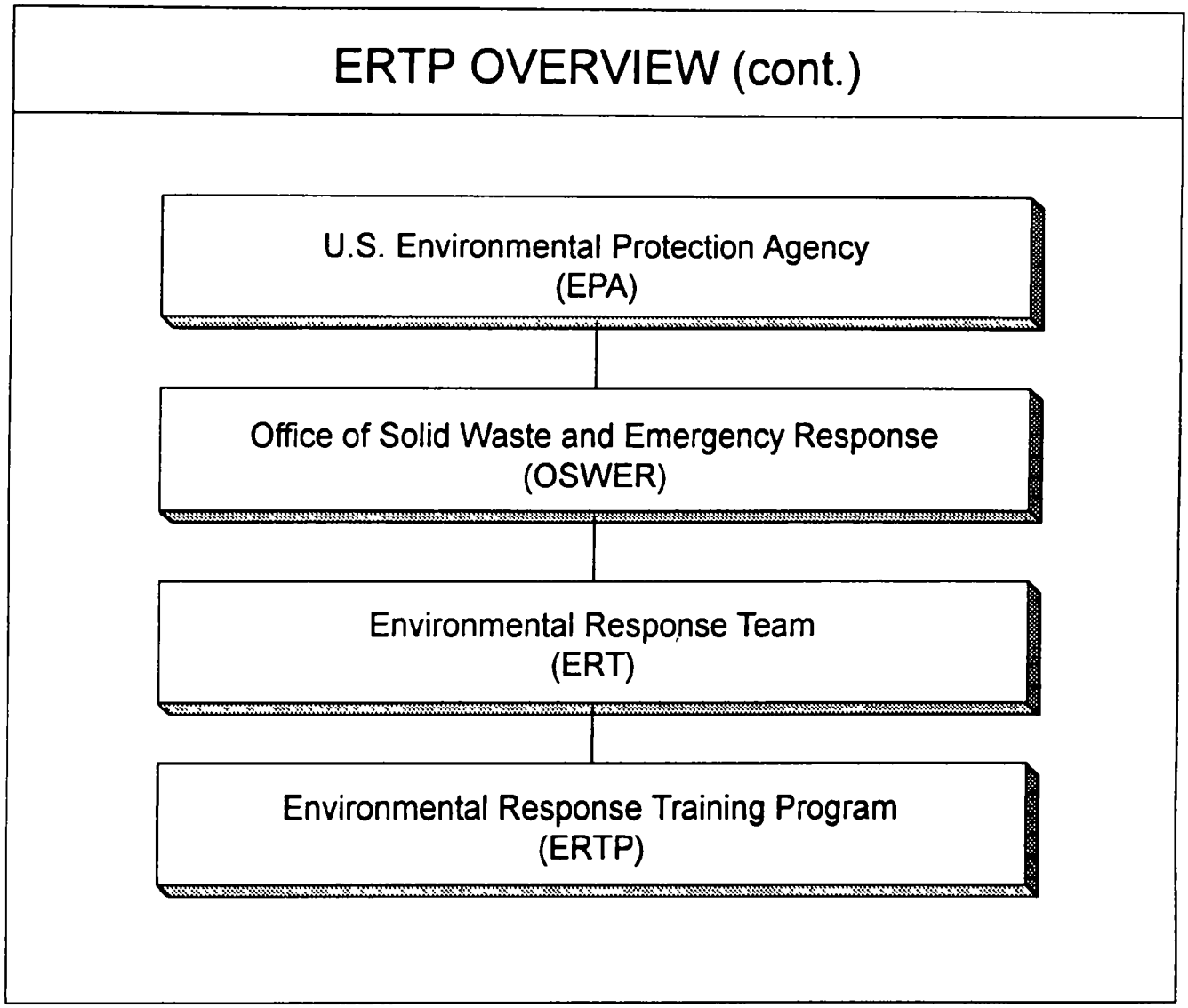
Notes:



ERTP Overview

In 1980, the U.S Congress passed the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund. In 1986, the Superfund Amendments and Reauthorization Act (SARA) was passed. This act amended CERCLA CERCLA provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and for the cleanup of inactive waste disposal sites. The U S. Environmental Protection Agency (EPA) allocated a portion of Superfund money to training. EPA's Environmental Response Team (ERT) developed the Environmental Response Training Program (ERTP) in response to the training needs of individuals involved in Superfund activities

Notes:



ERTP Overview (cont.)

ERTP is administered by ERT, which is part of the Office of Solid Waste and Emergency Response (OSWER) ERT offices and training facilities are located in Cincinnati, Ohio, and Edison, New Jersey ERT has contracted the development of ERTP courses to Halliburton NUS Corporation (EPA Contract No 68-C2-0121) ERTP provides education and training for environmental employees at the federal, state, and local levels in all regions of the United States Training courses cover areas such as basic health and safety and more specialized topics such as air sampling and treatment technologies.

Notes:

Types of Credit Available

Continuing Education Units (CEUs)

2.00 CEUs: 100% attendance at this course
≥ 70% on the exam

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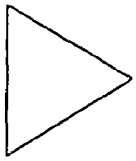
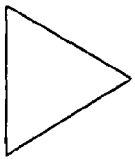


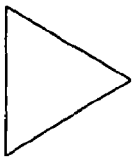
Health and Safety Courses

- *Hazardous Materials Incident Response Operations (165.5)*
- *Safety and Health Decision-Making for Managers (165.8)*
- *Emergency Response to Hazardous Material Incidents (165 15)*



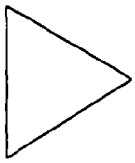
Technical Courses

- *Treatment Technologies for Superfund (165.3)*
- *Air Monitoring for Hazardous Materials (165.4)*
- *Risk Assessment Guidance for Superfund (165.6)*
- *Introduction to Groundwater Investigations (165.7)*
- *Sampling for Hazardous Materials (165.9)*
- *Radiation Safety at Superfund Sites (165.11)*



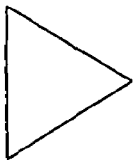
Special Courses

- *Health and Safety Plan Workshop (165.12)*
- *Designs for Air Impact Assessments at Hazardous Waste Sites (165.16)*
- *Removal Cost Management System (165.17)*
- *Inland Oil Spills (165.18)*



Courses Offered in Conjunction with Other EPA Offices

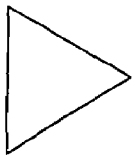
✓ *Chemical Emergency Preparedness and Prevention Office (CEPPO)*
- *Chemical Safety Audits (165.19)*



✓ *Site Assessment Branch*
- *Introductory Preliminary Assessment Training*
- *Introductory Site Investigation Training*
- *Federal Facilities Preliminary Assessment/Site Investigation*
- *Hazard Ranking System*
- *Hazard Ranking System Documentation Record*

Notes:

Course Goals



- Select the appropriate field screening method for a given contaminant and geologic environment.
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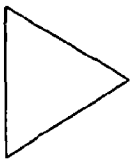
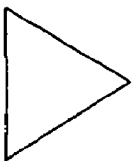


- Select the appropriate tools and methods for sampling surface water and sediments.
- Describe the basic methods of soil sampling in the unsaturated zone.
- Demonstrate the proper method for obtaining a groundwater sample from a monitoring well.



- Complete the required documentation, including chain of custody and sample labels, for shipment of environmental samples to an analytical laboratory.
- Complete fundamental tasks in a sampling event from initial site investigation through field data collection.

Notes:

About the Agenda

- Agenda times are only approximate. Every effort is made to complete units and to finish the day at the specified time.
- Class begins promptly at 8:00 a.m. on Tuesday. Please arrive on time to minimize distractions to fellow students.
- Ten-minute breaks are given between units.
- Lunch is 1 hour.

Points to Remember

- Attendance at each lecture and exercise is required in order to receive an EPA course completion certificate.
- Direct participation in field or lab exercises is optional. Roles for field exercises are randomly assigned to ensure fairness.
- Every student must take the examination given on Thursday.

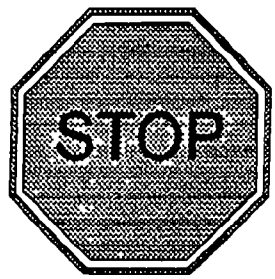
Notes:

CHEMICALS USED IN THIS COURSE

- Methanol
- Hydrochloric acid
- Tris (hydroxymethyl. aminimethane)
- Isopropanol
- Napthalene
- Ethanol
- Sulfuric acid
- Oxalic acid
- Acetone
- Ammonium hydroxide
- Nitric acid
- Succinic acid
- Tartaric acid
- Potassium chloride
- Ethylenediaminetetraacetic acid, disodium salt, dihydrate
- Indigo carmine
- Diethylene glycol
- Sodium potassium tartrate, tetrahydrate

CHEMICALS USED IN THIS COURSE (cont.)

- Mercuric (II) iodide
- Glycerin
- Bovine serum albumin
- Sodium
- Mercuric nitrate in water
- Organosulfur compound
- Bathocuproine
- Sodium bisulfite
- Glacial acetic acid
- Potassium nitrate, anhydrous
- Imidazole
- Sodium hydroxide
- Meso-tetra (4-N-methylpyridyl) porphine teratosylate
- Lead nitrate
- Potassium hydrogen phthalate
- Potassium hydroxide
- Potassium iodide
- Sodium borate, decahydrate



For your safety, please speak with the course director regarding any health concerns that may prohibit your direct participation in exercises or labs involving use or close proximity to these chemicals. Material Safety Data Sheets (MSDS) are available for review.

Chemical Use and Health-related Considerations

For the Field Screening and Field Sampling exercises, gloves will be furnished Please wear gloves and avoid ingestion, inhalation, and skin contact with these chemicals.

Notes:

About the Training Evaluation

The *Training Evaluation* is a tool to collect valuable feedback from YOU about this course.

We value YOUR comments!! Important modifications have been made to this course based on comments from previous students.

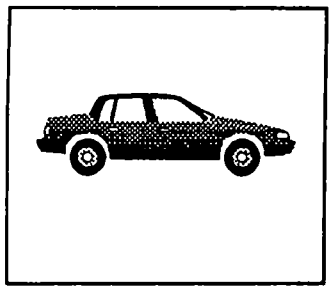
DO

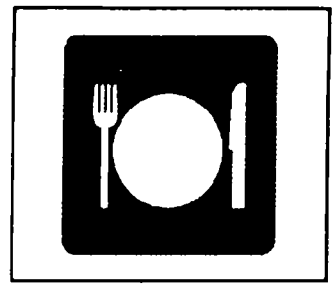
- Complete an evaluation at the end of each unit!
- Tell us if you feel the content of the course manual is clear and complete!
- Tell us if you feel the activities and exercises were useful and helpful!
- Tell us if you feel the course will help you perform related duties back on the job!
- Complete the first page of the evaluation at the end of the course before you leave!
- Write comments in ink.

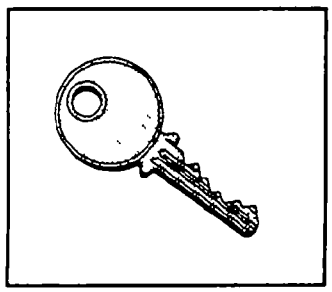
DON'T

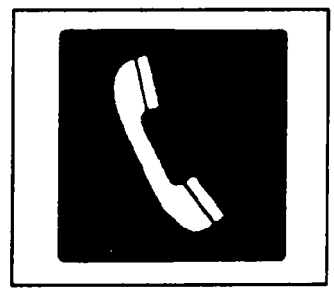
- Hold back!
- Focus exclusively on the presentation skills of the instructors.
- Write your name on the evaluation if it will inhibit you from being direct and honest.

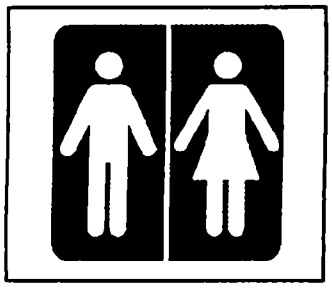
Notes:



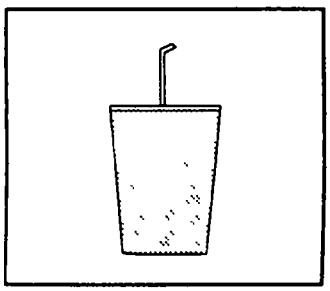








Please put beepers in the vibrate mode and turn off radios. Be courteous to fellow students and minimize distractions



Emergency Telephone Numbers

Emergency Exits

Alarms

Sirens

Notes:

Section 2

SAMPLE PLAN DEVELOPMENT

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Identify sources of background information
2. List and describe the 7-step data quality objectives (DQO) process
3. Describe advantages and disadvantages of the various sample designs discussed during the lecture
4. Identify proper containers, holding times, and detection limits for the selected media
5. Select the proper standard operating procedure for the media
6. Determine appropriate quality assurance requirements for the media selected
7. Describe the data validation process
8. Determine appropriate deliverables, given media and quality assurance level
9. Describe the organization and responsibilities of the sampling team.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

SAMPLE PLAN DEVELOPMENT

ELEMENTS OF A SAMPLING PLAN

- Background
- Data use objectives
- Sampling design
- Sampling and analysis
- Standard operating procedures
- Quality assurance requirements

ELEMENTS OF A SAMPLING PLAN (cont.)

- Data validation
- Deliverables
- Project organization and responsibilities
- Schedule of activities
- Attachments

BACKGROUND

- Federal, state, and local files
- Interview former employees, residents
- Potentially responsible party (PRP)

BACKGROUND (cont.)

- Maps
- Facility building plans
- Aerial photographs

SANBORN FIRE INSURANCE MAPS

- 1869 to 1950s
- Communities over 2000 population
- Updated periodically
- Locations of industries, pipelines, storage vats, old dumps, and wetlands

AERIAL PHOTOGRAPHY

- Historical photography (1920-present)
- Contract photography (current site)

U.S. DEPARTMENT OF AGRICULTURE

- USDA Farm Service Agency
  Aerial Photography Field Office
  801-975-3503
- 1945 - present
  black and white
  color infrared

local extensions can obtain maps quicker

PURPOSE OF SAMPLING

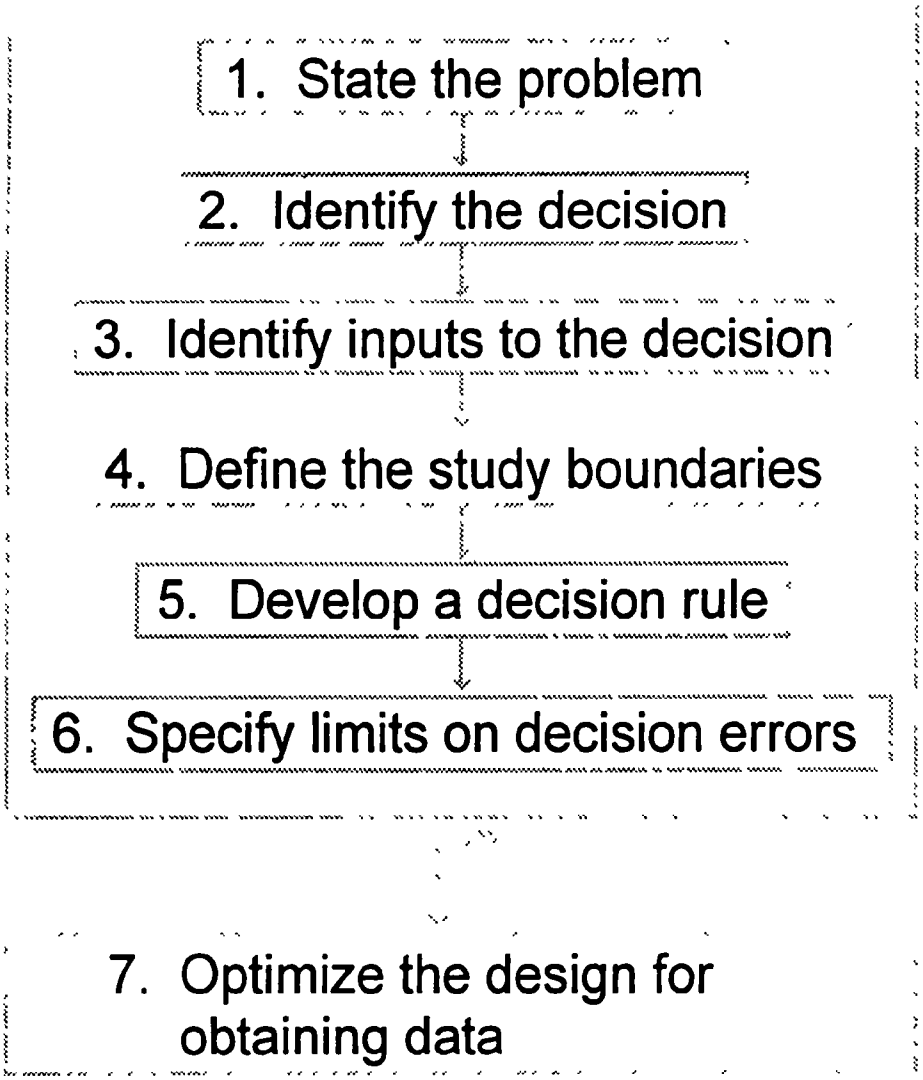
- Remedial investigation/ feasibility study (RI/FS)
- Removal
- Risk assessment
- Site assessment

Superfund is required to follow this protocol

WHAT IS THE DATA QUALITY OBJECTIVES (DQO) PROCESS?

Series of planning steps designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application

THE DQO PROCESS



SW846

WHAT ARE DQOs?

- Qualitative and quantitative statements that:
  - Clarify the objectives
  - Define appropriate data
  - Determine appropriate conditions to collect data
  - Specify acceptable levels of errors

WHY DEVELOP DOCUMENT FOR SUPERFUND?

- Mandatory QA requirements established in EPA Order 5360.1
  - NCP 40 CFR Part 300
  - SAP/QAPP quality assurance project plan

BENEFITS OF DQOs

- Improves sampling and analysis designs
- Saves money and time
- Improves decision making

MORE INFORMATION?

- Contact: Duane Geuder
  QA Manager for OERR
  703-603-8891

- Training: EPA Institute
  202-260-3297

QUALITY ASSURANCE OBJECTIVES

Parameters	Matrix	Intended Data Use
BNA (semivolatiles)	Drum liquid	Site characterization
Metals	Groundwater	Risk assessment
Metals	Potable water	Risk assessment
PAHs	Soil	Site characterization
PAHs	Waste material	Site characterization

SAMPLING METHODOLOGIES

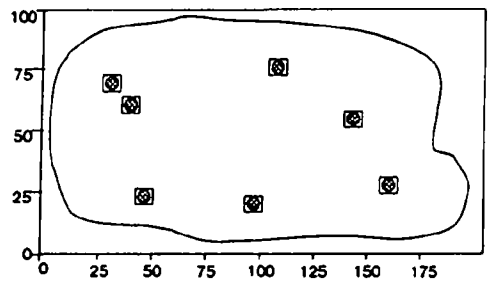
Sampling design:

- Judgmental
- Random sampling
- Stratified random sampling
- Systematic sampling
- Systematic random sampling

JUDGMENTAL SAMPLING

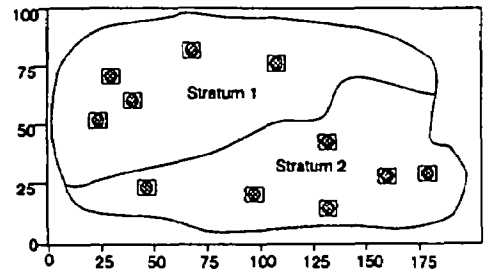
The subjective selection of sampling locations at a site, based on historical information, visual inspection, and the best professional judgment of the sampling team

RANDOM SAMPLING



Adapted from U S EPA 1989 Methods for Evaluating the Attainment of Cleanup Standards Volume 1 Soils and Solid Media

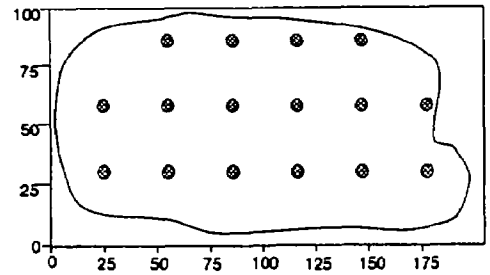
STRATIFIED RANDOM SAMPLING



Adapted from U S EPA. 1989 Methods for Evaluating the Attainment of Cleanup Standards. Volume 1 Soils and Solid Media

SYSTEMATIC SAMPLING

usually most expensive method.



Adapted from U S EPA. 1989 Methods for Evaluating the Attainment of Cleanup Standards. Volume 1 Soils and Solid Media

RANDOM SYSTEMATIC SAMPLING

The area is first subdivided into a grid as described in systematic sampling. Then samples are collected from within each cell using random selection procedures.

SAMPLING METHODOLOGIES
Sampling Equipment

Parameters/Matrix	Sampling Equipment	Fabrication Use	Dedicated	Decontamination Steps
BNA (semivolatiles)	COLIWASA	Glass	No	Physical removal Nonphosphate detergent wash Potable water rinse 10% nitric acid rinse Organic-free water rinse Air dry
Metals in groundwater	Bladder pump	Stainless steel	Yes	

SAMPLING METHODOLOGIES
Standard Operating Procedures

- Agency standard operating procedures
- Region standard operating procedures
- Other federal agency regulations

SAMPLING METHODOLOGIES
Standard Operating Procedures (cont.)

Minimum that should be addressed:

- Field documentation
- Sampling standard operating procedures
- Shipping and handling

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) GOALS

- Define requirements from the Quality Assurance Objectives
- Refers back to the QA Objectives and parameters identified in the plan
- Identify and implement correct sampling and analysis methods
- Limit the error introduced into the sampling and analysis procedure

QA/QC SAMPLES

- Analyze in addition to field samples
- Provide information on variability and usability of data

RINSATE BLANKS (Equipment Blanks)

- Obtain by running analyte-free deionized water over decontaminated sampling equipment
- Test for residual contamination

Accepted practice - perform for every 10 (or 10%) of equipment.

TRIP BLANKS

- Prepare prior to fieldwork
- Use certified clean sand or soil or analyte-free deionized water
- Test for residual contamination

TRIP BLANKS (cont.)

Assess error associated with:

- Sampling
- Sample handling and shipping
- Laboratory handling and analysis

MATRIX SPIKE SAMPLES

- Field sampling
  - Collect triple the volume for organic water samples
  - Collect double the volume for inorganic water samples
- Laboratory analysis
  - Use selected or requested field samples
  - Spike samples in the laboratory with known concentrations of target analytes

MATRIX SPIKE SAMPLES (cont.)

- Verify percent recoveries
- Check sample matrix interferences
- Monitor laboratory and method performance

FIELD REPLICATES

- Samples obtained from one location and divided into separate containers
- Treated as separate samples
- Used to assess laboratory error and sampling methodology error
- May be used as a split sample for PRP investigations

DATA VALIDATION

Describes the steps for data validation and states the criteria for each of the procedures

EPA manual (Risk Assessment)

DELIVERABLES

Describes the final product or outcome of the sampling event

ORGANIZATIONAL STRUCTURE

Designates the organizational structure of the sampling teams and defines responsibilities of onsite personnel and supporting agencies

SUMMARY

- Review historical information
- Perform site reconnaissance
- Evaluate migration pathways and receptors
- Determine sampling objectives
- Establish data quality objectives

SUMMARY (cont.)

- Select field screening techniques
- Select analytical parameters
- Select sampling approach
- Determine sampling locations

United States Environmental Protection Agency | Office of Solid Waste and Emergency Response | January 1992

QualityAssurance Sampling Plan for Emergency Response

Office of Emergency and Remedial Response
Emergency Response Division
Environmental Response Branch, MS-101

Quality Assurance Technical Information Bulletin

What is QASPER?

QASPER is a PC-based software package which compiles generic text and user-provided site-specific information into a draft Quality Assurance / Quality Control (QA/QC) Sampling Plan for the Removal Program QASPER addresses the nine sections of a QA/QC Sampling Plan, as specified in OSWER Directive 9360 4-01, QA/QC Guidance for Removal Activities, Sampling QA/QC Plan, and Data Validation Procedures (April 1990, EPA/540/G-90/004)

Who is the Anticipated QASPER User?

The On-Scene Coordinators (OSCs) or the Technical Assistance Team (TAT) contractors are the primary users of QASPER These individuals will have access to the site-specific information and the sampling objectives that characterize the site They are also the ones responsible for assembling that information into an acceptable game plan for implementation.

Why was QASPER Designed?

QASPER was created to facilitate the timely assembly of a comprehensive sampling plan for emergency response actions By thorough consideration and attention to the necessary requirements of QA/QC sample planning through an automated process, it is anticipated that reliable, accurate, and quality data will be generated to meet the intended use

Requirements

QASPER runs on an IBM PC or 100% compatible, with a hard drive, 640K RAM, and a printer (for hardcopy output)

Features of QASPER

- Requires no other software for support A word processing package is included with the QASPER program
- Generates ASCII output in both file and hardcopy formats Files may be uploaded to other word processing packages (i e , WordPerfect) for further manipulation
- Creates a hard copy QA/QC Sampling Plan ready for approval signatures and implementation
- Retains database files on all previous sampling plans created This allows for future manipulation of an existing plan without having to recreate the document or search for a similar sampling plan by location, facility type, or contaminant
- Improves the consistency and comprehensiveness of sampling plan creation efforts throughout the office, region, or zone by prompting the user to consider the same set of questions for each site to be addressed
- Improves efficiency for creating and reviewing QA/QC Sampling Plan documents by allowing easy modification of the document text either through the editor or through the word processing package
- Picks up information that has repetitive use in the plan and imports the information to all sections after the first entry, thus avoiding redundant data entry
- Provides the user with access to standardized generic text in various sections of the plan Based on the user's needs, this text may be imported directly or may be edited to fit site-specific conditions

- Has flexible data entry throughout plan generating activities and informs the user as to which sections are complete and which sections require additional information.

Contents of QASPER

QASPER addresses the nine sections of a QA/QC Sampling Plan, as specified in OSWER Directive 9360 4-01, QA/QC Guidance for Removal Activities, Sampling QA/QC Plan and Data Validation Procedures

0.0 Title Page Information
Section 0 0 identifies information required to complete the title page of a sampling plan This information includes site name, relevant work order numbers, primary site personnel and titles, and the date Some of this information is utilized elsewhere throughout the plan and will automatically appear in the proper places

1 0 Background Information
Section 1 0 solicits background information about the site This includes the location and type of facility, type and volume of material handled by the facility, current facility status and proximity and type of sensitive environments

2.0 Data Use Objectives
Section 2 0 requests information regarding the data use objectives and about decisions the data will support. The purpose(s) of the sampling event is specified and this information is forwarded to other sections of the plan The data quality objective (DQO) logic pathway begins in this section and is carried forward to Sections 3.0, 4 0, 6 0 and 8 0

3.0 Quality Assurance Objectives
Section 3.0 facilitates the linkage of the DQO logic with the matrix and parameters being investigated The user must also specify the purpose and QA objective (QA-1, QA-2, or QA-3) related to the selection The same sequence will be repeated for all parameters of concern at the site

4 0 Approach and Sampling Methodologies
Section 4.0 addresses the approach and sampling methodologies that will be employed Included are sections on sampling equipment, sampling design, standard operating procedures, schedule of activities and tables

In the case of equipment, there are pull down menus for type of equipment and materials of construction Where dedicated sampling equipment is not utilized, QASPER assists in the development of a decontamination sequence The sampling design section requires the user to input information related to the proposed design or grid to achieve the sample event objectives In conjunction with the sampling design, the user must specify the standard operating procedures (SOPs) that will be employed QASPER contains generic text for approximately 20 SOPs that can be imported as is or modified to fit a specific scenario A schedule of activities detailing site activities and tentative start and completion dates is in the next section The last components of this section are the sample summary tables and QC sample tables

5 0 Project Organization and Responsibilities
Section 5 0 helps the user organize information about what personnel are assigned which responsibilities and which labs will be analyzing which samples.

6 0 QA Requirements
Section 6.0 is automatically completed based on the QA selections made in Section 3 0 Capabilities exist to edit the generic text as needed

7.0 Deliverables
Section 7 0 allows the user to import generic text for standard deliverables that will be prepared for the site or input specific requirements

8.0 Data Validation
Section 8 0 contains the requirements for validating the data generated under this plan as per OSWER Directive 9360 4-01, Part II, Data Validation Procedures (April, 1990) The criteria used ensure that analytical results received from the laboratory are valid and accurate for the objective chosen. The section is automatically completed based on the QA selections made in Section 3.0. Capabilities exist to edit the generic text as needed

Once all the sections are completed, the user can compile the plan, make any necessary modifications, and print a hard copy of the site-specific QA/QC Sampling Plan

For copies of the software, contact

Mr. William Coakley
US EPA, ERT
Phone (908) 906-6921

Ms Christine Andreas
Roy F Weston, Inc /REAC
Phone (908) 632-9200

***NOTE:** The above phone numbers are no longer valid Please call 908-321-4398 for copies of QASPER, or mail the form on the following page*

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US EPA - ERT
2890 Woodbridge Avenue
Building #18 (MS101)
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Health and Safety Plan (HASP 9285.801)	_____
Quality Assurance Sampling Plan for Environmental Response (QASPER)	_____

(Distrib/Request FRM 12/95)

Sampling QA/QC Work Plan

Example Sample Plan

Prepared by
Amazing Consultants

EPA Project No.: **.***
Contractor Work Order No.: NA
EPA Contract No.: NA

Approvals

Amazing Consultants		EPA	
_____	_____	_____	_____
Task Leader	Date	O.S. Cee On-Scene Coordinator	Date
_____	_____		
Fred Amazing Project Manager	Date		

1.0 BACKGROUND

The [suspected] contamination is a result of:

- Leaking drums

The following information is known about the site:

The site is located in the city of Swartz Creek in the county of Genesse in the state of Michigan (Figure 1-1). The nearest residents are located within 500 feet of the site, in a south direction. Other residents or significant environments in proximity to this site are located 1000 feet due north of the site

It is a landfill site on an unknown number of acres which had been operating for an unknown period of time and is now abandoned since 1980.

The types of material(s) handled at this site were:

- Inorganics
- Petroleum products
- Unknown

The volume(s) of contaminated materials to be addressed are:

- Unknown

The contaminants of concern are:

- Unknown

The basis of this information may be found from:

- Citizens
- Records

Example Sample Plan
Figure 1-1 Site Location Map

2.0 DATA USE OBJECTIVES

The objective of this project/sampling event is to determine.

- The presence of contamination
- The extent of contamination
- The magnitude of contamination

For the purpose of:

- Site characterization
- Risk assessment
- Field personnel health and safety
- Enforcement plan

The data will be evaluated against:

- Federal/state action levels
- Michigan and federal ARARs

3.0 QUALITY ASSURANCE OBJECTIVES

As identified in Sections 1.0 and 2 0, the objective of this project/event applies to the following parameters:

Parameters	Matrix	Intended Data Use	QA Objective
BNA (semivolatiles)	Drum liquid	Site characterization	QA1
Metals	Groundwater	Risk assessment	QA3
Metals	Potable water	Risk assessment	QA3
PAHs	Soil	Site characterization	QA2
PAHs	Waste material	Site characterization	QA2

4.0 APPROACH AND SAMPLING METHODOLOGIES

4.1 Sampling Equipment

The following equipment will be used to obtain environmental samples from the respective media/matrix:

Parameter/Matrix	Sampling Equipment	Fabrication	Dedicated	Decontamination Steps
BNA (semivolatiles)	COLIWASA	Glass	No	Physical removal Nonphosphate detergent wash Potable water rinse 10% nitric acid rinse Organic-free water rinse Air dry
Metals in groundwater	Bladder pump	Stainless steel	Yes	
Metals in potable water	Sample bottle	Glass	Yes	
PAHs in soil	Trowel	Stainless steel	No	Physical removal Nonphosphate detergent wash Pesticide-grade acetone rinse Distilled/deionized water rinse Organic-free water rinse Air dry
PAHs in waste material	Bucket auger	Stainless steel	No	Physical removal Nonphosphate detergent wash Potable water rinse 10% nitric acid rinse Distilled/deionized water rinse Organic-free water rinse Air dry

4.2 Sampling Design

The sampling design is depicted on the attached Sample Location Map (Figure 4-1) and is based on the following rationale:

Example Sample Plan
Figure 4-1 Sample Location Map

4.3 Standard Operating Procedures

4.3.1 Sample Documentation

All sample documents will be completed legibly, in ink. Any corrections or revisions will be made by lining through the incorrect entry and by initialing the error.

Field Logbook

The field logbook is essentially a descriptive notebook detailing site activities and observations so that an accurate account of field procedures can be reconstructed in the writer's absence. All entries will be dated and signed by the individuals making the entries and should include (at a minimum) the following:

1. Site name and project number.
2. Name(s) of personnel onsite.
3. Dates and times of all entries (military time preferred).
4. Descriptions of all site activities, including site entry and exit times.
5. Noteworthy events and discussions.
6. Weather conditions.
7. Site observations.
8. Identification and description of samples and locations.
9. Subcontractor information and names of onsite personnel.
10. Date and time of sample collections, along with chain-of-custody information.
11. Record of photographs.
12. Site sketches.

Sample Labels

Sample labels will clearly identify the particular sample and should include the following:

1. Site name and number.
2. Time and date sample was taken.
3. Sample preservation.
4. Analysis requested.

Optional, but pertinent, information is the sample location.

Sample labels will be securely affixed to the sample container. Tie-on labels can be used if properly secured.

Chain-of-Custody Record

A chain-of-custody record will be maintained from the time the sample is taken to its final deposition. Every transfer of custody must be noted and signed for, and a copy of this record kept by each individual who has signed. When samples (or groups of samples) are not under direct control of the individual responsible for them, they must be stored in a locked container sealed with a custody seal.

The chain-of-custody record should include (at minimum) the following:

1. Sample identification number.
2. Sample information.
3. Sample location.
4. Sample date.
5. Name(s) and signature(s) of sampler(s).
6. Signature(s) of any individual(s) with control over samples.

Custody Seals

Custody seals demonstrate that a sample container has not been tampered with or opened.

The individual in possession of the sample(s) will sign and date the seal, affixing it in such a manner that the container cannot be opened without breaking the seal. The name of this individual, along with a description of the sample packaging, will be noted in the field logbook.

4.3.2 Sampling SOPs

Drum Sampling

Prior to sampling, drums must be inventoried, staged, and opened. Inventory entails recording visual qualities of each drum and any characteristics pertinent to the contents' classification. Staging involves the organization, and sometimes consolidation, of drums which have similar wastes or characteristics. Opening of closed drums can be performed manually or remotely. Remote drum opening is recommended for worker safety.

The most widely used method of sampling a drum involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and requires no decontamination. The thief is inserted into the drum until a solid layer or bottom of the drum is encountered. The waste is allowed to equilibrate in the sample tube, which is then capped and removed for discharge by gravity into the sample container.

Another drum sampling device is the Composite Liquid Waste Sampler (COLIWASA). Collection with a COLIWASA allows a sample to be collected from the full depth of a drum and maintain it in the transfer tube until delivery to the sample bottle. The COLIWASA is designed to permit representative sampling of multiphased wastes from containerized wastes. However, unlike the glass

thief, a COLIWASA is extremely difficult to field decontaminate and relatively expensive, thereby making it impractical to throw away.

Groundwater Well Sampling

Prior to sampling a well, the well will be purged. For this project, purging will be accomplished with a [(bailer), (submersible pump), (non-gas contact bladder pump), or (suction pumps)]

First, brush off the well cap prior to opening, then unlock and open the well cap. A photoionization detector (HNU) or flame ionization detector (OVA) will be used on the escaping gases to determine the need for respiratory protection. Using a decontaminated water level indicator, the water level will be measured to the nearest 0.01 ft Total depth of the well will be obtained with a depth sounder and the volume of water in the well will be calculated using the following procedure:

Well Volume = nr2h (7.48 gal/ft^3)

where:

n = pi
r = radius of well casing in ft
h = height of water column of well from water level
7.48 = conversion from ft^3 to number of gallons

At a minimum, three well volumes should be purged if possible. Equipment must be decontaminated both prior to use and between wells

Approximately 10 ft of plastic sheeting will be placed around the well. The assembly of the decontaminated purging equipment will be placedon this sheeting. The assembly will be lowered into the well to a point just below the surface of the water.

When pumping the well, lower the pump slowly to a point 3 ft above the bottom of the well. Record the flow rate and calculate the length of pumping time required to purge the requisite three casing volumes. [Discharged to ground surface adjacent to the well or containerized if necessary.] If the well yield is insufficient to produce the requisite three volumes, purging will continue to the point of well evacuation and then terminated; the well will be sampled upon recharge.

Once purging is completed and the correct sample jars and/or vials have been prepared, sampling will proceed. The sampling device (which may or may not be the same as the purging device) has been selected so as to not affect the integrity of the sample. Sampling equipment will be decontaminated as outlined elsewhere in Section 4.0. Sampling will occur in a progression from the least to most contaminated well, if known.

The water sample will be collected using a Teflon® or stainless steel bailer. The bailer will be attached to a clean, dedicated, nylon rope and introduced into the well. The bailer will be lowered to the approximate mid-point of the screened interval. Once the sample is collected, care will be taken not to unduly agitate or aerate the water while pouring into the appropriate sample containers.

Measure the conductivity, temperature, and pH of the groundwater in a separate container. Record all field measurements on the field data sheets and in the field logbook.

Potable Water Sampling

Potable water samples will be collected from the discharge spigot nearest the pump. Water will be purged from the system for approximately 15 minutes to remove all standing water in the holding tank. Any aerators or filtering systems will be bypassed if possible. Samples will be collected directly into sample bottles from the spigot. Samples will be iced and packaged in coolers as per the applicable shipping and handling SOPs.

Soil Sampling

(This text requires modification for site-specific application)

Collection of samples from near-surface soil will be accomplished with tools such as spades, shovels, and scoops. Surface debris will be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample. This method can be used in most soil types but is limited to sampling near surface areas. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications.

Sampling a depth will be accomplished with augers and thin-walled tube samplers. This system consists of an auger, a series of extensions, a "T" handle, and a thin-walled tube sampler. The auger is used to bore a hole to the desired sampling depth and is then withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the soil at the completion depth. The core is then withdrawn and the sample is collected. Several augers are available. These include bucket type, continuous flight (screw), and post hole augers. Bucket types are better for direct sample recovery because they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly off the flights, which are usually at 5-ft intervals. The continuous flight augers are satisfactory for use when a composite of the complete soil column is desired. Post hole augers have limited utility for sample collection because they are designed to cut through fibrous, rooted, swampy soil.

Depth samples will be collected via split spoon samplers. A series of consecutive cores may be sampled to give a complete soil column, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core is extracted.

Subsurface soil sample collection will involve test pit/trench excavation activities. Test pits and trenches are used for detailed examination of soil characteristics. Samples are collected from the pit using a trowel scoop or coring device.

All sampling devices should be laboratory cleaned, preferably by the laboratory performing the analysis, using pesticide grade acetone (assuming that acetone is not a target compound) or methanol, then wrapped in cleaned and autoclaved aluminum foil, and custody sealed for identification. The

sampling device should remain in this wrapping until it is needed. Each sampler should be used for one sample only. However, dedicated samplers may be impractical if there are a large number of soil samples required. In this case, samplers should be cleaned in the field using the decontamination procedure described elsewhere in Section 4.0.

4.3.3 Sample Handling and Shipment

Each of the sample bottles will be sealed and labeled according to the following protocol. Caps will be secured with custody seals. Bottle labels will contain all required information including site name and sample number, time and date of collection, analysis requested, and preservative used. Sealed bottles will be placed in large metal or plastic coolers, and padded with an absorbent material such as vermiculite.

All sample documents will be affixed to the underside of each cooler lid. The lid will be sealed and affixed on at least two sides with custody seals so that any sign of tampering is easily visible.

4.4 Schedule of Activities

The proposed schedule of work is provided in the following table:

Activity	Start Date	End Date
Soil sampling	07/28/93	08/10/93
Potable water sampling	07/28/93	08/10/93
Groundwater sampling	08/10/93	09/10/93
Drum sampling	08/10/93	11/22/93

5.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The EPA On-Scene Coordinator, O.S. Cee, will provide overall direction to Amazing Consultants staff concerning project sampling needs, objectives, and schedule.

The Amazing Consultants Task Leader, _____ , is the primary point of contact with the EPA On-Scene Coordinator. The Task Leader is responsible for the development and completion of the Sampling QA/QC Plan, project team organization, and supervision of all project tasks, including reporting and deliverables.

The Amazing Consultants Site QC Coordinator, _____ , is responsible for ensuring field adherence to the Sampling QA/QC Plan and recording any deviations. The Site QC Coordinator is also the primary project team contact with the analytical laboratory.

The following sampling personnel will work on this project:

Personnel	Responsibility

The following laboratories will be performing the analyses listed below:

Laboratory Name/Address	Type of Laboratory	Parameters
Amazing Analytical Lab 123 Reading Road Pittsburgh, KN	Non-CLP	All

6.0 QUALITY ASSURANCE REQUIREMENTS

The requirements detailed in this section apply to the respective QA objectives and parameters identified in Section 3.0.

The following QA protocols for QA2 data are applicable to all sample matrices and include:

1. Provide sample documentation in the form of field logbooks, the appropriate field data sheets and chain-of-custody records. Chain-of-custody records are optional for field screening locations.

2. All instrument calibration and/or performance check procedures/methods will be summarized and documented in the field/personal or instrument log notebook.

3. The detection limit will be determined and recorded, along with the data, where appropriate.

4. Document sample holding times; including documentation of sample collection and analysis dates.

5. Provide initial and continuing instrument calibration data.

6a. For soil, sediment, and water samples, include rinsate blanks, field blanks, and trip blanks, as specified in the attached table.

6b. For air samples, include lot blanks, field blanks, collocated samples, trip blanks, breakthrough, and QC positive samples, as specified in the attached table.

7. Performance Evaluation samples are optional, if available.

8. Choose any one or combination of the following three options:

   (1) Definitive identification - confirm the identification of analytes on 10% of the screened (field or lab) or 100% of the unscreened samples via an EPA-approved method; provide documentation such as gas chromatograms, mass spectra, etc.

   (2) Quantitation - provide documentation for quantitative results from screening and the EPA-approved verification method (for screened samples) or just the quantitative results (in the case of unscreened samples).

   (3) Analytical error determination - determine the analytical error by calculating the precision, accuracy, and coefficient of variation on a subset of the screened or all of the unscreened samples using an EPA-approved method.

The following QA Protocols for QA3 data are applicable for all matrices and include:

1. Provide sample documentation in the form of field logbooks, the appropriate field data sheets, and chain-of-custody records. Chain-of-custody records are optional for field screening locations.

2. All instrument calibration and/or performance check procedures/methods will be summarized and documented in the field/personal or instrument log notebook.

3. The detection limit will be determined and recorded, along with the data, where appropriate.

4. Document sample holding times; including documentation of sample collection and analysis dates.

5. Provide initial and continuing instrument calibration data.

6a. For soil, sediment, and water samples, include rinsate blanks, field blanks, and trip blanks, as specified in the attached table.

6b. For air samples, include lot blanks, field blanks, collocated samples, trip blanks, breakthrough, and QC positive samples, as specified in the attached table.

7. Performance Evaluation samples are required.

8. Definitive identification on 100% of the "critical" samples by an EPA-approved method.

9. Quantitation - provide documentation for quantitative results from screening and EPA-approved verification methods (for screened samples) or just quantitative results (in the case of unscreened samples).

10. Analytical error determination on 100% of the "critical" samples by an EPA-approved method. Determine precision, accuracy and coefficient of variation. Determine false-positive and false-negative values.

7.0 DELIVERABLES

The Amazing Consultants Task Leader, _____, will maintain contact with the EPA On-Scene Coordinator, O.S. Cee, to keep him/her informed about the technical and financial progress of this project. This communication will commence with the issuance of the work assignment and project scoping meeting. Activities under this project will be reported in status and trip reports and other deliverables (e.g., analytical reports, final reports) described herein. Activities will also be summarized in appropriate format for inclusion in monthly and annual reports.

The following deliverables will be provided under this project:

- Final Report

A (draft) final report will be prepared to correlate available background information with data generated under this sampling event and identify supportable conclusions and recommendations which satisfy the objectives of this sampling QA/QC plan.

8.0 DATA VALIDATION

8.1 QA2

Data generated under this QA/QC Sampling Plan will be evaluated accordingly with appropriate criteria contained in the Removal Program Data Validation Procedures which accompany OSWER Directive #9360.4-1.

The results of 10% of the samples in the analytical data packages should be evaluated for all of the elements listed in Section 6.0 of the QA/QC Sampling Plan. The holding times, blank contamination, and detection capability will be reviewed for all remaining samples.

8.2 QA3

Data generated under this QA/QC Sampling Plan will be evaluated accordingly with appropriate criteria contained in Removal Program Data Validation Procedures which accompany OSWER Directive #9360.4-1.

This objective, the most stringent of all objectives, requires that at least 10% of the samples in the laboratory data package be evaluated for all of the elements listed in Section 6.0 of this QA/QC Sampling Plan Of the remaining samples, holding times, blank contamination, precision, accuracy, error determination, detection limits, and confirmed identification will be reviewed. This objective also requires review of all elements for all samples in each analyte category (i.e., VOAs and PCBs) in every tenth data package received from an individual laboratory.

FIELD SAMPLING SUMMARY

Analytical Parameter	Level of Sensitivity	Matrix	Container: Type and Volume	Container: Quantity	Preservative	Holding Time	Subtotal Samples	Rinsate Blanks	Trip Blanks	Performance Evaluation (PE) Samples	Matrix Spikes	Total Field Samples
BNA[a] *semivolatiles*	5 ppm	Drum liquid	1-L amber glass	2	4°C	7/40 days	100	NA[b]	NA	NA	NA	100
Metals	0.05 ppm	Groundwater	1-L polyethylene	1	HNO_3 to pH <2; 4°C	6 months	20	2	NA	1	8	23
Metals	1 ppm	Potable water	1-L polyethylene	1	HNO_3 to pH <2; 4°C	6 months	20	2	NA	1	8	23
PAHs[c]	0.01 mg/kg	Soil	8-oz. glass	1	4°C	7/40 days	35	3	NA	0	2	38
PAHs	5 ppm	Waste material	8-oz. glass	1	4°C	NA[d]	100	NA	NA	NA	NA	101
PAHs	1 ppm	Waste material	8-oz. glass	1	4°C	7/40 days	10[e]	1	NA	0	1	<11>[e]

[a] BNA - base, neutral, acid
[b] NA - not applicable
[c] PAH - polycyclic aromatic hydrocarbon.
[d] Field test (immunoassay).
[e] Confirmation samples sent to laboratory.

TABLE 3. QA/QC ANALYSIS AND OBJECTIVES SUMMARY

Analytical Parameter	Matrix	Analytical Method Reference	Matrix Spike		QA/QC	
			Laboratory	Additional	Detection Limits	QA Objective
BNA[a] *semivolatiles*	Drum liquid	8270	NA[b]	NA	See attachments	QA1
Metals	Groundwater	SW-846[c]	8	NA	See attachments	QA3
Metals	Potable water	SW-846	8	NA	See attachments	QA3
PAHs[d]	Soil	8100	2	NA	Analyte specific	QA2
PAHs	Waste material	Immunoassay[e]	NA	NA	Analyte specific	QA2
		SW-846	1	NA	Analyte specific	QA2

[a] BNA - base, neutral, acid.
[b] NA - not applicable.
[c] SW-846 - U.S. EPA. 1986. *Test methods for evaluating solid waste: physical/chemical methods (SW-846).* U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.
[d] PAH - polycyclic aromatic hydrocarbon.
[e] Used for field screening.

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QL)[a]

Volatiles		CAS Number	Quantitation Limits[b] Water (µg/L)	Low Soil/Sediment[c] (µg/kg)
1.	Chloromethane	74-87-3	10	10
2.	Bromomethane	74-83-9	10	10
3.	Vinyl chloride	75-01-4	10	10
4.	Chloroethane	75-00-3	10	10
5.	Methylene chloride	75-09-2	10	10
6.	Acetone	67-64-1	10	10
7.	Carbon disulfide	75-15-0	10	10
8.	1,1-Dichloroethene	75-35-4	10	10
9.	1,1-Dichloroethane	75-34-3	10	10
10.	1,2-Dichloroethene (total)	540-59-0	10	10
11	Chloroform	67-66-3	10	10
12.	1,2-Dichloroethane	107-06-2	10	10
13.	2-Butanone	78-93-3	10	10
14.	1,1,1-Trichloroethane	71-55-6	10	10
15.	Carbon tetrachloride	56-23-5	10	10
16.	Bromodichloromethane	75-27-4	10	10
17.	1,2-Dichloropropane	78-87-5	10	10
18.	*cis*-1,3-Dichloropropene	10061-01-5	10	10
19.	Trichloroethene	79-01-6	10	10
20.	Dibromochloromethane	124-48-1	10	10
21.	1,1,2-Trichloroethane	79-00-5	10	10
22.	Benzene	71-43-2	10	10
23.	*trans*-1,3-Dichloropropene	10061-02-6	10	10
24.	Bromoform	75-25-2	10	10
25.	4-Methyl-2-pentanone	108-10-1	10	10
26	2-Hexanone	591-78-6	10	10
27.	Tetrachloroethene	127-18-4	10	10
28.	Toluene	108-88-3	10	10
29.	1,1,2,2-Tetrachloroethane	79-34-5	10	10
30.	Chlorobenzene	108-90-7	10	10
31.	Ethylbenzene	100-41-4	10	10
32.	Styrene	100-42-5	10	10
33.	Xylenes (total)	1330-20-7	10	10

[a] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[b] Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment on dry weight basis will be higher.

[c] Medium Soil/Sediment Quantitation Limits (QL) for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment QL.

Based on the Contract Laboratory Program Statement of Work, OLM01.6 (6/91)

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QL)[a]

	Semivolatiles	CAS Number	Quantitation Limits[b] Water (µg/L)	Low Soil/Sediment[c] (µg/kg)
34.	Phenol	108-95-2	10	330
35.	bis(2-Chloroethyl)ether	111-44-4	10	330
36.	2-Chlorophenol	95-57-8	10	330
37.	1,3-Dichlorobenzene	541-73-1	10	330
38.	1,4-Dichlorobenzene	106-46-7	10	330
39.	1,2-Dichlorobenzene	95-50-1	10	330
40.	2-Methylphenol	95-48-7	10	330
41.	2,2-oxybis(1-Chloropropane)	108-60-1	10	330
42.	4-Methylphenol	106-44-5	10	330
43.	*N*-Nitroso-di-*n*-propylamine	621-64-7	10	330
44.	Hexachloroethane	67-72-1	10	330
45.	Nitrobenzene	98-95-3	10	330
46.	Isophorone	78-59-1	10	330
47.	2-Nitrophenol	88-75-5	10	330
48.	2,4-Dimethylphenol	105-67-9	10	330
49.	bis(2-Chloroethoxy)methane	111-91-1	10	330
50.	2,4-Dichlorophenol	120-83-2	10	330
51.	1,2,4-Trichlorobenzene	120-82-1	10	330
52.	Naphthalene	91-20-3	10	330
53.	4-Chloroaniline	106-47-8	10	330
54.	Hexachlorobutadiene	87-68-3	10	330
55.	4-Chloro-3-methylphenol	59-50-7	10	330
56.	2-Methylnaphthalene	91-57-6	10	330
57.	Hexachlorocyclopentadiene	77-47-4	10	330
58.	2,4,6-Trichlorophenol	88-06-2	10	330
59.	2,4,5-Trichlorophenol	95-95-4	25	800
60.	2-Chloronaphthalene	91-58-7	10	330
61.	2-Nitroaniline	88-74-4	25	800
62.	Dimethylphthalate	131-11-3	10	330
63.	Acenaphthylene	208-96-8	10	330
64.	2,6-Dinitrotoluene	606-20-2	10	330
65.	3-Nitroaniline	99-09-2	25	800
66.	Acenaphthene	83-32-9	10	330
67.	2,4-Dinitrophenol	51-28-5	25	800
68.	4-Nitrophenol	100-02-7	25	800
69.	Dibenzofuran	132-64-9	10	330
70.	2,4-Dinitrotoluene	121-14-2	10	330
71.	Diethylphthalate	84-66-2	10	330
72.	4-Chlorophenyl-phenyl ether	7005-72-3	10	330
73.	Fluorene	86-73-7	10	330

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QL)[a]

	Semivolatiles (cont.)	CAS Number	Quantitation Limits[b] Water (µg/L)	Low Soil/Sediment[c] (µg/kg)
74.	4-Nitroaniline	100-01-6	25	800
75.	4,6-Dinitro-2-methylphenol	534-52-1	25	800
76.	*N*-Nitrosodiphenylamine	86-30-6	10	330
77.	4-Bromophenyl-phenyl ether	101-55-3	10	330
78.	Hexachlorobenzene	118-74-1	10	330
79.	Pentachlorophenol	87-86-5	25	800
80.	Phenanthrene	85-01-8	10	330
81.	Anthracene	120-12-7	10	330
82.	Carbazole	86-74-8	10	330
83.	Di-*n*-butyl phthalate	84-74-2	10	330
84.	Fluoranthene	206-44-0	10	330
85.	Pyrene	129-00-0	10	330
86.	Butylbenzyl phthalate	85-68-7	10	330
87.	3,3-Dichlorobenzidine	91-94-1	20	660
88.	Benz(a)anthracene	56-55-3	10	330
89.	Chrysene	218-01-9	10	330
90.	bis(2-Ethylhexyl)phthalate	117-81-7	10	330
91.	Di-*n*-octyl phthalate	117-84-0	10	330
92.	Benzo(b)fluoranthene	205-99-2	10	330
93.	Benzo(k)fluoranthene	207-08-9	10	330
94.	Benzo(a)pyrene	50-32-8	10	330
95.	Indeno(1,2,3-cd)pyrene	193-39-5	10	330
96.	Dibenz(a,h)anthracene	53-70-3	10	330
97.	Benzo(g,h,i)perylene	191-24-2	10	330

[a] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[b] Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment on dry weight basis will be higher.

[c] Medium Soil/Sediment Quantitation Limits (QL) for Semivolatile TCL Compounds are 60 times the individual Low Soil/Sediment QL.

Based on Contract Laboratory Program Statement of Work, OLMO1.6 (6/91).

TARGET COMPOUND LIST (TCL) AND QUANTITATION LIMITS (QL)[a]

Pesticides/PCBs		CAS Number	Quantitation Limits[b] Water (µg/L)	Low Soil/Sediment[c] (µg/kg)
98.	alpha-BHC	319-84-6	0.05	1.7
99.	beta-BHC	319-85-7	0.05	1.7
100.	delta-BHC	319-86-8	0.05	1.7
101.	gamma-BHC (Lindane)	58-89-9	0.05	1.7
102.	Heptachlor	76-44-8	0.05	1.7
103.	Aldrin	309-00-2	0.05	1.7
104.	Heptachlor epoxide	1024-57-3	0.05	1.7
105.	Endosulfan I	959-98-8	0.05	1.7
106.	Dieldrin	60-57-1	0.10	3.3
107.	4,4'-DDE	72-55-9	0.10	3.3
108.	Endrin	72-20-8	0.10	3.3
109.	Endosulfan II	33213-65-9	0.10	3.3
110.	4,4'-DDD	72-54-8	0.10	3.3
111.	Endosulfan sulfate	1031-07-8	0.10	3.3
113.	4,4'-DDT	50-29-3	0.10	3 3
114.	Methoxychlor	72-43-5	0.50	17.0
115.	Endrin ketone	53494-70-5	0.10	3.3
116.	Endrin aldehyde	7421-36-3	0.10	3.3
117.	alpha-Chlordane	5103-71-9	0.5	1.7
118.	gamma-Chlordane	5103-74-2	0.5	1.7
119.	Toxaphene	8001-35-2	1.0	170.0
120.	Aroclor-1016	12674-11-2	0.5	33.0
121.	Aroclor-1221	11104-28-2	0.5	33.0
122.	Aroclor-1232	11141-16-5	0.5	67.0
123.	Aroclor-1242	53469-21-9	0.5	33.0
124.	Aroclor-1248	12672-29-6	0.5	33.0
125.	Aroclor-1254	11097-69-1	1.0	33.0
126.	Aroclor-1260	11096-82-5	1.0	33.0

[a] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[b] Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment on dry weight basis will be higher.

[c] Medium Soil/Sediment Quantitation Limits (QL) for Pesticides/PCB TCL compounds are 15 times the individual Low Soil/Sediment QL.

Based on the Contract Laboratory Program Statement of Work, OLMO1.6 (6/91)

INORGANIC TARGET ANALYTE LIST (TAL)

Analyte	Detection Limit[a] (µg/L - water)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	3
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Cyanide	10

[a] Sediment detection limit 100 x water (µg/kg - soil/sediment).

Based on the Contract Laboratory Program Statement of Work, ILM02.1 (9/91).

PB92 - 963356
Publication 9285.7-09A
April 1992

Appendix II

of the

"Guidance for Data Useability in Risk Assessment (Part A)"

Final

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, D.C. 20460

APPENDIX II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES

Appendix II identifies seven industries that generate waste which contains pollutants that are known to pose human and environmental hazards. This appendix is intended to aid the reader in three ways:

- To assist in the identification of target compounds and potential exposure pathways.
- To predict associated contaminants that potentially yield interferences
- To assist in early identification of sites that contain high levels of compounds that may not be included as target analytes for routinely available methods

The data for these tables were obtained by searching the USEPA Toxic Release Inventory System using the Standard Industrial Classification (SIC) codes listed below.

	Industry	SIC Code
1	Battery Recycling	3691, 3692
2	Munitions/Explosives	2892
3	Pesticides Manufacturing	2842, 2879
4	Electroplating	3471
5	Wood Preservatives	2491
6	Leather Tanning	3111
7	Petroleum Refining	2911

The appendix consists of seven tables and depicts the pollutants associated with each of the seven industries, the CAS number of each pollutant, and the matrices where each pollutant has been found. The list is not inclusive of all pollutants or industrial sources. The seven industries were selected based on the recommendation of the Risk Assessment Subgroup of the Data Useability Workgroup because of the frequency of occurrence of the pollutants produced by those industries in Superfund sites.

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 1: BATTERY RECYCLING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	LEAD	7439921	Y	Y	Y	Y
2	SODIUM SULFATE (SOLUTION)	7757826		Y		
3	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y		Y
4	SULFURIC ACID	7664939	Y	Y		Y
5	AMMONIUM SULFATE (SOLUTION)	7783202		Y		
6	MANGANESE	7439965	Y	Y	Y	Y
7	1,1,1-TRICHLOROETHANE	71556	Y	Y		Y
8	METHANOL	67561	Y	Y		Y
9	FREON 113	76131	Y			Y
10	TRICHLOROETHYLENE	79016	Y	Y		Y
11	TOLUENE	108883	Y			Y
12	ZINC	7440666		Y	Y	Y
13	AMMONIA	7664417	Y	Y		Y
14	CADMIUM	7440439	Y	Y	Y	Y
15	ANTIMONY	7440360	Y	Y		Y
16	BARIUM	7440393	Y	Y		Y
17	NICKEL	7440020	Y	Y	Y	Y
18	FORMALDEHYDE	50000	Y			Y
19	ACETONE	67641	Y			
20	XYLENE (MIXED ISOMERS)	1330207	Y			
21	TETRACHLOROETHYLENE	127184	Y			Y
22	DICHLOROMETHANE	75092	Y			Y
23	PHENOL	108952	Y			Y
24	MERCURY	7439976	Y	Y		Y
25	N-BUTYL ALCOHOL	71363	Y			
26	METHYL ETHYL KETONE	78933	Y			Y
27	METHYL ISOBUTYL KETONE	108101	Y			
28	HYDROCHLORIC ACID	7647010	Y	Y		
29	NITRIC ACID	7697372	Y			Y
30	1,1,1-TRICHLOROETHANE (METHYL CHLOROFORM)	71556	Y			
31	COBALT	7440484	Y		Y	Y
32	ARSENIC	7440382	Y			Y
33	COPPER	7440508		Y		Y
34	SILVER	7440224	Y	Y		Y
35	ACETONITRILE	75058	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 2: MUNITIONS/EXPLOSIVES

Rank [a]	Compound	CAS Number	Air	Water	Soil	Other [b]
1	ACETONE	67641	Y	Y	Y	Y
2	NITRIC ACID	7697372	Y	Y	Y	Y
3	AMMONIUM NITRATE (SOLUTION)	6484522	Y	Y	Y	Y
4	PENTACHLOROPHENOL	87865			Y	
5	SODIUM SULFATE (SOLUTION)	7757826		Y		
6	AMMONIA	7664417	Y	Y	Y	
7	SULFURIC ACID	7664939	Y	Y	Y	Y
8	METHYL ETHYL KETONE	78933	Y			Y
9	CYCLOHEXANE	110827	Y			Y
10	CHLORINE	7782505	Y	Y		
11	NITROGLYCERIN	55630	Y	Y	Y	Y
12	DICHLOROMETHANE	75092	Y			Y
13	CALCIUM CYANAMIDE	156627	Y		Y	
14	LEAD	7439921	Y	Y	Y	Y
15	ETHYLENE GLYCOL	107211	Y	Y	Y	
16	N-BUTYL ALCOHOL	71363	Y			
17	TERT-BUTYL ALCOHOL	75650	Y			Y
18	M-XYLENE	108383	Y			
19	METHANOL	67561	Y	Y		Y
20	ASBESTOS (FRIABLE)	1332214				Y
21	1,1,1-TRICHLOROETHANE	71556	Y			Y
22	POLYCHLORINATED BIPHENYLS	1336363				Y
23	COPPER	7440508	Y	Y	Y	Y
24	ALUMINUM	7429905	Y	Y	Y	Y
25	2,4-DINITROTOLUENE	121142	Y	Y		
26	GLYCOL ETHERS	79141	Y			
27	BENZENE	71432	Y	Y	Y	Y
28	BIS(2-ETHYLHEXYL) ADIPATE	103231		Y		
29	ZINC	7440666	Y			
30	DIBUTYL PHTHALATE	84742	Y	Y	Y	
31	SODIUM HYDROXIDE (SOLUTION)	1310732	Y		Y	
32	DIETHYL PHTHALATE	84662		Y		

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3: PESTICIDES MANUFACTURING

Rank [a]	Compound	CAS Number	Air	Water	Soil	Other [b]
1	SODIUM SULFATE (SOLUTION)	7757826		Y	Y	Y
2	AMMONIA	7664417	Y	Y	Y	Y
3	TOLUENE	108883	Y	Y	Y	Y
4	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
5	TITANIUM TETRACHLORIDE	7550450				Y
6	METHANOL	67561	Y	Y	Y	Y
7	DICHLOROMETHANE	75092	Y	Y	Y	Y
8	XYLENE (MIXED ISOMERS)	1330207	Y	Y	Y	Y
9	CHLOROBENZENE	108907	Y	Y		Y
10	HYDROCHLORIC ACID	7647010	Y	Y	Y	Y
11	CHLOROPHENOLS	106489	Y	Y	Y	Y
12	STYRENE	100425	Y	Y		Y
13	ACRYLONITRILE	107131	Y	Y		Y
14	FORMALDEHYDE	50000	Y	Y	Y	Y
15	CARBON TETRACHLORIDE	56235	Y	Y	Y	Y
16	CHLOROTHALONIL	1897456	Y	Y		Y
17	1,2-DICHLOROETHANE	107062	Y	Y	Y	Y
18	ACETONE	67641	Y	Y	Y	Y
19	HEXACHLOROBENZENE	118741	Y	Y		Y
20	1,1,1-TRICHLOROETHANE	71556	Y	Y		Y
21	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
22	GLYCOL ETHERS	79141	Y	Y	Y	Y
23	1,3-BUTADIENE	106990	Y	Y		Y
24	CHLOROMETHANE	74873	Y			Y
25	CAPTAN	133062	Y		Y	Y
26	TETRACHLOROETHYLENE	127184	Y	Y	Y	Y
27	CHLORINE	7782505	Y	Y	Y	Y
28	CARBARYL	63252	Y	Y		Y
29	COPPER	7440508	Y	Y	Y	Y
30	PARATHION	56382	Y			Y
31	ZINEB	12122677				Y
32	PYRIDINE	110861	Y	Y		
33	AMMONIUM NITRATE (SOLUTION)	6484522		Y		
34	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
35	CARBON DISULFIDE	75150	Y		Y	
36	1,2,4-TRICHLOROBENZENE	120821	Y		Y	Y
37	SULFURIC ACID	7664939	Y	Y	Y	Y
38	MALEIC ANHYDRIDE	108316	Y		Y	Y
39	ETHYLBENZENE	100414	Y	Y		Y
40	2,4-D	94757	Y	Y	Y	Y
41	BROMOMETHANE	74839	Y			
42	SEC-BUTYL ALCOHOL	78922	Y	Y		

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3: PESTICIDES MANUFACTURING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
43	LEAD	7439921				Y
44	CUMENE	98828	Y	Y		Y
45	M-XYLENE	108383	Y			Y
46	ASBESTOS (FRIABLE)	1332214			Y	Y
47	FREON 113	76131	Y			Y
48	DICHLOROBENZENE (MIXED ISOMERS)	25321226	Y		Y	Y
49	CYCLOHEXANE	110827	Y		Y	Y
50	2,4-DICHLOROPHENOL	120832			Y	Y
51	1,4-DICHLOROBENZENE	106467	Y			
52	DICHLOROBROMOMETHANE	75274	Y			Y
53	TRIFLURALIN	1582098	Y	Y	Y	Y
54	1,2,4-TRIMETHYLBENZENE	95636	Y	Y		Y
55	METHYL ISOBUTYL KETONE	108101	Y	Y		Y
56	1,4-DIOXANE	123911	Y			Y
57	NITRIC ACID	7697372	Y	Y		Y
58	N-BUTYL ALCOHOL	71363	Y	Y		Y
59	FLUOMETURON	2164172	Y	Y		Y
60	2-METHOXYETHANOL	109864				Y
61	BIS(2-ETHYLHEXYL) ADIPATE	103231	Y			Y
62	PHENOL	108952	Y	Y		Y
63	ACRYLIC ACID	79107	Y		Y	Y
64	QUINTOZENE	82688	Y			Y
65	ALUMINUM	1344281	Y	Y	Y	Y
66	BENZOYL PEROXIDE	94360			Y	Y
67	O-XYLENE	95476	Y			
68	CHROMIUM	7440473	Y	Y		Y
69	2-PHENYLPHENOL	90437	Y	Y		
70	HYDROGEN CYANIDE	74908	Y	Y		Y
71	ZINC	7440666	Y	Y	Y	Y
72	HEXACHLOROCYCLOPENTADIENE	77474				Y
73	DICOFOL	115322	Y			Y
74	BIPHENYL	92524	Y	Y		Y
75	4-NITROPHENOL	100027	Y		Y	Y
76	METHYL ETHYL KETONE	78933	Y			Y
77	TRICHLOROETHYLENE	79016	Y		Y	
78	M-CRESOL	108394	Y			Y
79	TETRACHLORVINPHOS	961115				Y
80	DI(2-ETHYLHEXYL) PHTHALATE (DEHP)	117817		Y		Y
81	TEREPHTHALIC ACID	100210	Y			Y
82	DICHLORVOS	62737	Y			Y
83	MANEB	12427382	Y			Y
84	P-XYLENE	106423	Y			Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 3: PESTICIDES MANUFACTURING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
85	METHYLENE BROMIDE	74953	Y			
86	CHLORAMBEN	133904	Y			Y
87	BENZENE	71432	Y			Y
88	HYDROGEN FLUORIDE	7664393	Y	Y		
89	ETHYLENE	74851	Y			
90	C I. ACID BLUE 9, DISODIUM SALT	3844459		Y		Y
91	DIMETHYL SULFATE	77781	Y			
92	ISOPROPYL ALCOHOL	67630	Y			
93	HYDRAZINE	302012	Y	Y		
94	VINYL CHLORIDE	75014	Y			
95	METHYLENEBIS(PHENYLISOCYANATE)	101688	Y			Y
96	EPICHLOROHYDRIN	106898	Y			
97	PROPYLENE	115071	Y			
98	NITRILOTRIACETIC ACID	139139		Y		
99	ARSENIC	7440382	Y			Y
100	NAPHTHALENE	91203	Y	Y		
101	VINYLIDENE CHLORIDE	75354	Y			
102	TRICHLORFON	52686	Y			Y
103	DIBUTYL PHTHALATE	84742		Y		
104	ANILINE	62533	Y	Y		
105	METHOXYCHLOR	72435	Y	Y		Y
106	DIETHANOLAMINE	111422	Y	Y	Y	Y
107	NITROBENZENE	98953	Y	Y		
108	CYANIDE COMPOUNDS	57125	Y	Y		
109	AMMONIUM SULFATE (SOLUTION)	7783202		Y		
110	LINDANE	58899	Y			Y
111	POLYCHLORINATED BIPHENYLS	1336363	Y			Y
112	PROPYLENE OXIDE	75569	Y			
113	2,4-DINITROPHENOL	51285	Y	Y		Y
114	PHOSGENE	75445	Y			
115	HEXACHLOROETHANE	67721	Y			
116	CADMIUM	7440439				Y
117	ETHYLENE OXIDE	75218	Y			
118	BENZYL CHLORIDE	100447	Y	Y		
119	4,6-DINITRO-O-CRESOL	534521	Y			
120	CHLOROBENZILATE	510156	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 4: ELECTROPLATING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	SULFURIC ACID	7664939	Y	Y	Y	Y
2	HYDROCHLORIC ACID	7647010	Y	Y	Y	Y
3	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
4	1,1,1-TRICHLOROETHANE	71556	Y	Y	Y	Y
5	SODIUM SULFATE (SOLUTION)	7757826	Y	Y		Y
6	NITRIC ACID	7697372	Y	Y	Y	Y
7	DICHLOROMETHANE	75092	Y	Y		Y
8	NICKEL	7440020	Y	Y	Y	Y
9	TRICHLOROETHYLENE	79016	Y	Y		Y
10	CHROMIUM	7440473	Y	Y	Y	Y
11	TETRACHLOROETHYLENE	127184	Y	Y	Y	Y
12	METHYL ETHYL KETONE	78933	Y	Y		Y
13	ZINC	7440666	Y	Y	Y	Y
14	FREON 113	76131	Y		Y	Y
15	ALUMINUM	7429905	Y	Y	Y	Y
16	COPPER	7440508	Y	Y	Y	Y
17	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
18	TOLUENE	108883	Y	Y	Y	Y
19	LEAD	7439921	Y	Y	Y	Y
20	XYLENE (MIXED ISOMERS)	1330207	Y			Y
21	ACETONE	67641	Y	Y		Y
22	CADMIUM	7440439		Y	Y	Y
23	ETHYLBENZENE	100414	Y			Y
24	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
25	CYANIDE COMPOUNDS	57125	Y	Y	Y	Y
26	AMMONIA	7664417	Y	Y		Y
27	FORMALDEHYDE	50000	Y	Y		Y
28	GLYCOL ETHERS	79141	Y	Y		Y
29	CHLORINE	7782505	Y	Y		Y
30	METHANOL	67561	Y	Y		Y
31	ETHYLENE OXIDE	75218	Y			
32	METHYL ISOBUTYL KETONE	108101	Y			Y
33	2-METHOXYETHANOL	109864	Y			Y
34	HYDROGEN FLUORIDE	7664393	Y	Y		Y
35	PHENOL	108952	Y			Y
36	1,2-DICHLOROBENZENE	95501	Y			Y
37	N-BUTYL ALCOHOL	71363	Y			Y
38	TERT-BUTYL ALCOHOL	75650	Y			
39	BARIUM	7440393				Y
40	VINYLIDENE CHLORIDE	75354	Y			
41	2-ETHOXYETHANOL	110805	Y			Y
42	ISOPROPYL ALCOHOL	67630	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 4: ELECTROPLATING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
43	MANGANESE	7439965	Y			Y
44	HYDROGEN CYANIDE	74908				Y
45	STYRENE	100425	Y			
46	TETRACHLORVINPHOS	961115	Y			
47	MELAMINE	108781				Y
48	N-DIOCTYL PHTHALATE	117840				Y
49	1,4-DIOXANE	123911	Y			
50	COBALT	7440484		Y		
51	NAPHTHALENE	91203				Y
52	AMMONIUM SULFATE (SOLUTION)	7783202				Y
53	SILVER	7440224		Y		Y
54	PROPYLENE	115071	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 5: WOOD PRESERVATION

Rank[a]	Compound	CAS Number	Air	Wat
1	CHROMIUM	7440473	Y	Y
2	NAPHTHALENE	91203	Y	Y
3	AMMONIA	7664417	Y	
4	PENTACHLOROPHENOL	87865	Y	Y
5	DIBENZOFURAN	132649	Y	Y
6	ANTHRACENE	120127	Y	Y
7	COPPER	7440508	Y	Y
8	ARSENIC	7440382	Y	Y
9	FORMALDEHYDE	50000	Y	
10	BIPHENYL	92524	Y	Y
11	BENZENE	71432	Y	Y
12	DICHLOROMETHANE	75092	Y	
13	1,1,1-TRICHLOROETHANE	71556	Y	
14	AMMONIUM SULFATE (SOLUTION)	7783202		Y
15	QUINOLINE	91225	Y	Y
16	PHENOL	108952	Y	Y
17	ZINC	7440666	Y	Y
18	PHOSPHORIC ACID	7664382	Y	
19	O-CRESOL	95487	Y	Y
20	HYDROCHLORIC ACID	7647010	Y	
21	M-CRESOL	108394	Y	Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 6: LEATHER TANNING

Rank [a]	Compound	CAS Number	Air	Water	Soil	Other [b]
1	AMMONIUM SULFATE (SOLUTION)	7783202	Y	Y	Y	Y
2	SULFURIC ACID	7664939	Y	Y		Y
3	SODIUM HYDROXIDE (SOLUTION)	1310732		Y		Y
4	AMMONIA	7664417	Y	Y	Y	Y
5	TOLUENE	108883	Y			Y
6	SODIUM SULFATE (SOLUTION)	7757826		Y		
7	METHYL ETHYL KETONE	78933	Y			Y
8	XYLENE (MIXED ISOMERS)	1330207	Y	Y		Y
9	CHROMIUM	7440473	Y	Y	Y	Y
10	GLYCOL ETHERS	79141	Y	Y		Y
11	METHYL ISOBUTYL KETONE	108101	Y	Y		Y
12	2-METHOXYETHANOL	109864	Y	Y		Y
13	ACETONE	67641	Y	Y		Y
14	2-ETHOXYETHANOL	110805	Y	Y		Y
15	N-BUTYL ALCOHOL	71363	Y	Y		Y
16	TETRACHLOROETHYLENE	127184	Y	Y		
17	CYCLOHEXANE	110827	Y			Y
18	AMMONIUM NITRATE (SOLUTION)	6484522			Y	
19	MANGANESE	7439965		Y	Y	Y
20	1,1,1-TRICHLOROETHANE	71556	Y			
21	DICHLOROMETHANE	75092	Y			
22	DIETHANOLAMINE	111422	Y			Y
23	METHANOL	67561	Y	Y		
24	ISOPROPYL ALCOHOL	67630	Y			Y
25	PHOSPHORIC ACID	7664382		Y		
26	ETHYLENE GLYCOL	107211	Y			
27	FREON 113	76131	Y			
28	PHENOL	108952		Y		
29	ETHYL ACRYLATE	140885	Y			

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 7: PETROLEUM REFINING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
1	SODIUM SULFATE (SOLUTION)	7757826	Y	Y	Y	Y
2	ALUMINUM	7429905	Y	Y	Y	Y
3	AMMONIA	7664417	Y	Y	Y	Y
4	SODIUM HYDROXIDE (SOLUTION)	1310732	Y	Y	Y	Y
5	SULFURIC ACID	7664939	Y	Y	Y	Y
6	TOLUENE	108883	Y	Y	Y	Y
7	XYLENE (MIXED ISOMERS)	1330207	Y	Y	Y	Y
8	BENZENE	71432	Y	Y	Y	Y
9	METHYL ETHYL KETONE	78933	Y	Y	Y	Y
10	PROPYLENE	115071	Y	Y		Y
11	PHENOL	108952	Y	Y	Y	Y
12	DIETHANOLAMINE	111422	Y	Y	Y	Y
13	ETHYLENE	74851	Y	Y		Y
14	METHANOL	67561	Y	Y	Y	Y
15	CYCLOHEXANE	110827	Y	Y	Y	Y
16	1,2,4-TRIMETHYLBENZENE	95636	Y	Y	Y	Y
17	ETHYLBENZENE	100414	Y	Y	Y	Y
18	PHOSPHORIC ACID	7664382	Y	Y	Y	Y
19	CHROMIUM	7440473	Y	Y	Y	Y
20	METHYL TERT-BUTYL ETHER	1634044	Y	Y	Y	Y
21	ASBESTOS (FRIABLE)	1332214			Y	Y
22	P-XYLENE	106423	Y	Y	Y	Y
23	AMMONIUM SULFATE (SOLUTION)	7783202		Y		Y
24	M-XYLENE	108383	Y	Y	Y	Y
25	CUMENE	98828	Y	Y	Y	Y
26	ACETONE	67641	Y	Y	Y	
27	CRESOL (MIXED ISOMERS)	1319773	Y	Y	Y	Y
28	HYDROGEN FLUORIDE	7664393	Y	Y	Y	Y
29	O-XYLENE	95476	Y	Y	Y	Y
30	NAPHTHALENE	91203	Y	Y	Y	Y
31	NICKEL	7440020	Y	Y	Y	Y
32	CHLORINE	7782505	Y	Y		Y
33	LEAD	7439921	Y	Y	Y	Y
34	METHYL ISOBUTYL KETONE	108101	Y	Y		
35	ETHYLENE GLYCOL	107211	Y	Y	Y	Y
36	MOLYBDENUM TRIOXIDE	1313275	Y	Y	Y	Y
37	ZINC	7440666	Y	Y	Y	Y
38	HYDROCHLORIC ACID	7647010	Y	Y		Y
39	GLYCOL ETHERS	79141	Y	Y	Y	Y
40	BARIUM	7440393	Y	Y	Y	Y
41	COPPER	7440508	Y	Y	Y	Y
42	1,1,1-TRICHLOROETHANE	71556	Y	Y	Y	Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 7: PETROLEUM REFINING

Rank [a]	Compound	CAS Number	Air	Water	Soil	Other [b]
43	ANTIMONY	7440360	Y	Y	Y	Y
44	1,3-BUTADIENE	106990	Y	Y		Y
45	N-BUTYL ALCOHOL	71363	Y			
46	FORMALDEHYDE	50000	Y	Y	Y	Y
47	EPICHLOROHYDRIN	106898	Y		Y	
48	COBALT	7440484	Y	Y	Y	Y
49	VANADIUM (FUME OR DUST)	7440622	Y		Y	Y
50	CUMENE HYDROPEROXIDE	80159	Y			
51	TERT-BUTYL ALCOHOL	75650	Y		Y	
52	4,4'-ISOPROPYLIDENEDIPHENOL	80057	Y		Y	
53	BUTYRALDEHYDE	123728	Y			
54	BIPHENYL	92524	Y	Y	Y	Y
55	CARBON TETRACHLORIDE	56235	Y	Y	Y	Y
56	STYRENE	100425	Y	Y	Y	Y
57	TRICHLOROETHYLENE	79016	Y	Y		
58	MANGANESE	7439965	Y	Y		Y
59	ETHYLENE OXIDE	75218	Y			
60	AMMONIUM NITRATE (SOLUTION)	6484522		Y		
61	CARBON DISULFIDE	75150	Y	Y		
62	1,2-DICHLOROETHANE	107062	Y	Y	Y	Y
63	POLYCHLORINATED BIPHENYLS	1336363				Y
64	PHOSPHORUS (YELLOW OR WHITE)	7723140				Y
65	QUINOLINE	91225	Y			
66	2-METHOXYETHANOL	109864	Y		Y	Y
67	1,2-DIBROMOETHANE	106934	Y	Y	Y	Y
68	TETRACHLOROETHYLENE	127184	Y	Y	Y	
69	ANTHRACENE	120127	Y	Y	Y	
70	2,4-DIMETHYLPHENOL	105679		Y	Y	
71	HYDROGEN CYANIDE	74908	Y	Y		
72	CHLOROMETHANE	74873	Y			
73	NITROBENZENE	98953		Y		
74	1,2-DICHLOROPROPANE	78875	Y	Y	Y	
75	CARBONYL SULFIDE	463581	Y	Y		
76	ACETONITRILE	75058	Y			
77	SILVER	7440224	Y	Y		Y
78	2-ETHOXYETHANOL	110805	Y			
79	THALLIUM	7440280		Y		Y
80	FREON 113	76131	Y			
81	SELENIUM	7782492	Y	Y	Y	Y
82	DICHLOROMETHANE	75092	Y			
83	MERCURY	7439976		Y	Y	Y
84	CADMIUM	7440439		Y	Y	Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

Appendix II
LISTING OF COMMON POLLUTANTS GENERATED BY SEVEN INDUSTRIES
INDUSTRY 7: PETROLEUM REFINING

Rank[a]	Compound	CAS Number	Air	Water	Soil	Other[b]
85	1,1,2-TRICHLOROETHANE	79005	Y	Y		
86	ARSENIC	7440382	Y	Y	Y	Y
87	CYANIDE COMPOUNDS	57125				Y
88	CHLORINE DIOXIDE	10049044	Y			
89	ACRYLIC ACID	79107	Y			
90	1,3-DICHLOROPROPYLENE	542756	Y			
91	1,2-BUTYLENE OXIDE	106887	Y			
92	CHLOROBENZENE	108907				Y
93	1,4-DIOXANE	123911	Y			
94	DI(2-ETHYLHEXYL) PHTHALATE (DEHP)	117817			Y	
95	BERYLLIUM	7440417	Y			
96	CHLOROFORM	67663				Y

[a] Rank = Order of Frequency of Occurrence

[b] Other = Other Matrices (Biota, Hazardous Waste, Sludge, etc.)

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United States
Environmental Protection
Agency

Office of
Solid Waste and
Emergency Response

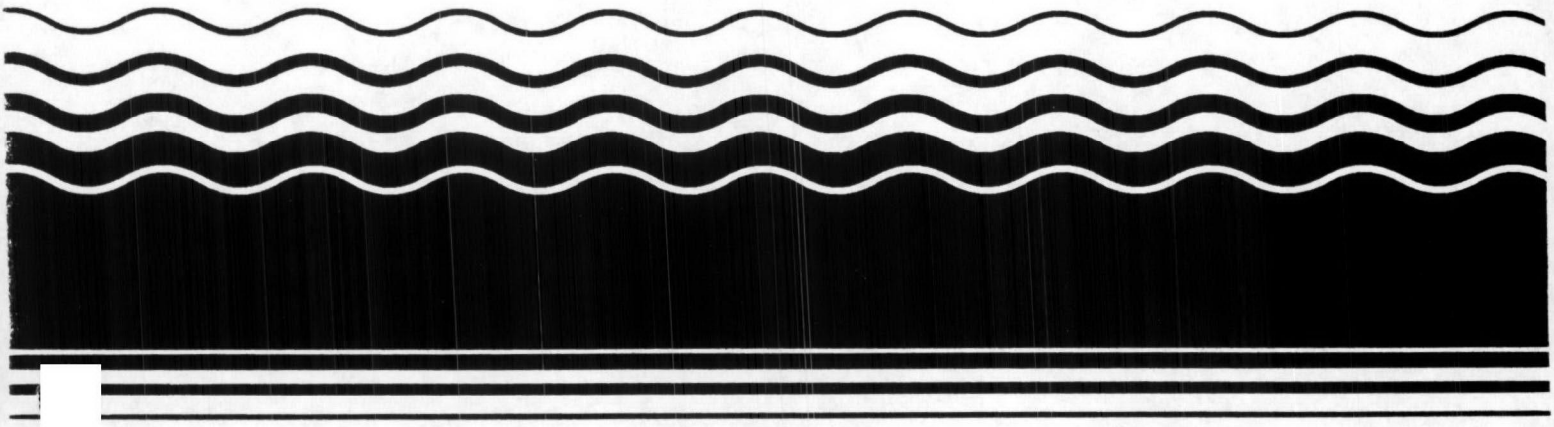
Publication 9355.9-01
EPA540-R-93-071
PB94-963203
September 1993

Superfund

EPA

DATA QUALITY OBJECTIVES PROCESS FOR SUPERFUND

Interim Final Guidance



9355.9-01
EPA540-R-93-071
PB94-963203
September 1993

DATA QUALITY OBJECTIVES PROCESS FOR SUPERFUND

Interim Final Guidance

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

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NOTICE

The procedures set forth in this document are intended as guidance to employees of the United States Environmental Protection Agency (EPA) and other government agencies. These guidelines do not constitute EPA rulemaking and cannot be relied upon to create any substantive or procedural rights enforceable by any party in litigation with the United States. EPA reserves the right to act at variance with the policies and procedures in this guidance, based on analysis of site-specific circumstances. EPA also reserves the right to modify this guidance at any time without public notice.

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FOREWORD

The U.S. Environmental Protection Agency (EPA) undertakes cleanup activities at abandoned hazardous waste sites under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the Superfund program. Many of the activities involve the collection and evaluation of site-specific environmental data EPA has developed and implemented a mandatory Agency-wide program of quality assurance for environmental data, including a process for developing Data Quality Objectives (DQOs), as an important tool for project managers and planners to determine the type, quantity, and quality of data needed to make defensible decisions.

The Office of Emergency and Remedial Response (OERR) is promoting a common understanding of the quality assurance requirements for site-specific data collection activities. The DQO Process is an effective means by which managers and technical staff can implement the mandatory Superfund quality assurance requirements. The Agency has developed this guidance on *Data Quality Objectives Process for Superfund* to replace the earlier guidance, *Data Quality Objectives for Remedial Response Activities* (EPA 540/G-87/003, OSWER Directive 9355.0-7B) and the five analytical levels introduced in that document.

It is the goal of the Superfund program and the regulated community to collect data of appropriate quality for environmental decisions while minimizing expenditures related to data collection by eliminating unnecessary duplication or unnecessarily detailed data. The most effective way to accomplish this is to implement the DQO Process.

for Henry L. Longest II, Director
Office of Emergency and Remedial Response

Bruce M. Diamond, Director
Office of Waste Programs Enforcement

LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DQO or DQOs	Data Quality Objectives
EE/CA	Engineering Evaluation and Cost Analysis
ESI	Expanded Site Investigation
EU	Exposure Unit
FS	Feasibility Study
HRS	Hazard Ranking System
MCL	Maximum Contaminant Level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
OSC	On-Scene Coordinator
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
QAPP	Quality Assurance Project Plan
RD	Remedial Design
RDT	Regional Decision Team
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RPM	Regional Project Manager
RU	Remediation Unit
SACM	Superfund Accelerated Cleanup Model
SAM	Site Assessment Manager
SEA	Site Evaluation Accomplished
SI	Site Inspection

INTRODUCTION

OVERVIEW AND PURPOSE OF THIS DOCUMENT

This document provides guidance on developing Data Quality Objectives (DQOs) for Superfund sites. This guidance replaces EPA/540/G-87/003, *Data Quality Objectives for Remedial Response Activities: Development Process.*

Each year the U.S. Environmental Protection Agency (EPA) and the regulated community spend approximately $5 billion collecting environmental data for scientific research, regulatory decision making, and regulatory compliance. While these activities are necessary for effective environmental protection, it is the goal of EPA and the regulated community to minimize expenditures related to data collection by eliminating unnecessary, duplicative, or overly precise data. At the same time, they would like to collect data of sufficient quantity and quality to support defensible decision making. The most efficient way to accomplish both of these goals is to begin by ascertaining the type, quality, and quantity of data necessary to address the problem before the study begins.

What is the DQO Process? The DQO Process is a series of planning steps based on the Scientific Method that is designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application. The steps of the DQO Process are illustrated in Figure 1.

What are DQOs? DQOs are qualitative and quantitative statements derived from the outputs of each step of the DQO Process that:

1) Clarify the study objective;
2) Define the most appropriate type of data to collect;
3) Determine the most appropriate conditions from which to collect the data; and
4) Specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision.

The DQOs are then used to develop a scientific and resource-effective sampling design.

The DQO Process was developed by EPA to help Agency personnel collect data that are important to decision making. The process allows decision makers to define their data requirements and acceptable levels of decision errors[1] during planning, before any data are collected. Application of the DQO Process should result in data collection designs that will yield results of appropriate quality for defensible decision making.

Why was this document developed for Superfund? Mandatory quality assurance (QA) requirements for EPA environmental data collection activities are established in EPA Order 5360.1, *Policy and Program Requirements to Implement the Quality Assurance Program.* Additionally, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; 40 CFR Part 300) mandates specific Superfund QA requirements. Both documents emphasize that Superfund environmental data must be of known quality and require the development of Quality Assurance Project Plans (QAPPs) for all environmental data collection activities to achieve this goal. The NCP mandates the development of a

[1]Decision errors occur when variability or bias in data mislead the decision maker into choosing an incorrect course of action. Decision errors are discussed in detail in Chapter 6: SPECIFY LIMITS ON DECISION ERRORS.

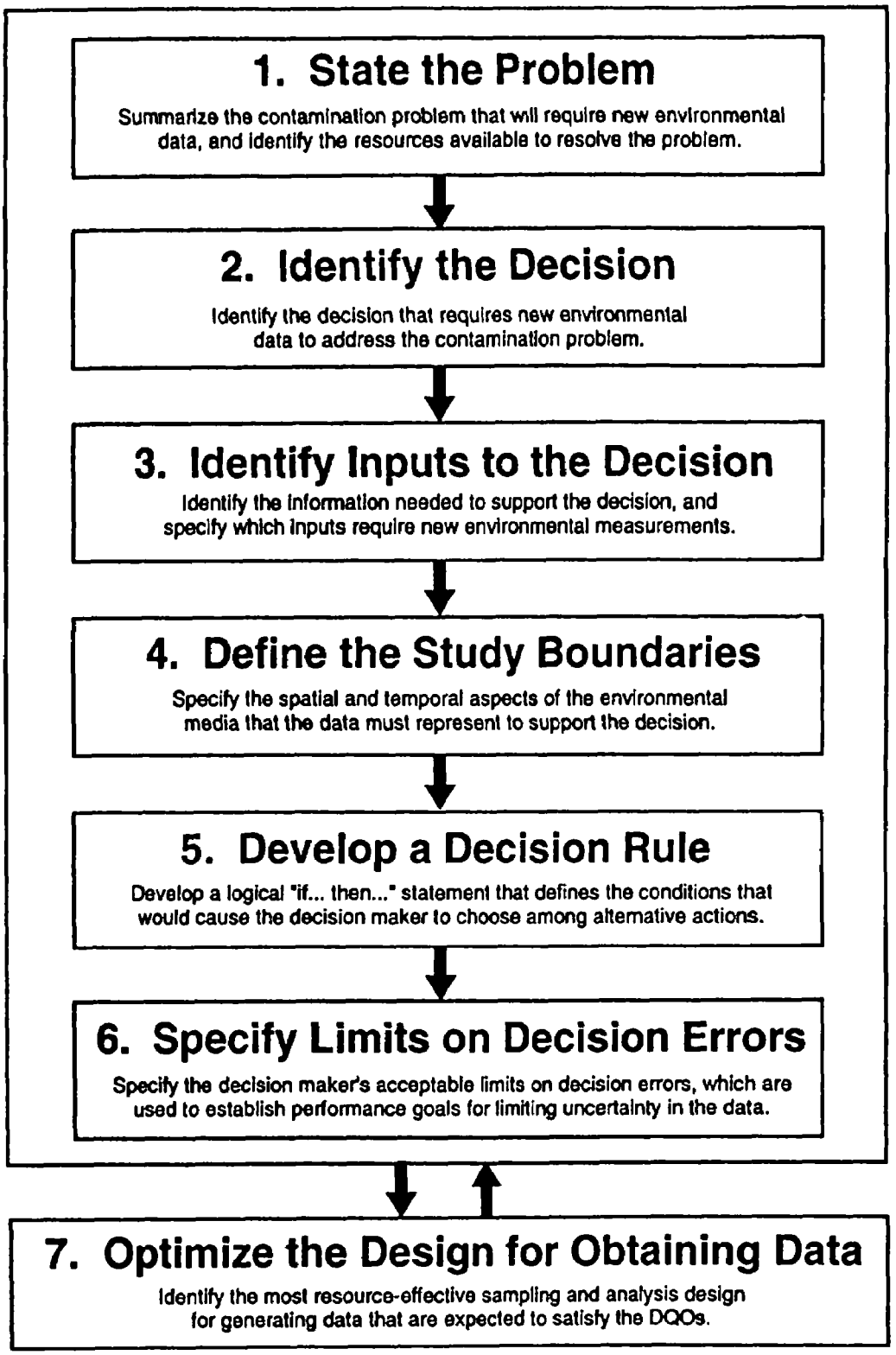

Figure 1. The Data Quality Objectives Process

Sampling and Analysis Plan (SAP), which specifies acceptable data quality goals, defines responsibility for achieving these goals, and includes as its key elements a field sampling plan and a QAPP. Figure 2 illustrates the elements of QA planning for Superfund.

The DQO Process requires site managers to specify acceptable data quality goals by establishing acceptable limits on decision errors. The DQO Process outputs, including the acceptable limits on decision errors, provide the information necessary to develop the SAP. The DQO Process and the SAP requirements satisfy EPA Order 5360.1 and the NCP's mandate. This guidance document revises the Superfund program's approach to developing DQOs to be consistent with the following Agency-wide QA requirements and guidance documents:

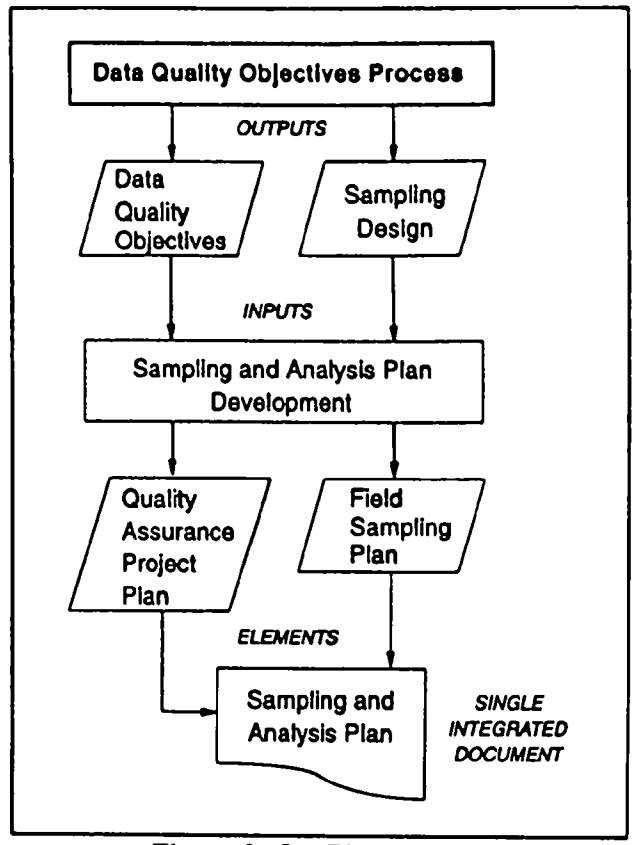

Figure 2. QA Planning for Superfund Data Collection

EPA Quality System Requirements for Environmental Programs. EPA/QA/R-1. 1993.

Interim Draft EPA Requirements for Quality Management Plans. EPA/QA/R-2. 1992.

EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations. EPA/QA/R-5. 1993.

Guidance for Planning for Data Collection in Support of Environmental Decision Making Using the Data Quality Objectives Process. EPA/QA/G-4. 1993.

Guidance for Conducting Environmental Data Quality Assessments. EPA/QA/G-9. 1993.

How is this document organized? This document is organized as follows: Chapters 1 through 7 describe procedures for implementing the DQO Process at Superfund sites. Each of these chapters describes a step of the DQO Process, and includes a background section that explains the purpose of that step, activities for developing the outputs of that step, and a list of expected outputs. Chapter 8 discusses the relationships between the DQO Process, the Sampling and Analysis Plan, and Data Quality Assessment.

This guidance is supported by several appendices. Appendix I describes in more detail selected topics relating to DQO development activities. Appendix II provides three examples of DQO development: a pre-remedial program (site inspection) ground-water example, a removal program soil example, and a remedial program soil example. Appendix III contains a glossary of terms used in this guidance document, and Appendix IV contains a bibliography of documents used in the development of this guidance.

BENEFITS OF THE DQO PROCESS

The DQO Process is a planning tool to help site managers decide what type, quality, and quantity of data will be sufficient for environmental decision making. The outputs of the DQO Process can be used to develop a statistical sampling design and to effectively plan field investigations that can stand up to rigorous review.

By using the DQO Process, a site manager provides criteria for determining when data are sufficient for site decisions. This provides a stopping rule — a way for site managers to determine when they have collected enough data. In addition, the DQO Process:

Improves Sampling and Analysis Designs	• helps site managers streamline field investigations and decide how many samples and analyses are required to support defensible decision making; • helps site managers define where and when samples should be collected; • provides the QA community with a scientific basis for defining the right type and number of quality control and quality assessment samples and associated analytical precision and recovery requirements;
Saves Money and Time	• helps field personnel identify resource-efficient sample collection methods; • helps laboratory analysts identify resource-effective analytical methods; • can drastically reduce overall project costs by improving the quality of information for decision making (for example, defining areas of the site that require remediation) and by eliminating expensive rework;
Improves Decision Making	• helps site managers develop a statistical sampling design that controls decision errors. • provides a structure for clarifying multiple study objectives into specific decisions. • encourages the participation and communication of data users and relevant technical experts in planning, implementation, and assessment.

The DQO Process is based on the scientific method, and therefore improves the legal defensibility of site decisions by providing a complete record of the decision process and criteria for arriving at conclusions.

It is important to remember that there is a tradeoff between the desire to limit decision errors and the cost of reducing decision errors. Reducing decision errors can be costly because more samples and more analyses are often required. One of the goals of the DQO Process is to help decision makers strike the best balance between acceptable limits on decision errors and the cost of meeting those decision error limits.

THE DQO PROCESS AND STATISTICS

The DQO Process has both a quantitative and a qualitative aspect. The quantitative aspect seeks to use statistics to design the most efficient field investigation that controls the possibility of making an incorrect decision. The qualitative aspect seeks to encourage good planning for field investigations and complements the statistical design. Users of this guidance are encouraged to pursue both aspects of the DQO Process. A field investigation can always benefit from good planning, even if planning does not lead to a statistical design.

Generally, the quantitative aspect and subsequent statistical design are important when site contaminant levels are close to an action level, or when variability in the data is so great that the results are inconclusive. In such cases, a statistical design can provide quantitative estimates of the level of uncertainty in the data and, therefore, help the decision maker understand and control the probability of making an incorrect decision based on the data.

The statistical procedures used in the DQO Process provide:

- a scientific basis for making inferences about a site (or a portion of a site) based on information contained in environmental samples;
- a basis for defining data quality criteria and assessing the achieved data quality for supporting integrated site assessment decisions;
- a foundation for defining meaningful quality control procedures that are based on the intended use of the data;
- quantitative criteria for knowing when site managers should stop sampling (i.e., when the site has been adequately characterized); and
- a solid foundation for planning subsequent data collection activities.

Non-probabilistic or subjective (judgmental) sampling approaches can be useful and appropriate for satisfying certain field investigation (study) objectives. For instance, if the study objective is to locate and identify potential sources of contamination, a subjective identification of sampling locations may be the most efficient method to employ.[2] If the objective is to establish that a threat exists in a complete exposure pathway by confirming the presence of a hazardous substance associated with the site or process, a judgmental sampling approach can be used. However, because of the subjective nature of the selection process, data generated from non-probabilistic samples should not be used if the goal of the study is to characterize some property of the site as a whole.

IMPLEMENTING THE DQO PROCESS

The scoping team should follow each step of the DQO Process for each medium of concern. Once the scoping team has gone through the process completely for one medium, it becomes easier and quicker to develop additional sets of DQOs in other media. For example, typically at Superfund sites the contaminants of concern identified in the early assessment phase remain the focus of subsequent field investigations in the advanced assessment, even though the decision and the action level may change. Similarly, the areas of concern that are directly related to the geographical boundaries of the study usually do not vary much through the site assessment process. Therefore, much of the DQO outputs generated in the early assessment will be applicable in advanced assessment planning.

The DQO Process is flexible and iterative. Often, especially for more complicated sites, the scoping team will need to return to earlier steps to rethink or better focus the output. These iterations through the earlier steps of the DQO Process can lead to a more focused design that can save resources in later field investigation activities.

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[2]An important caveat here is that if contamination is not found, then without a statistical approach very little can be said about the probability of having missed the source of contamination.

The DQO Process should be used repeatedly during the life cycle of a project. Early in the project, a more preliminary and qualitative application of the DQO Process may be appropriate to meet the site manager's needs. As more details and decisions about the site develop, a more thorough and quantitative application of the DQO Process usually is warranted. Figure 3 illustrates this point graphically. During early assessment, a site manager may decide to apply only the more qualitative aspects of the DQO Process, rely less on the quantitative aspect, and not use a statistical sampling design, especially since this is not a decision that requires a full assessment of health or environmental risks. In the advanced assessment phase, the possibility that uncertainty in environmental data may lead to incorrect decisions becomes more critical and a site manager may place more emphasis on the quantitative aspects of DQO development.

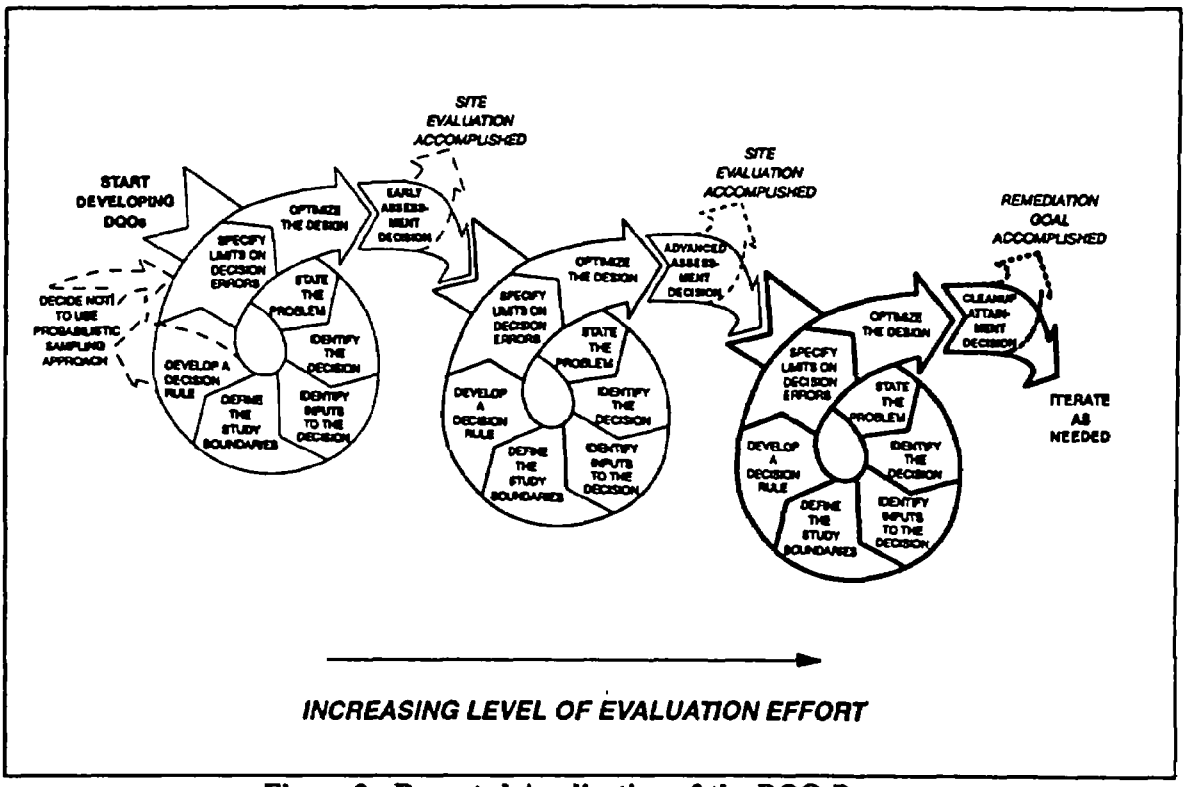


Figure 3. Repeated Application of the DQO Process

HOW THE DQO PROCESS FITS INTO INTEGRATED SITE ASSESSMENT/SACM

The DQO Process provides a logical framework for planning multiple field investigations, thereby fulfilling the integrated site assessment goal of cross-program response planning and allowing optimal cross-program data useability. By emphasizing the need to place limits on the probability of taking incorrect actions, the DQO Process complements the integrated site assessment objective of evaluating the need for action. The DQO Process places a worthwhile investment on planning, which results in timely and efficient cleanups, thereby increasing the chances of taking the correct action. For these reasons, the DQO Process is an effective approach for accomplishing and satisfying the goals of the Superfund Accelerated Cleanup Model (SACM). This guidance document is the primary document for planning site assessment field investigations. However, users should consult other relevant Superfund guidance that provide more detailed information on specific site assessment activities. Appropriate references are included throughout this guidance, and Appendix IV provides a summary of references organized by DQO topic.

WHERE TO FIND MORE INFORMATION ABOUT THE DQO PROCESS

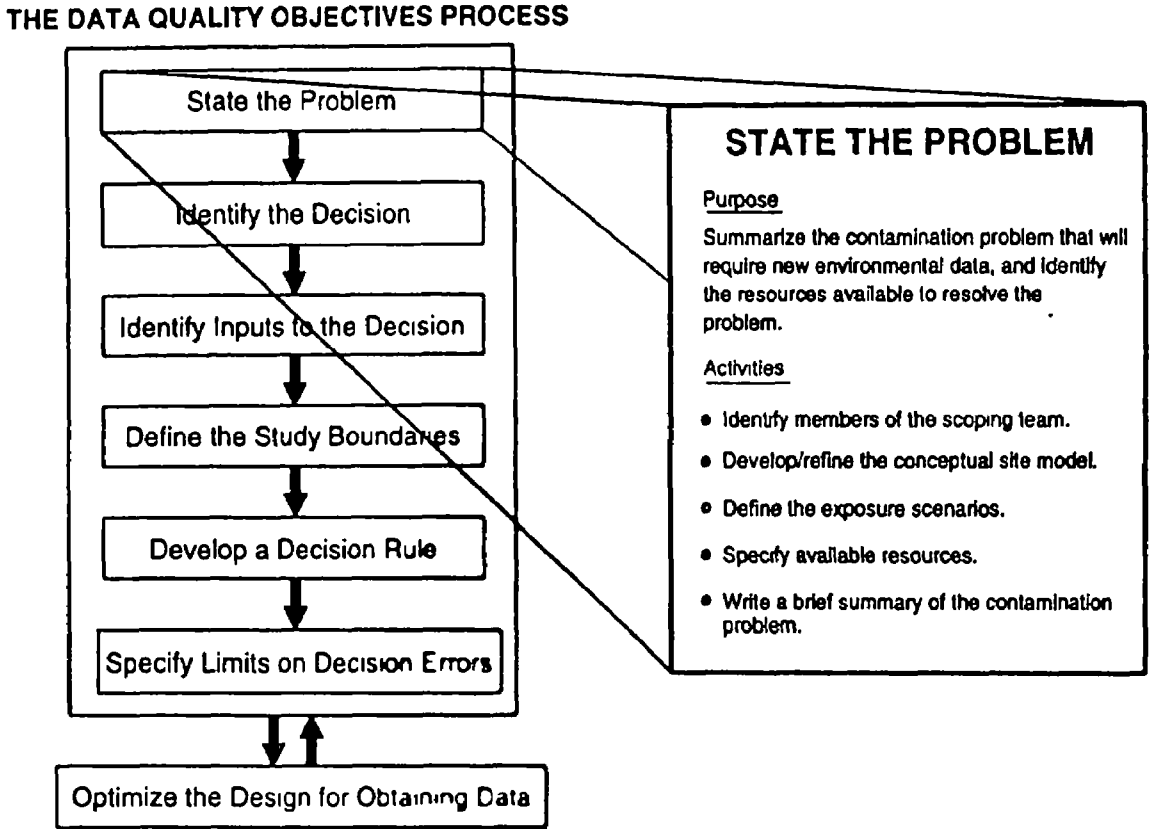
A DQO training course is available through the EPA Training Institute at U.S. EPA Headquarters in Washington, D.C.

Additional documents on DQO applications can be obtained from the Quality Assurance Management Staff at EPA Headquarters.

EPA regional and national program office quality assurance managers can provide assistance in learning more about the DQO Process.

CHAPTER 1

STEP 1: STATE THE PROBLEM



1.1 BACKGROUND

The purpose of this step is to

- establish the DQO scoping team;
- provide a brief description of the contamination problem that presents a potential threat/unacceptable risk to human health and the environment; and
- identify resources available to address the problem.

Stating the problem typically involves a description of the source and/or location of contamination including physical and chemical factors associated with the site that could result in contaminant release or unacceptable exposures. The description should include the regulatory and programmatic context of the problem, such as the regulatory objectives and basis for the field investigation. The description of the potential contamination problem should also include appropriate action levels for evaluating and responding to releases or exposures, and appropriate response actions.

The scoping team is a multidisciplinary group of experts. They develop or refine a conceptual site model that describes and illustrates the known and suspected sources of contamination, potential migration pathways, and potential human and environmental receptors. The scoping team begins by collecting and evaluating all historical site data to formulate the conceptual site model and assess the extent to which the available historical site data support exposure scenarios that are developed later in the site assessment process. These descriptions aid in understanding the relationship among potential contaminant releases, sources of contamination, and physical and environmental targets.

1.2 ACTIVITIES

Identify Members of the Scoping Team

The creation of the scoping team is a two-step process. The first step is to identify the decision maker for the site. The decision maker (usually the site manager) and his technical staff identify the other members of the scoping team based on a preliminary understanding of the nature of the contamination problem (e.g., potentially affected media). The site manager[1] delegates responsibility for accomplishing planning tasks to the other members of the scoping team. However, the site manager makes the final decisions at the site.

The second step is to choose the members of the scoping team. The team should include representatives who are knowledgeable about several project phases, including QA specialists, samplers, chemists, modelers, technical project managers, human health and ecological risk assessors, toxicologists, biologists, ecologists, administrative and executive managers, data users, Natural Resource Trustees, and a statistician (or someone knowledgeable and experienced with environmental statistical design).

Every member of the scoping team will support or actively participate in all steps of the DQO Process. Their roles will include interpreting historical site data and preparing their team members for accomplishing DQO activities. They will also attend meetings to help generate DQO outputs that will guide the field investigation data collection designs.

Develop/Refine the Conceptual Site Model

Collect all available historical site data, including QA/QC documentation associated with previous environmental data collection activities. Use the information to develop a diagram that illustrates the relationships between:

- locations where contamination exists or contaminant/waste sources,
- types and concentrations of contaminants,
- potentially contaminated media, migration pathways,
- potential physical and environmental targets or receptors.

Presenting historical site data in this manner provides a foundation for identifying data gaps and focusing on where the problems of potentially unacceptable contamination may or may not exist.

More information on developing the conceptual site model (CSM) can be found in Appendix I, Section A. For more extensive information sources, refer to the *Guidance for Performing Site Inspections Under CERCLA*, and the *Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA*.

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[1]Throughout this document, the site manager is assumed to be the decision maker.

Define Exposure Pathways and Exposure Scenarios

The goal of this step is to define site conditions that indicate or could lead to an unacceptable threat or exposure at the site. Use the conceptual site model and relevant information on migration pathways as a base for accomplishing this task. For the early phases of site assessment activities, it is necessary to establish that a complete exposure pathway exists. In general, identify currently contaminated media to which individuals or sensitive ecosystems may be exposed. Following identification of the media of concern, identify potential contaminants of concern based on historical site use, analytical data, or anecdotal information. Next, define the current and future land use. Following this, determine the local/state applicable or relevant and appropriate requirements (ARARs) for the site. For cases where multiple contaminants exist and ARARs are not available for all the contaminants, develop risk-based contaminant-specific preliminary remediation goals (PRGs). Chemical-specific PRGs are concentrations based on ARARs or concentrations based on risk assessment. PRGs should also be developed even when ARARs are available for all contaminants and meeting all ARARs is not considered protective. For each medium and land use combination, identify complete exposure pathways and assemble all this information into exposure scenarios that are expected to represent the highest exposure that could reasonably occur at the site. More detailed information on accomplishing the above activities during scoping can be found in the *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)*, EPA/540/R-92/004.

It is efficient to evaluate the potential for an unacceptable ecological threat during the human health evaluation. The following text discusses important relationships between human health and environmental evaluations:

> Environmental evaluation and human health evaluation are parallel activities in the evaluation of hazardous waste sites. Much of the data and analyses relating to the nature, fate, and transport of a site's contaminants will be used for both evaluations. At each point of these common stages, however, analysts should be sensitive to the possibility that certain contaminants and exposure pathways may be more important for the environmental evaluation than for the health evaluation, or vice versa. It is also important to recognize that each of the two evaluations can sometimes make use of the other's information. For example, the potential of a contaminant to bioaccumulate may be estimated for a health evaluation but be useful for the environmental evaluation. Similarly, measurement of contaminant levels in sport and commercial species for an environmental evaluation may yield useful information for the health evaluation.[2]

For additional information on Exposure Assessment issues and ARARs refer to the *Risk Assessment Guidance for Superfund, Volume I-Human Health Evaluation Manual, Part A and Part B; Risk Assessment Guidance for Superfund, Volume II-Environmental Evaluation Manual; Framework for Ecological Risk Assessment; EPA Risk Assessment Forum (Feb, 1992); A Review of Ecological Assessment Case Studies from A Risk Assessment Perspective; EPA Risk Assessment Forum (May, 1993); CERCLA Compliance with Other Laws Manual;* and *Guidance for Data Useability in Risk Assessment (Part A).*

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[2]*Risk Assessment Guidance for Superfund, Volume II - Environmental Evaluation Manual.* p. 3.

Specify the Available Resources

(1) **Define the budget.** Specify the approximate monetary budget for the field investigation. This estimate should account for developing DQOs and for carrying out the potential sampling and analysis activity under consideration.

(2) **Define the time constraints.** Determine the time constraints, such as the Superfund recommended time frame, for completing the various required site evaluations. Other factors to consider include political factors such as public concern and the timeliness of addressing health and ecological risks.

Write a Brief Summary of the Contamination Problem

Summarize relevant background into a concise description of the problem to be resolved.

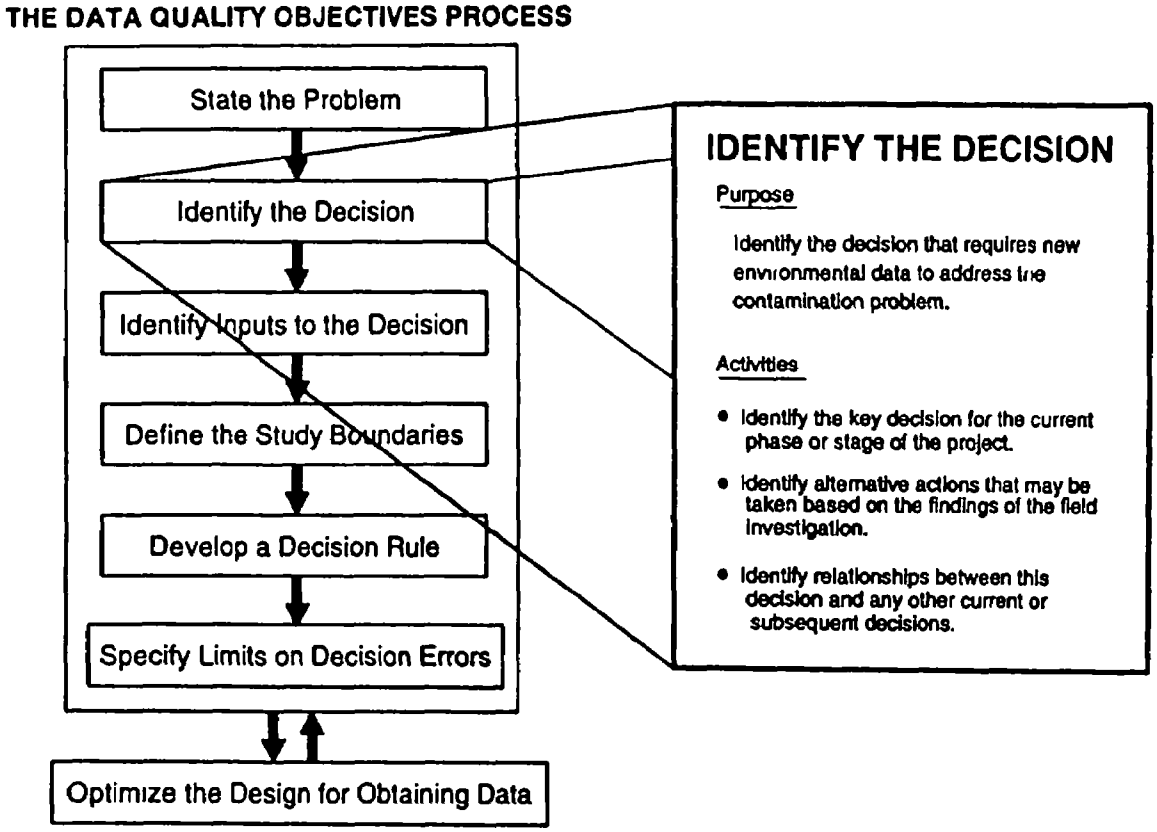
1.3 OUTPUTS

The main output of this step is a complete description of the contamination problem that includes the regulatory and programmatic context of the problem. This description typically consists of:

- a list of the known and suspected contaminants in each medium and estimates of their concentration, variability, distribution, and location;
- the conceptual site model and exposure pathways;
- a summary of the outcome and status of any previous response(s) at the site, such as early actions or previous data collection activities;
- the site's physical and chemical characteristics that influence migration and associated human, environmental, and physical target(s); and
- an estimate of the budget, schedule, and available personnel necessary to implement the appropriate response for the site.

CHAPTER 2

STEP 2: IDENTIFY THE DECISION



2.1 BACKGROUND

The purpose of this step is to identify the decision that will use environmental data to address the potential contamination problem and to state the actions that could result from the resolution of each decision statement. This is how the scoping team defines the objective of the field investigation.

Generally, environmental field investigations may be designed to satisfy a broad array of objectives, such as demonstration of regulatory compliance, research, monitoring for trends, or estimation of average characteristics. For Superfund, however, most field investigations are designed to support the site manager's selection of appropriate response actions (i.e., recommend the Site Evaluation Accomplished (SEA) or further assessment or even a removal/remedial response action). Since the field investigation objective can be viewed as a choice between alternative actions, this document describes the objectives as being synonymous with the decision and associated actions. This chapter presents four major site assessment decisions and associated actions. The site assessment decisions and associated actions listed below address the most important Removal and Remedial data collection activities. Site managers who are addressing at least one of these major site assessment decisions should proceed directly to that section below and identify the decision and corresponding actions. For site managers who are not addressing one of the major decisions, this guidance provides activities to help develop project-specific decision statements below.

Stating the decision will help focus the efforts of the scoping team toward a common objective. The actions taken will be based on the outcome of the field investigations and will lay the foundation for defining the data quality requirements. The decision statement and alternative actions together provide an initial confirmation of the assumption that environmental data are needed to help resolve the potential contamination problem.

2.2 ACTIVITIES

Identify the Key Decision for the Current Phase or Stage of the Project

Review the list of decisions presented below and select the appropriate decision for the current phase of the site assessment process.

EARLY ASSESSMENT DECISION
Determine whether the release poses a potential threat to human health or the environment.

ADVANCED ASSESSMENT DECISION, PHASE I
Determine whether the concentration of contaminants of concern exceed ARARs or exceed contaminant concentrations corresponding to the preliminary remediation goal for the site.

ADVANCED ASSESSMENT DECISION, PHASE II (EXTENT OF CONTAMINATION)
Determine the volume of media that exceeds action level(s) (i.e., ARARs, concentrations corresponding to the preliminary remediation goal, removal action levels, or final remediation levels).

CLEANUP ATTAINMENT DECISION
Determine whether the final remediation level(s) or removal action level(s) have been achieved.

If a decision other than one from the list above will be addressed, perform the following activities:

(1) Consider the actions that EPA, the potentially responsible parties, or another collective group will take based on the outcome of the field investigation. For example, what will be done to resolve the potential contamination problem? Is it necessary to collect data on contaminant concentrations in order to decide if the site-related contamination exceeds regulatory standards, including ecological screening levels?

(2) Examine the regulatory objectives for this phase of the remedial process. For example, when a site is listed on the National Priorities List (NPL), but a baseline risk assessment has not been conducted, then the regulatory objective is to determine the nature and magnitude of contamination.

(3) Perform a consistency check by assessing whether the decision will be responsive to the potential contamination problem.

Identify Alternative Actions that May Be Taken Based on the Findings of the Field Investigation

Select the actions that will be taken based on the outcome of the field investigation that correspond with the selected decision above.

Actions based on early assessment decision

(i) Recommend the site evaluation accomplished (SEA) response for the site; or
(ii) Recommend that the site warrants consideration of further assessment or a possible response action.

Actions based on advanced assessment decision, Phase I

(i) Recommend the SEA response for the site; or
(ii) Recommend that the site warrants consideration of further assessment or a possible response action.

Actions based on advanced assessment decision, Phase II

(i) Designate the area/volume for remediation; or
(ii) Do not designate the area/volume for remediation.

Actions based on cleanup attainment decision

(i) Recommend the SEA response and proceed with delisting procedures; or
(ii) Recommend that further response is appropriate for the site.

Confirm that the actions associated with the list of decisions above will help to resolve the contamination problem by determining if actions are consistent with and satisfy regulatory objectives. Also, based on the statement of the problem and decision, assess if the range of actions helps to achieve the goal of protecting human health and the environment.

Identify Relationships Between This Decision and Any Other Current or Subsequent Decisions

If several decisions will be made, identify each decision and establish the relationship among them and their order of priority. Then, identify the actions that are associated with each decision and determine a logical sequence for these actions. Use this information to determine if it would be more efficient to conduct the field investigation in stages.

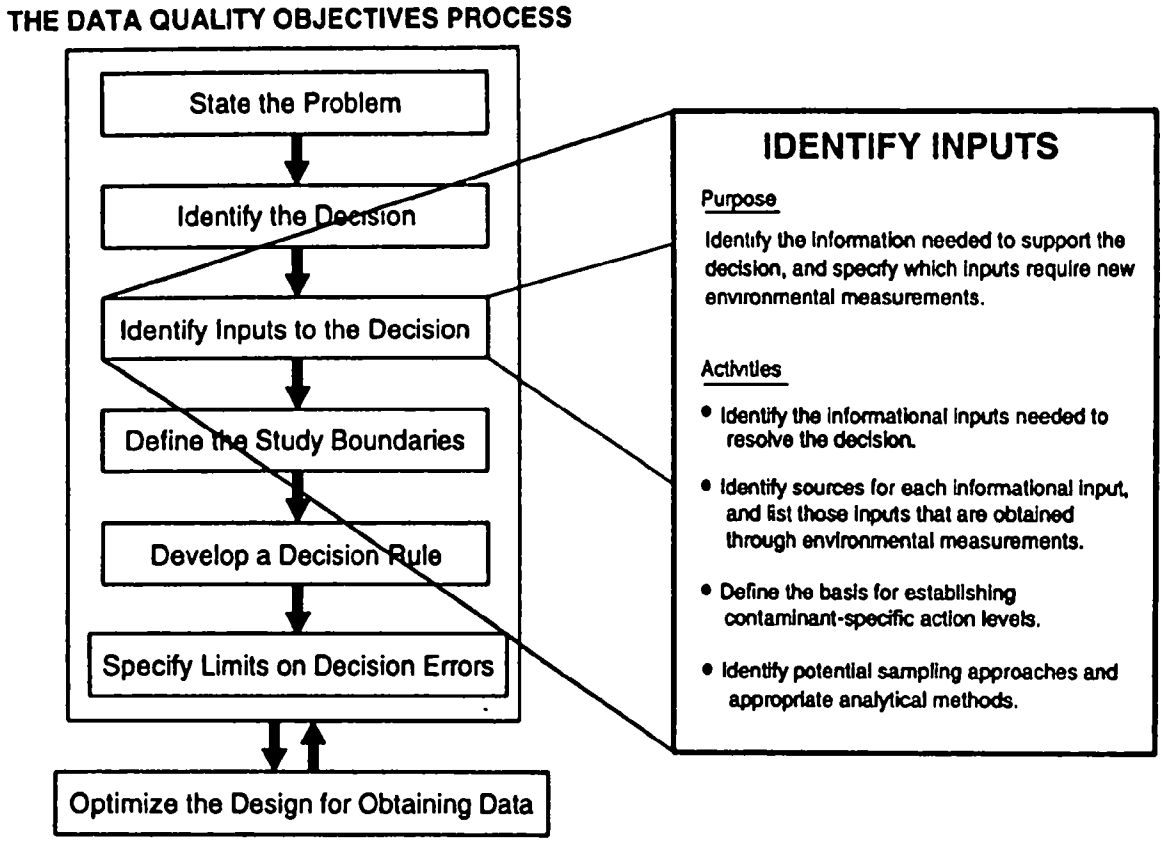
2.3 OUTPUTS

The outputs of this step are:

- a statement of the decision that will use Superfund environmental data; and
- a list of the actions that will be taken toward remediation or removal of the potential contamination problem based on the outcome of the field investigation.

CHAPTER 3

STEP 3: IDENTIFY THE INPUTS TO THE DECISION



3.1 BACKGROUND

The purpose of this step is to:

- identify the informational inputs needed to support the decision; and
- specify which inputs will require new environmental measurements.

The conceptual understanding of the site (i.e., conceptual site model), developed in Step 1: STATE THE PROBLEM, relates sources and retention or transport media to receptors. This conceptual understanding of the contamination problem and the decision statement defined in Step 2: IDENTIFY THE DECISION are previous outputs that are important to consider during this step. The action level, such as an ARAR or preliminary remediation goal(s), is another important input that will be considered during this step.

3.2 ACTIVITIES

The following subsections describe suggested activities that will help identify inputs to the decision.

Identify the Informational Inputs Needed to Resolve the Decision

It is important to determine whether monitoring, modeling, or a combination of these approaches will be used to support the decision. The decision inputs depend on the approach selected. For example, data on soil characteristics and hydrogeology could be useful for calibrating a computer model of contaminant transport and dispersion through ground water. When decisions are supported by modeling, it may be useful to consider the conceptual site model as a frame of reference. The conceptual site model summarizes how the site-related contamination may pose a risk to human health and the environment. Some components of the conceptual site model may be estimated using mathematical equations and assumptions (i.e., modeling), and other compohents will be estimated by directly measuring some characteristic of the site (i.e., monitoring). The conceptual site model concept was discussed in Step 1: STATE THE PROBLEM. Based on the selected approach, list all of the informational inputs needed to support the decision. Diagramming techniques may be used to help organize the list of inputs into categories and show logical or temporal relationships.

Identify Sources for Each Informational Input and List Those Inputs That are Obtained Through Environmental Measurements

Identify existing sources for information that can support the decision. Sources may include historical records, regulations, directives, engineering standards, scientific literature, previous site field investigations, or professional judgement.

Determine the Basis for Establishing Contaminant-Specific Action Level(s)

Determine if ARARs are available for the potential contaminants or if preliminary remediation goals have been developed for the site. If no regulatory threshold or standard can be identified during this step, the decision maker will need to decide how to develop a realistic concentration goal to serve as an action level for the field investigation design and evaluation. These action levels will be used as targets for developing and evaluating the study designs in the last step of the DQO Process.

Identify Potential Sampling Techniques and Appropriate Analytical Methods

Review the decision and associated regulatory objectives identified in Step 2: IDENTIFY THE DECISION. Use the list of contaminants identified earlier in this step and contaminant-specific action levels as a preliminary basis for identifying the most appropriate analytical methods. The decision on analytical methodology will be made in Step 7: OPTIMIZE THE DESIGN when more information about sampling and measurement error is available. Finally, identify potential sampling techniques and associated equipment.

Further discussion of these decision-specific activities is included in Appendix I, Section C.

3.3 OUTPUTS

The outputs that will result from the activities above include a list of informational inputs needed to make the decision and a list of environmental variables or characteristics that will be measured. There is a potential for confusion at this point because the outputs of this step are actually the inputs to the decision.

Example List of Advanced Assessment Decision, Phase I, Inputs

(1) List of Inputs Needed to Support the Decision:

- potential contaminants
  - -- concentrations in space and time
  - -- slope factors or dose/response relationships

- exposure pathways
  - -- media (e.g., soil, surface water, ground water, air, biota, sediments)
  - -- rates of migration (within and between media)
  - -- rates of dispersion/accumulation

- receptors
  - -- types/subpopulations
  - -- ecosystems
  - -- sensitivities
  - -- numbers/densities
  - -- activity levels/patterns

- preliminary remediation goal/ARARs

- site's physical and chemical characteristics that influence technology applicability (e.g., presence of organic components, soil permeability, and depth to impervious formation)

(2) List of Inputs That Require New Environmental Measurements:

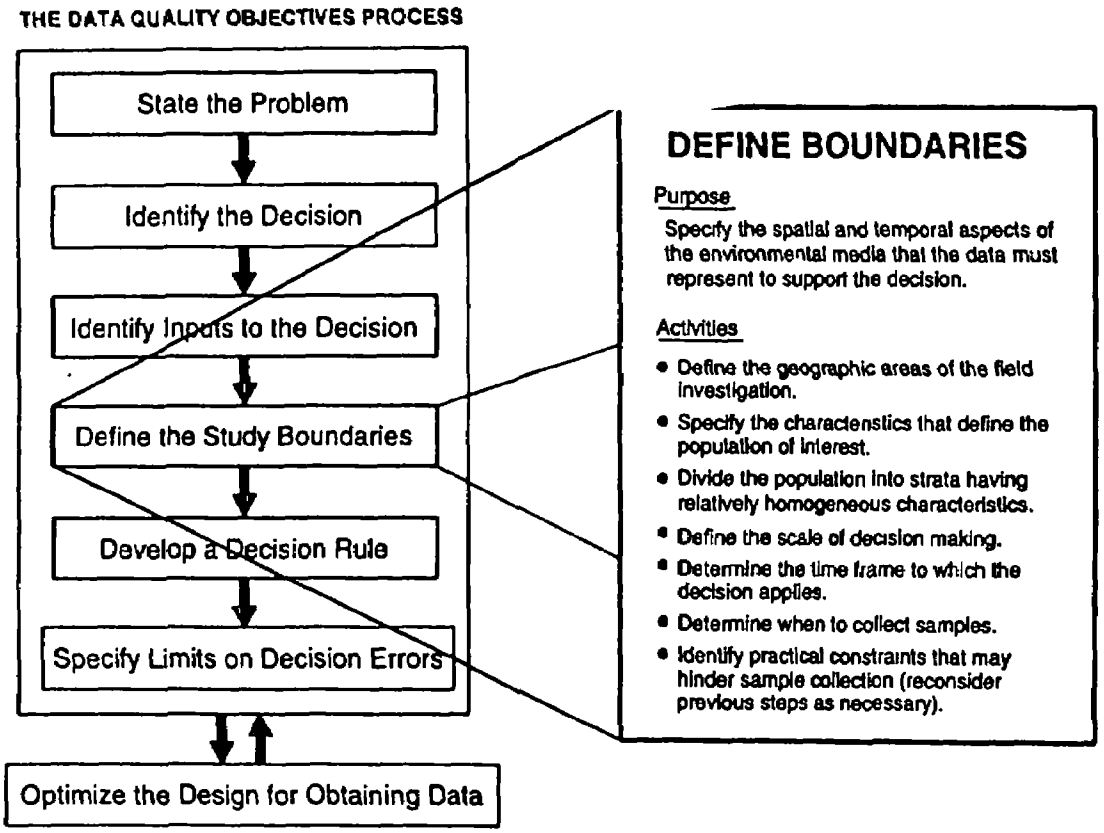
- contaminant concentrations in space and time for each media of concern

- small- and large-scale variability in potential contaminant concentrations

- other measurements related to risk assessment, such as fate and transport model parameters.

CHAPTER 4

STEP 4: DEFINE THE BOUNDARIES OF THE STUDY



4.1 BACKGROUND

The purpose of this step is to define the spatial and temporal boundaries of the study, so as to clarify the domain of what the samples are intended to represent. In addition, Step 4: DEFINE THE BOUNDARIES provides guidance on how to partition a site so as to prevent inappropriately pooling and averaging data in a way that could mask potentially useful information.

In order for samples to be representative of the domain or area for which the decision will be made, the boundaries of the study must be precisely defined. The purpose of this step is to clearly define the set of circumstances (boundaries) that will be covered by the decision. These include:

- Spatial boundaries that define what should be studied and where the samples should be taken; and
- Temporal boundaries that describe when samples should be taken and what time frame the study data should represent.

These boundaries will be used to ensure that the study design incorporates the time periods in which the study should be implemented, areas that should be sampled, and the time period to which the study results should apply. This will help ensure that the study data are representative of the objects or people being studied.

Practical constraints that could interfere with sampling are also identified in this step. A practical constraint is any hinderance or obstacle that may interfere with the full implementation of the study design.

Applicable information from previous DQO steps that will be necessary to develop boundaries includes:

- site contaminant(s) identification;
- potential migration pathways and exposure routes and potential receptors;
- the site's physical and chemical characteristics that enhance or decrease the likelihood of contaminant distribution movement within and among media;
- future use of the site;
- the decision(s) identified in the Step 2: IDENTIFY THE DECISION; and
- the "sampling and analysis action level" or "final remediation/removal action level."

4.2 ACTIVITIES

Define the Spatial Boundary of the Decision.

Figure 4-1 is a representation of this step

(1) *Define the domain or geographic area within which all decisions must apply.* The domain or geographic area is a region distinctively marked by some physical features (i.e., volume, length, width, boundary) to which the decision will apply. Some examples are property boundaries, operable units, and exposure areas.

(2) *Specify the characteristics that define the population of interest.* The "population" is a term that refers to the total collection of objects or people to be studied, and from which the sample is to be drawn For instance, a population may be PCB concentrations in soil at a Superfund site, or blood lead levels in the exposed human population. Clearly define the attributes that make up the population by stating them in a way that makes the focus of the study unambiguous. For example, "the top 12 inches of soil" is less ambiguous than merely "surface soil".

Some of the considerations in defining the media of concern are:

- What medium was originally contaminated?
- What inter-media transfer of cross-contamination is likely to have occurred (i.e., leaching, transport, etc.)?

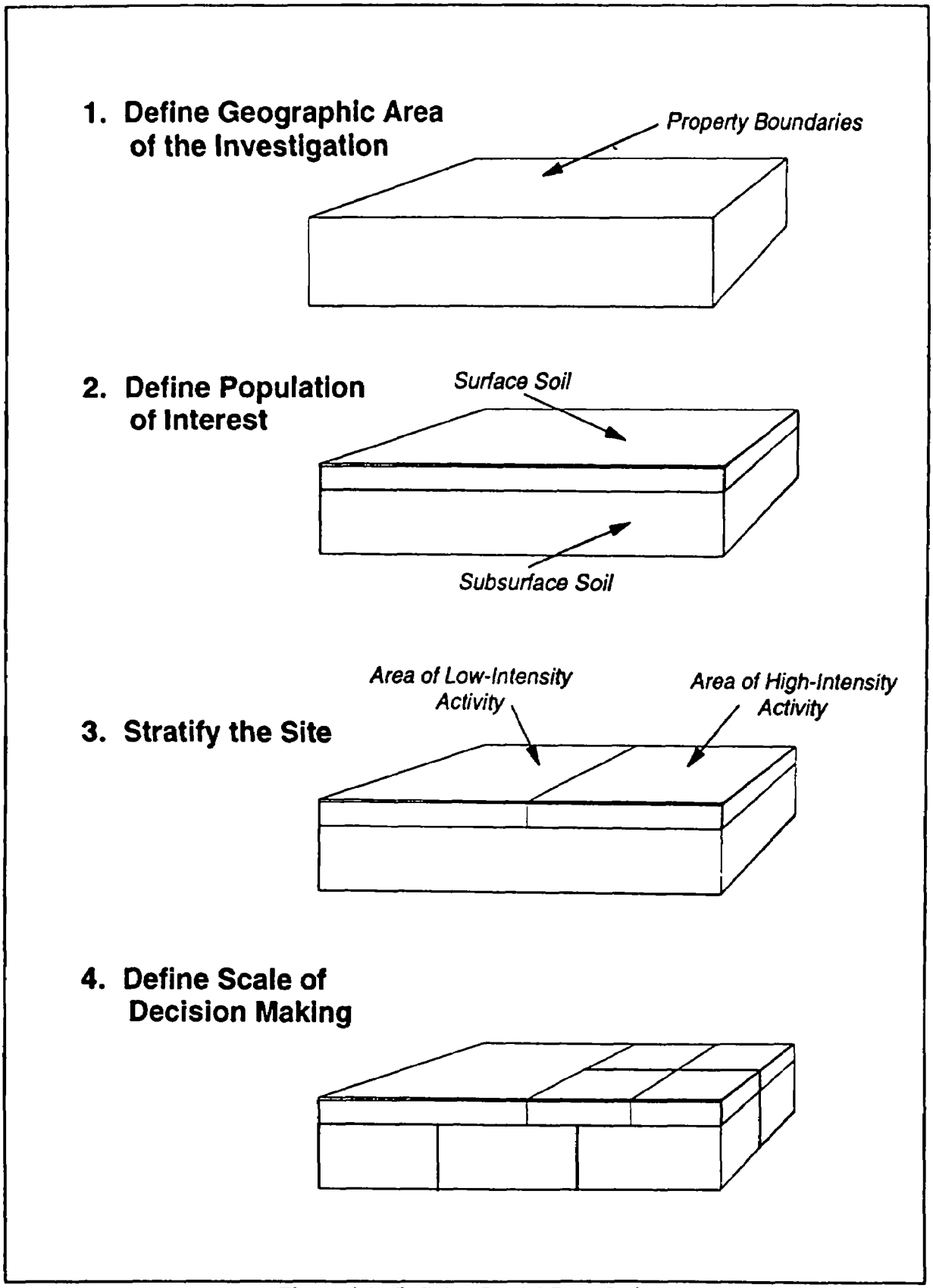


Figure 4-1. Defining Spatial Boundaries.

(3) *When appropriate, divide the population into strata that have relatively homogeneous characteristics.* Using existing information, stratify[1] each medium or set of objects into subsets of categories that exhibit relatively homogeneous properties, such as contaminant concentrations. Stratification is desirable for studying sub-populations or reducing the complexity of the problem by breaking it into more manageable pieces. The decision maker can choose to make separate decisions about each stratum or the entire population.

(4) *Define the scale of decision making.* The scale of decision making is the smallest area, volume, or time frame of the media in which the scoping team wishes to control decision errors. The goal of this activity is to define subsets of media that the scoping team will make decisions about in order to evaluate health and environmental risks and the cleanup goals of the site, and, at the same time, meet the constraints of the DQOs. The size may range from the entire geographic boundaries of the site to the smallest size area that presents an exposure to the receptor. The size of the scale of decision making is generally based on:

(A) *Risk*: Here, the scale of decision making is determined by the relative risk that exposure presents to the receptor (i.e., the size of the scale is correlated with the risks that it poses to the receptor). The scale of decision making that is based on risk is referred to as an "Exposure Unit" (EU). An example of an EU could be a ½-acre potential homestead on a remediated site.

(B) *Technological considerations*: Here, the scale of decision making is based on the most efficient area or volume of medium that can be removed or remediated with the selected technology. These areas or volumes are called Remediation Units (RUs). An example of an RU is the area of topsoil that can be removed by one pass of a bulldozer.

(C) *Other considerations*: Here, the scale of decision making is based on practical factors or a combination of risk and technological factors that dictate a specific size. These factors may include "hot spots" whose size should be based on historical site use.

As an example, consider a study of contaminated soil where the goal is to protect future residents from exposure and where the future land use is residential. The planning team may set the scale of decision making to a 14' by 14' area (EU) if the children derive most of their exposure from an outdoor play area of this size. Consequently, the decision that will be made at the site would be protective of children, a sensitive population in exposure assessment.

Define the Temporal Boundaries of the Decision.

(1) *Determine the time frame to which the study data apply.* It may not be possible to collect data over the full time period to which the decision will apply. Therefore the scoping team must determine the most appropriate time frame that the data should reflect (e.g., the study data will reflect the condition of contaminant leaching into ground water over a period of a hundred years).

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[1]Stratification is used to reduce the variability of contaminant concentrations and therefore reduce the number of samples needed to meet the limits of decision error that will be defined in Chapter 7. Decisions are generally made about an area the size of the stratum or smaller.

(2) *Determine when to collect samples.* Conditions may vary over the course of a study due to weather or other factors. Moreover, the study decision may be influenced by the seasons. For example, a study to measure exposure to volatile organic compounds from a contaminated site may give misleading information if the sampling is conducted in the colder winter months rather than the warmer summer months. Therefore the scoping team must determine the most appropriate time period to collect data that will reflect the conditions that are of interest.

Identify any Practical Constraints on Data Collection.

These constraints include seasonal or meteorological conditions when sampling is not possible and the unavailability of personnel, time, or equipment. For example, it could occur that surface soil samples could not be taken beyond the east boundaries of a site under investigation because access to that area had not been granted by the owner of the adjacent property.

Further discussion of the scale of decision making, including examples, is included in Appendix I, Section D.

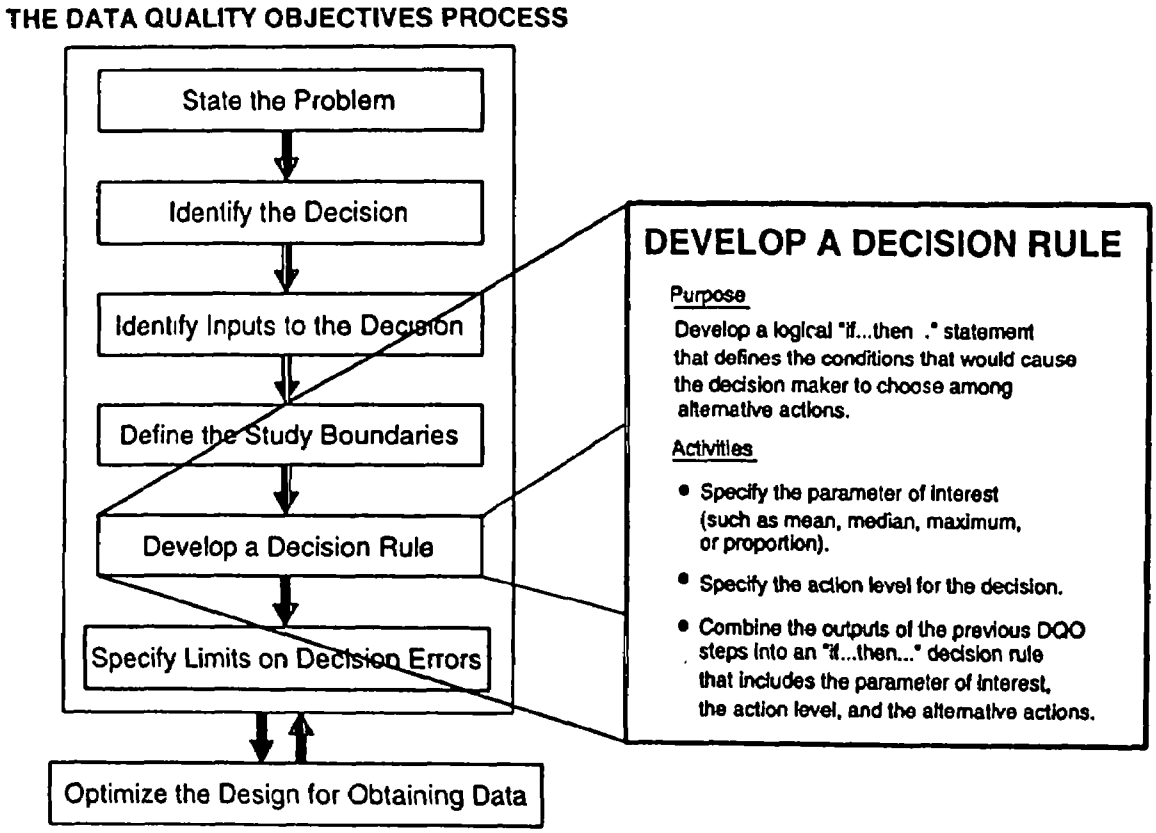
4.3 OUTPUTS

The outputs of this step are:

- a detailed description and physical representation (map) of the geographic limits (boundaries) of each environmental medium (soil, water, air, etc.) within which the decision(s) will be made;
- a detailed description of the characteristics that define the population of interest;
- definition of the time period in which samples will be taken and to which decisions will apply;
- the most appropriate scale of decision making for each medium of concern; and
- description of practical constraints that may impede sampling.

CHAPTER 5

STEP 5: DEVELOP A DECISION RULE



5.1 BACKGROUND

The purpose of this step is to integrate the output from the previous steps of the DQO Process into a statement that defines the conditions that would cause the decision maker to choose among alternative actions. The outputs from earlier steps include the actions and the decision from Step 2: IDENTIFY THE DECISION, the action level from Step 3: IDENTIFY THE INPUTS TO THE DECISION, and the scale of decision making from Step 4: DEFINE THE STUDY BOUNDARIES.

5.2 ACTIVITIES

Specify the Statistical Parameter that Characterizes the Population of Interest

The statistical parameter of interest is a descriptive measure (such as a mean, median, proportion, or maximum) that specifies the characteristic or attribute that the decision maker would like to know about the statistical population. Review the study objectives to determine if a particular statistical parameter is implied or stated. Consult other members of the planning team, such as a risk

assessor or person with statistical training, to determine the most appropriate statistical parameter for the problem.

Appendix I, Section E, contains additional information on choosing a population parameter.

Specify the Action Level (Final Remediation Level or Removal Action Level) for the Decision

The action level is the contaminant concentration which, if exceeded, would indicate that action should be taken at the site (the action prescribed in Step 2: IDENTIFY THE DECISION).[1]

If the decision maker believes that the final remediation level could be one of two different levels, then the more stringent one should be chosen for the action level. A more stringent action level will require analytical methods (detection limits) that would satisfy the less stringent action level as well. If multiple contaminants are of concern and ARARs are not available or not sufficiently protective, risk-based PRGs need to be developed. Refer to the *Risk Assessment Guidance for Superfund, Volume I-Human Health Evaluation Manual, Part B, Development of Preliminary Remediation Goals.*

Combine the Outputs from the Previous DQO Steps and Develop a Decision Rule

Recall the actions specified in Step 2: IDENTIFY THE DECISION. Combine the actions, sampling and analysis action level, and the parameter of interest (including the scale of decision making) in a statement that describes the conditions that would lead to a specific course of action. An example of a decision rule for a Superfund site is, "If the mean PCE concentration of each downgradient well is greater than the upgradient well, then further assessment and response is required; otherwise recommend SEA."

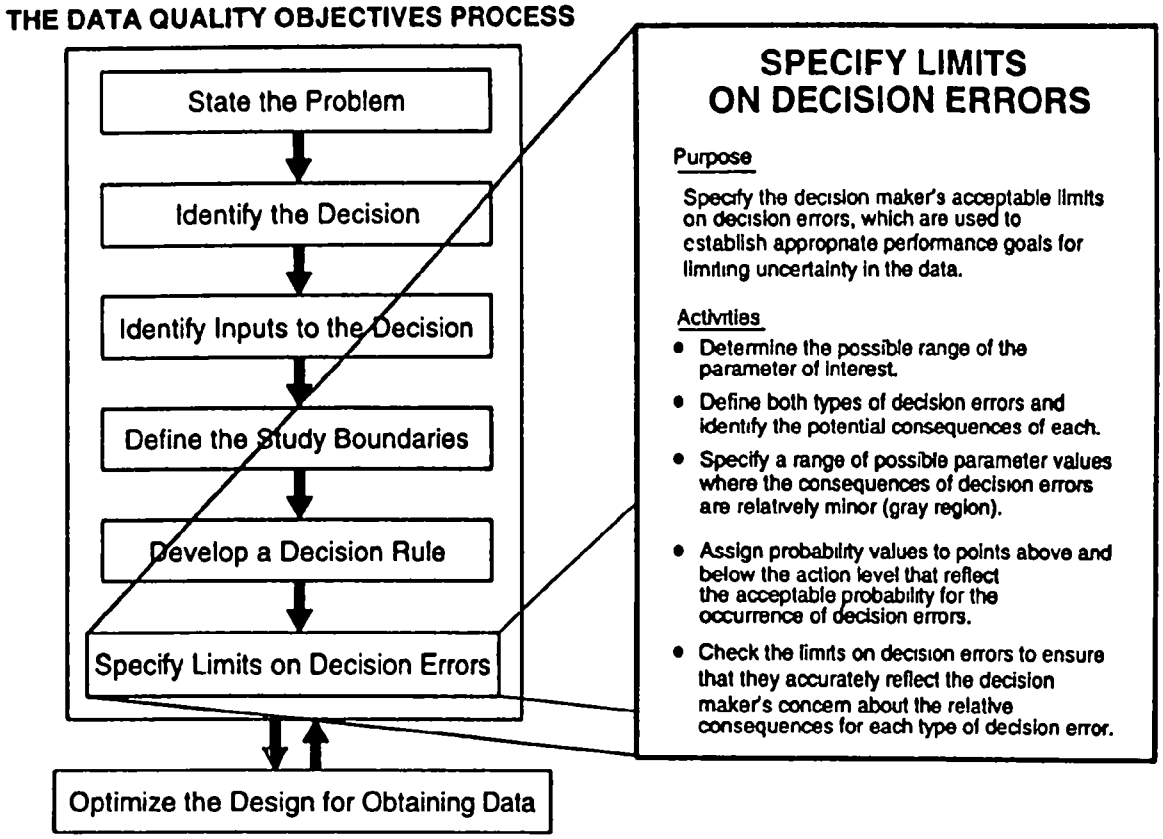
5.3 OUTPUTS

The output for this step is an "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative courses of action. It should include the decision, the actions, the parameter of interest, the action level, and the scale of decision making. For example, if the mean concentration of contaminants in sediments within the stream reach the ecological screening level(s), then recommend that the site warrants consideration of further assessment on a response action.

[1]This action level is not the final remediation level. The final remediation level is not determined until the ROD Rather, this action level is an assumption made during planning based on the decision maker's expectation of the final remediation level. The action level is only an assumption, and does not bind the decision maker to a specific value for the final remediation level

CHAPTER 6

STEP 6: SPECIFY LIMITS ON DECISION ERRORS



6.1 BACKGROUND

The purpose of this step is to specify the site manager's acceptable decision error rates based on a consideration of the consequences of making an incorrect decision. These limits will be used in Step 7: OPTIMIZE THE DESIGN to generate the most resource-effective sampling design.

Site managers are interested in knowing the true state of some feature of a site. Since measurement data can only estimate this state, however, decisions that are based on measurement data could be in error (decision error). Therefore, the goal of the scoping team is to design a sampling plan that limits the chance of making a decision error to an acceptable level. This step of the DQO Process will help the site manager define what constitutes acceptable limits on the probability of making a decision error.

There are two reasons why the site manager cannot know the true value of a population parameter:

(1) The population of interest almost always varies over time and space. Limited sampling will miss some features of this natural variation because it is usually impossible or impractical to measure every point of a population or to measure over all time frames. Sampling error

occurs when sampling is unable to capture the complete scope of natural variability that exists in the true state of the environment.

(2) A combination of random and systematic errors inevitably arises during the various steps of the measurement process, such as sample collection, sample handling, sample preparation, sample analysis, data reduction, and data handling. These errors are called measurement errors because they are introduced during measurement process activities.

The combination of sampling error and measurement error is called total study error, which is directly related to decision error.

The probability of making decision errors can be controlled by adopting a scientific approach. The scientific method employs a system of decision making that controls decision errors through the use of hypothesis testing. In hypothesis testing, the data are used to select between one condition of the environment (the baseline condition or null hypothesis, H_o) and the alternative condition (the alternative hypothesis, H_a). For example, the site manager may decide that a site is contaminated (the baseline condition) in the absence of strong evidence (study data) that indicates that the site is clean (alternative hypothesis). Hypothesis testing places the greater weight of evidence on disproving the null hypothesis or baseline condition. Therefore, the site manager can guard against making the decision error that has the greatest undesirable consequence by setting the null hypothesis equal to the condition that, if true, has the greatest consequence of decision error.

A decision error occurs when the measurement data lead the site manager to reject the null hypothesis when it is true, or to fail to reject the null hypothesis when it is false. These two types of decision errors are classified as false positive errors and false negative errors, respectively.

False Positive Error — A false positive error occurs when sampling data mislead the site manager into believing that the burden of proof has been satisfied and that the null hypothesis (H_o or baseline condition) should be rejected. Consider an example where the site manager presumes that concentrations of contaminants of concern exceed the action level (i.e., the baseline condition or null hypothesis is: concentrations of contaminants of concern exceed the action level). If the sampling data lead the site manager to incorrectly conclude that the concentrations of contaminants of concern do not exceed the action level when they actually do exceed the action level, then the site manager would be making a false positive error. A statistician usually refers to the false positive error as alpha (α), the level of significance, the size of the critical region, or a Type I error.

False Negative Error — A false negative error occurs when the data mislead the site manager into wrongly concluding that the burden of proof has not been satisfied so that the null hypothesis (H_o) is not rejected when it should be. A false negative error in the previous example occurs when the data lead the site manager to wrongly conclude that the site is contaminated when it truly is not. A statistician usually refers to a false negative error as beta (β), or a Type II error. It is also known as the complement of the power of a test.

While the possibility of making decision errors can never be totally eliminated, it can be reduced. To reduce decision errors, the scoping team must develop an acceptable estimate of the population parameter. This can be accomplished by collecting a large number of samples (to reduce sampling error) and by analyzing individual samples several times using more precise laboratory methods (to reduce measurement error). Better sampling designs can also be developed to collect data that more accurately and efficiently represent the population of interest. Reducing decision errors, however, generally increases costs. In some cases, reducing decision errors is unnecessary for making

a reasonable decision. For instance, if the consequences of decision errors are minor, a reasonable decision could be made based on relatively crude data. Similarly, if the consequences of decision errors are severe, the site manager will want to develop a sampling design that eliminates as much sampling and measurement error as possible (within budget constraints).

A site manager must balance the desire to limit decision errors to acceptable levels with the cost of reducing decision errors. To find the best balance and thereby efficiently determine whether to reduce sampling and/or measurement error, the site manager must define acceptable probabilities of decision errors. Once the acceptable probabilities of decision errors are defined, then the effort necessary to reduce sampling and measurement errors to meet these limits can be quantified in Step 7: OPTIMIZE THE DESIGN. It may be necessary to iterate between Step 6 and Step 7 more than once before an acceptable balance between limits on decision errors and the cost of a sampling design can be achieved.

6.2 ACTIVITIES

The combined information from the activities section of this chapter can be graphically displayed onto a "Design Performance Goal Diagram" (Figures 6-1 and 6-2), or charted in a "Decision Error Limits Table" (Tables 6-1 and 6-2). The activities section will refer to these figures and tables to help the reader understand the relationships between the activities and the outputs of this step.

Determine the possible range of the parameter of interest.

Establish the possible range of the parameter of interest by estimating its upper and lower bounds. This means defining the lowest (typically zero in environmental studies) and highest concentrations at which the contaminant(s) is expected to exist at the site. This will help focus the remaining activities of this step on only the relevant values of the parameter. Use historical data, including analytical data, if available. For example, the range of the parameter shown in Figures 6-1 and 6-2 and Tables 6-1 and 6-2 is between 0 and 210 ppm. Note that when interpreting the Design Performance Goal Diagram, the concentration values on the horizontal axis represent the <u>true</u> concentration of the parameter of interest.

Define both types of decision errors and identify the potential consequences of each.

Using the action level specified in Step 5: DEVELOP A DECISION RULE, designate the areas above and below the action level as the range where the two types of decision errors could occur. The process of defining the decision errors has four steps:

(1) *Define both types of decision errors and establish which decision error has more severe consequences near the action level.* For instance, the threat of health effects from a contaminated hazardous waste site may be considered more serious than spending extra resources to remediate the site. Therefore, a site manager may judge that the consequences of incorrectly concluding that the concentrations of site-related contaminants do not exceed the action level are more severe than the consequences of incorrectly concluding that the concentrations of site-related contaminants exceed the action level.

(2) *Establish the true state of nature for each decision error.* In the example above, from the site manager's perspective, the true state of the site for the more severe decision error will be that the concentrations of site-related contaminants exceed the action level. The true state of nature for the less severe decision error is that the concentrations of site-related contaminants do not exceed the action level.

(3) *Define the true state of nature for the more severe decision error as the baseline condition or null hypothesis* (H_0= the site is contaminated), *and define the true state of nature for the less severe decision error as the alternative hypothesis* (H_a= the site is not contaminated). Since the burden of proof rests on the alternative hypothesis, the data must demonstrate enough information to authoritatively reject the null hypothesis and conclude the alternative. Therefore by setting the null hypothesis equal to the true state of nature that exists when the more severe decision error occurs, the site manager is guarding against making the more severe decision error.

(4) *Assign the terms "false positive" and "false negative" to the proper decision errors.* A false positive decision error corresponds to the more severe decision error and a false negative decision error corresponds to the less severe decision error. The definition of false positive and false negative errors depends on the viewpoint of the decision maker and the actions that are taken. Consider the viewpoint where a person has been presumed to be "innocent until proven guilty" (i.e., H_0 is: innocent, H_a is: guilty). A false positive error would be convicting an innocent person; a false negative error would be not convicting the guilty person. From a decision maker's viewpoint the errors are reversed when a person is presumed to be "guilty until proven innocent" (i.e., H_0 is: guilty, H_a is: innocent). Here, the false positive error would be not convicting the guilty person and the false negative error would be convicting the innocent person.

Define and evaluate the potential consequences of decision errors at several points within the false positive and false negative ranges. For example, the consequences of a false positive decision error when the true parameter value is merely 10% above the action level may be minimal because it would cause only a moderate increase in the risk to human health. On the other hand, the consequences of a false positive error when the true parameter is ten times the action level may be severe because it could greatly increase the exposure risk to humans as well as cause severe damage to a local ecosystem. In this case, site managers would want to have less control (tolerate higher probabilities) of decision errors of relatively small magnitudes and would want to have more control (tolerate small probabilities) of decision errors of relatively large magnitudes.

The action level has been set at 100 ppm in Figures 6-1 and 6-2. (Note that the action level is represented by a vertical dashed line at 100 ppm.) Figure 6-1 shows the case where a site manager considers the more severe decision errors to occur above the action level. Figure 6-2 shows the case where the site manager considers the more severe decision error to occur below the action level. The hypothesis test for the second case is the reverse of the first case, so the false positive and false negative errors are on opposite sides of the action level. This chapter will focus on Figure 6-1 for illustrative purposes.

Specify a range of possible parameter values where the consequences of decision errors are relatively minor (gray region).

The gray region is a range of points (bounded on one side by the action level) where the consequences of a false negative decision error are relatively minor. Establish the general location of the gray region by evaluating the consequences of wrongly concluding that the baseline condition (the null hypothesis) is true.

The gray region establishes the minimum distance from the action level to which the site manager would like to control decision errors. In statistics, this distance is called delta (δ), and is an essential part of the calculations needed to determine the number of samples that need to be collected. The width of the gray region reflects the site manager's concern for decision errors. A more narrow gray region implies a desire to conclusively detect the condition when the true parameter value is close to the action level. When the sample estimate of the parameter falls within the gray region, the site manager may have a high probability of making a decision error (i.e., the data may be "too close to call"), and may wrongly conclude that the baseline condition is true.

The gray region is an area where it will not be feasible or reasonable to control the false negative decision error rate to low levels because the resources that would be required would exceed the expected costs of the consequences of making that decision error. In order to determine with confidence whether the true value of the parameter is above or below the action level (depending on the more severe decision error), the site manager would need to collect a large amount of data, increase the precision of the measurements, or both. If taken to an extreme, the cost of collecting data can exceed the cost of making a decision error, especially where the consequences of the decision error may be relatively minor. Therefore, the site manager should establish the gray region by balancing the resources needed to "make a close call" versus the consequences of making that decision error.

In Figure 6-1, the gray region has been set below the action level in the area where the site manager has determined that the decision errors have the least consequence. The width of the gray region indicates that the site manager does not wish to control decision errors when the true concentration at the site is between 80 and 100 ppm.

Assign probability values to points above and below the action level that reflect the acceptable probability for the occurrence of decision errors.

Assign probability values to points above and below the action level that reflect the site manager's acceptable limits for making an incorrect decision. The most stringent limits on decision errors that are typically encountered for environmental data are .01 (1%) for both the false positive and false negative decision errors (α and β). This guidance recommends using .01 as the starting point for setting decision error rates.[1] The most frequent reasons for setting limits greater than .01 are that the consequences of the decision errors may not be severe enough to warrant setting decision error rates that are this stringent. If the decision is made to relax the decision error rates from 01 for false positive and false negative decision errors, the scoping team should document the rationale for setting the decision error rate. This rationale may include potential impacts on cost, human health, and ecological conditions.

[1] The value of 01 should not be considered a prescriptive value for setting decision error rates, nor should it be considered as the policy of EPA to encourage the use of any particular decision error rate.

Repeat this activity for both sides of the gray region. Generally, the acceptable limits for making a decision error should decrease as the consequences of a decision error become more severe further away from the action level.

Figure 6-1 shows that from the action level to a true value of 150 ppm for the parameter of interest, the site manager will tolerate a 5% chance of deciding that the true value is below the action level, based on field investigation data. If the true value is greater than 150 ppm, the site manager will tolerate only a 1% chance of deciding the true value is really below the action level. Below the action level, from 60-80 ppm the site manager will tolerate deciding the true value is above the action level 10% of the time, and between 40-60 ppm the site manager will allow a false negative decision error rate of 5%.

Check the limits on decision errors to ensure that they accurately reflect the site manager's concerns about the relative consequences for each type of decision error.

The acceptable limits on decision errors should be smallest (i.e., have the lowest probability of error) for cases where the site manager has greatest concern for decision errors. This means that if one type of error is more serious than another, then its acceptable limits should be smaller (more restrictive). In addition, the limits on decision errors are usually largest (high probability of error can be tolerated) near the action level, since the consequences of decision errors are generally less severe as the action level is approached. Verify that the site manager's acceptable limits on decision errors are consistent with these principles.

The Design Performance Goal Diagram (which is sometimes called a "Decision Performance Curve") can be refined by breaking the "steps" of decision errors into smaller units. This would have the effect of adding rows of information to its corresponding Decision Error Limits Table. The information from the diagram will be used in the final step of the DQO Process (Step 7: OPTIMIZE THE DESIGN) in order to construct a statistically based evaluation of how well the sampling design will meet the DQOs. This evaluation involves the construction of a power curve, which is a graphical description of a sampling design's expected performance. If the power curve lies within the acceptable regions of the Design Performance Goal Diagram, then the corresponding sampling design satisfies the site manager's acceptable limits on decision errors.

Appendix I, Section F, contains additional information on specifying limits on decision errors.

6.3 OUTPUTS

The outputs from this step are the site manager's acceptable decision error rates based on a consideration of the consequences of making an incorrect decision. These limits on decision errors can be expressed in a Decision Error Limits Table or in a Design Performance Goal Diagram.

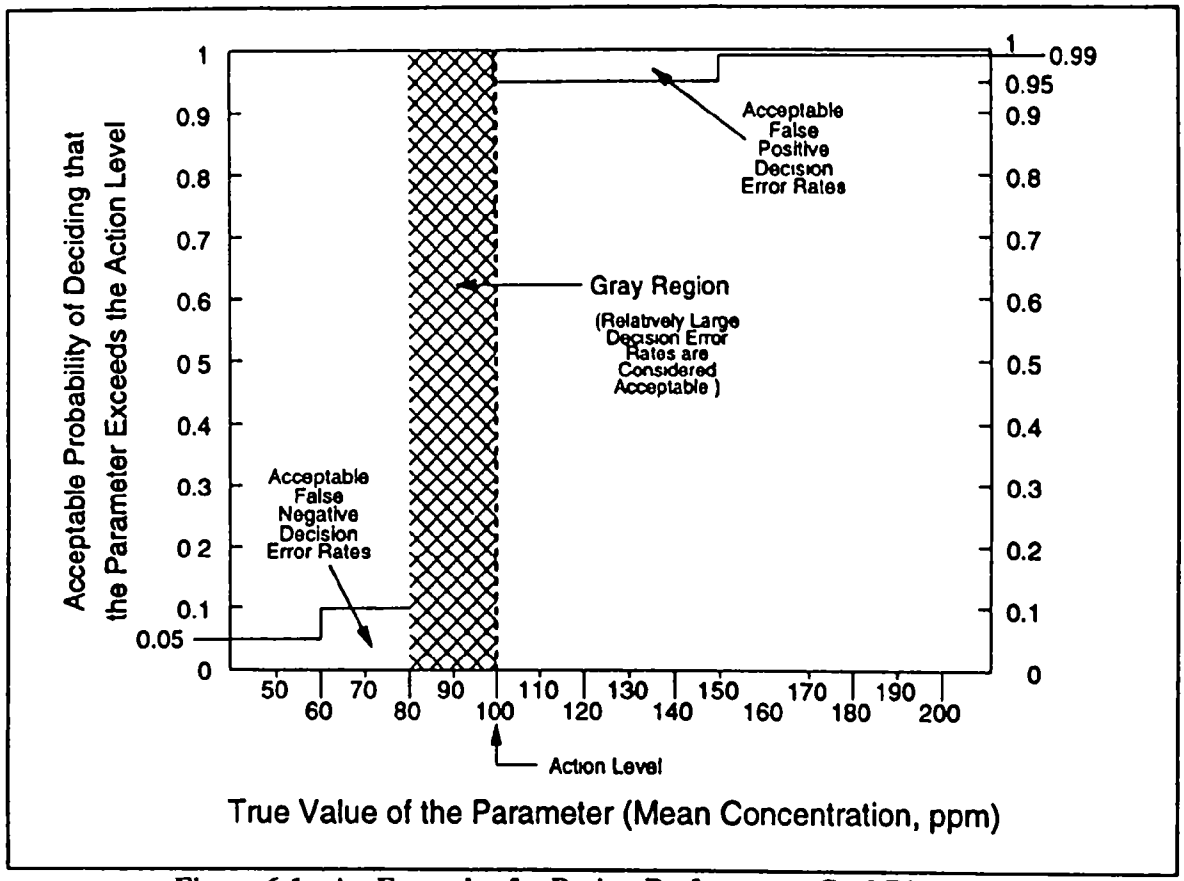


Figure 6-1. An Example of a Design Performance Goal Diagram (Baseline condition: parameter exceeds action level)

True concentration	Correct decision	Acceptable probability of making an incorrect decision (a decision error)
50 to 60 ppm	does not exceed action level	5%
60 to 80	"	10%
80 to 100	"	gray region—no probability specified
100 to 150	exceeds action level	5%
150 to 200	"	1%

Table 6-1. Decision Error Limits Table Corresponding to Figure 6-1

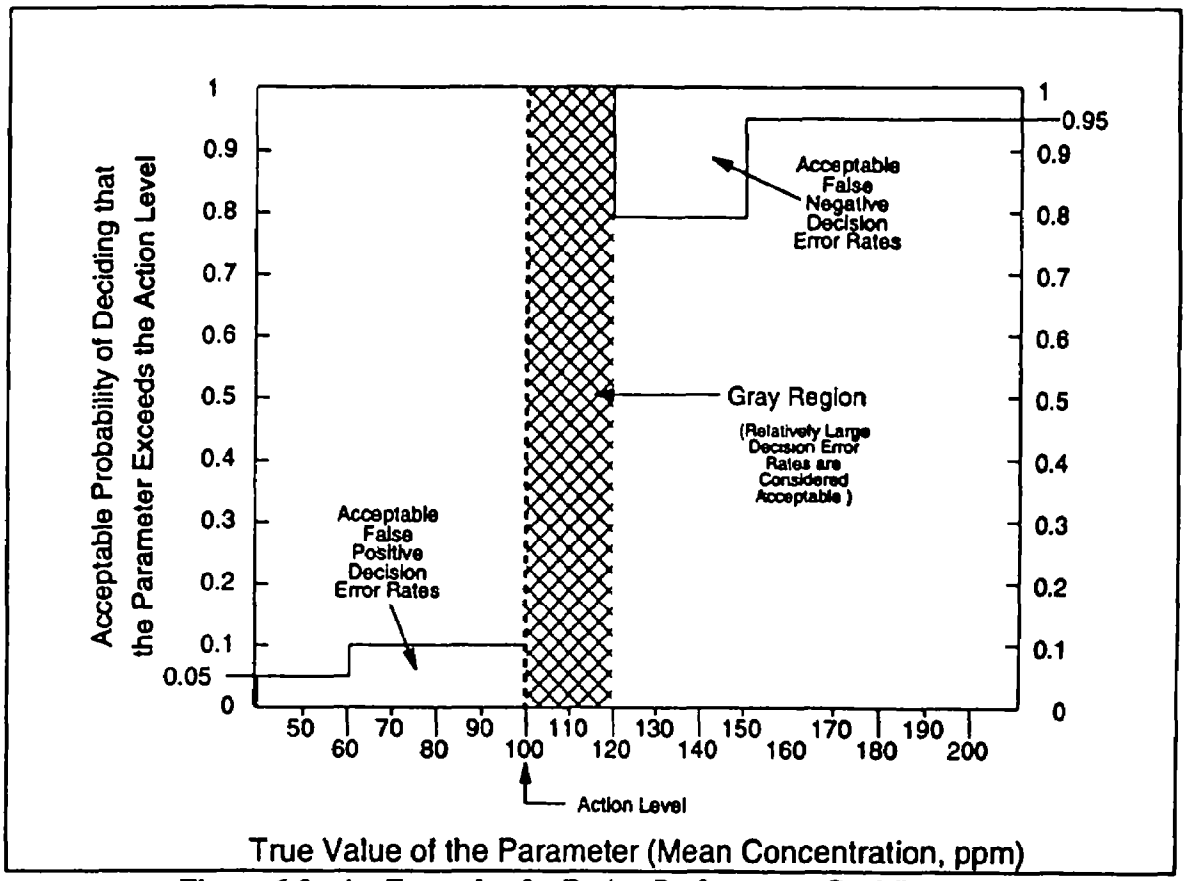


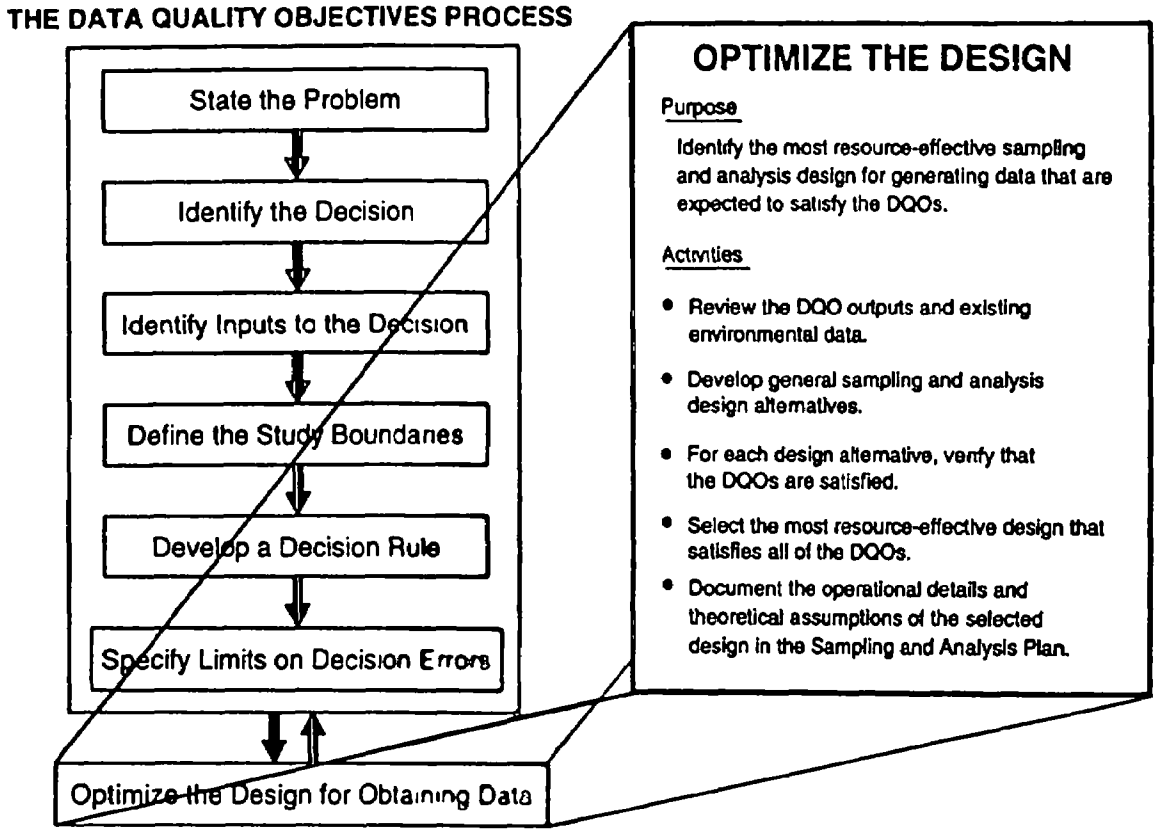
Figure 6-2. An Example of a Design Performance Goal Diagram (Baseline condition: parameter less than action level)

True concentration	Correct decision	Acceptable probability of making an incorrect decision (a decision error)
50 to 60 ppm	does not exceed action level	5%
60 to 100	"	10%
100 to 120	"	gray region—no probability specified
120 to 150	exceeds action level	20%
150 to 200	"	5%

Table 6-2. Decision Error Limits Table Corresponding to Figure 6-2

CHAPTER 7

STEP 7: OPTIMIZE THE DESIGN



7.1 BACKGROUND

The purpose of this step is to identify the most resource-effective sampling design that generates data which satisfy the DQOs specified in the preceding steps. To develop the optimal design for this study, it may be necessary to work through this step more than once after revisiting previous steps of the DQO Process.

This step provides a general description of the activities necessary to generate and select sampling designs that satisfy the DQOs. In addition, it contains information about how the outputs from the previous six steps of the DQO Process are used in developing a statistical design. Appendix I, Section G, discusses the basic principles of developing a statistical design and some basic design options. This document, however, does not give detailed guidance on the mathematical procedures involved in developing a statistical sampling design; for this type of guidance, see the references cited in Appendix I, Section G, or consult with a statistician. Site managers also may want to use EPA's DQO Decision Error Feasibility Trials software,[1] which provides a first-pass rough estimate of sample

[1] U.S. EPA. 1993 *Data Quality Objectives Decision Error Feasibility Trials Software for Personal Computers.*

sizes required to satisfy the DQOs. This user-friendly PC software can help speed up the first iteration through the DQO process.

For most field investigations, a probabilistic sampling approach is necessary for extrapolating results from a set of samples to the entire site. By combining an efficient probabilistic sampling design with a statistical hypothesis test, the decision maker will be able to optimize resources such as funding, personnel, and temporal constraints while still meeting the DQOs. The hypothesis test used in analyzing the data is an extremely important part of the statistical design, since it provides the theoretical underpinnings for selecting the number, type, location, and timing of environmental samples. While it may be true that the hypothesis test may be refined or changed later in the light of what is discovered when collecting and examining the data, it is essential to have a plan for the statistical analysis of the data *before* collecting samples so that the data are more likely to support the ultimate decision.

For some field investigations, a non-probabilistic (judgmental) sampling approach is acceptable. A judgmental sampling design consists of directed samples where the decision maker (or technical expert) selects the specific sampling locations.[2] Typically this occurs when the site manager wants to confirm the existence of contamination at specific locations, based on visual or historical information. However, when non-probabilistic sampling approaches are used, quantitative statements about data quality are limited to the measurement error component of total study error. If the site manager wishes to draw conclusions about areas of the site beyond the exact locations where samples were taken, then a probabilistic approach should be used. This will allow the site manager to make quantitative statement about the sampling error component of total study error, and thus determine the probability of making a decision error regarding larger areas of the site.

Even if a judgmental sampling design is chosen, it is important to implement all applicable activities of this step. This will ensure that the qualitative data quality objectives, such as budget, schedule, and the temporal and spatial constraints (boundaries) are met. In addition, this step will help the scoping team document:

1. the reasons for selecting a non-probabilistic sampling approach;
2. the reasons for selecting specific sampling locations; and
3. the expected performance of the sampling design with respect to the qualitative DQOs.

7.2 ACTIVITIES

Review the DQO Outputs and Existing Environmental Data

The outputs from the previous steps of the DQO Process provide a succinct collection of information that is used to develop the sampling design in the following way:

- The limits on decision errors provide crucial information for selecting the number of samples to be collected, the number of analyses per sample, and the hypotheses to be tested.

[2]Grid samples or transect samples contain an element of randomization because the initial sampling point is chosen randomly. Therefore they are considered probabilistic designs, not judgmental.

- The inputs, boundaries, and decision rule are used in deciding the location and timing of samples.

Therefore, the scoping team should review the previous DQO outputs and confirm the budget for sampling and analysis, and the project schedule (especially deadlines). List any logistical or administrative limitations, such as weather, equipment, and personnel availability identified in Step 4: DEFINE THE BOUNDARIES. Site characteristics, previous sample locations, quality control data, and audit reports from earlier field investigations also provide valuable information to the sampling design team (or statistician).

For probabilistic sampling designs, additional information will be needed regarding the expected variability of contaminants. Consequently, any existing environmental data from the site (or from similar sites) should be reviewed. Information about existing environmental data may have been identified during Step 1: STATE THE PROBLEM and Step 3: IDENTIFY THE INPUTS. If no existing data are available, it may be necessary to conduct a limited field investigation to develop an adequate estimate of variability.

Develop General Sampling and Analysis Design Alternatives

The sampling design team will develop alternative sampling and analysis designs that could generate data needed to test the hypothesis. To generate alternative designs, the statistician may vary several different aspects of the design, such as the number and locations of samples collected in the field, the types of samples collected, or the number of replicate analyses performed on samples.

For each sampling design, a statistical model should then be developed that describes the relationship of the measured value to the "true" value. This mathematical formulation clarifies how data generated from a design is to be interpreted and processed in testing the hypothesis. A tentative analytic form for analyzing the resulting data (for example, a student's t-test or a tolerance interval) should also be specified. Use this information to solve for the minimum sample size that satisfies the decision maker's limits on decision errors. If the design involves multiple subsample sizes (e.g., for stratification schemes), then select the optimal mix of subsample sizes.

It is important not to rule out any alternative analytical or field sampling methods due to preconceptions about whether or not the method is "good enough." It must be remembered that the objectives of the statistical design are to limit the *total* error, which is a combination of sampling and measurement error, to acceptable levels. Traditional laboratory methods tend to minimize measurement error, but they can be so expensive that only a limited number of samples can be analyzed within the budget. There often may be advantages to using less precise methods that are relatively inexpensive, thereby allowing a significantly larger number of samples to be taken. Such a design would trade off an increase in measurement error for a decrease in sampling error. Given the large amount of natural variability in many environmental studies, this approach may reduce overall costs while limiting the total decision error rates to acceptable levels just as well as a design based on traditional laboratory methods.

For Each Design Alternative, Verify that the DQOs are Satisfied

Verify that each design alternative satisfies all of the DQOs, including limits on decision errors, budget, schedule, and practical constraints. If none of the designs satisfy the DQOs, the scoping team may need to:

- increase the acceptable decision errors rates;
- increase the width of the gray region;
- relax other project constraints, such as available personnel;
- increase funding for sampling and analysis; or
- change the boundaries; it may be possible to reduce sampling and analysis costs by changing or eliminating subgroups that will require separate decisions.

Select the Most Resource-Effective Design that Satisfies All of the DQOs

The design team should perform a sensitivity analysis on the alternative designs to see how each design performs when the assumptions are changed, together with the impact on costs and resources. Typically, this means changing certain parameters within some reasonable range, and seeing how each of these changes influences the expected decision error rates. For example, if the contaminant variability is higher or lower than assumed for the design, what happens to the design performance? Or, if the final remedial level is more/less stringent than the assumed action level, what happens to the design performance? A Statistical Power Curve is a useful statistical tool used to evaluate whether a sampling design has the ability to meet the DQOs.[3] An example of a Power Curve is shown in Figure 7-1.

Evaluate the design options based on cost and ability to meet the DQO constraints and select the most resource-effective design among the alternatives. The "most resource-effective" may be the lowest cost alternative that meets the DQOs, or it may be a relatively low-cost design that still performs well when the design assumptions change.

Document the Operational Details and Theoretical Assumptions of the Selected Design in the Sampling and Analysis Plan

Once the final design has been selected, it is important to ensure that the design is properly documented. This will improve efficiency and effectiveness of later stages of the data collection and analysis process, such as the development of field sampling procedures, quality control procedures, and statistical procedures for analysis of the data. The key to successful design documentation is in drawing the link between the statistical assumptions on which the design is based and the practical activities that ensure that these assumptions generally hold true.

The operational requirements for implementing the sampling design are documented in the Field Sampling Plan and the Quality Assurance Project Plan, both of which are included in the Sampling and Analysis Plan. Design elements that must be documented include:

- sample types (e.g., composite vs. grab samples);

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[3]A Power Curve provides a graphical depiction of the sensitivity of a design, the steeper the curve, the more sensitive the design will be in detecting conditions when the baseline (null) hypothesis should be rejected.

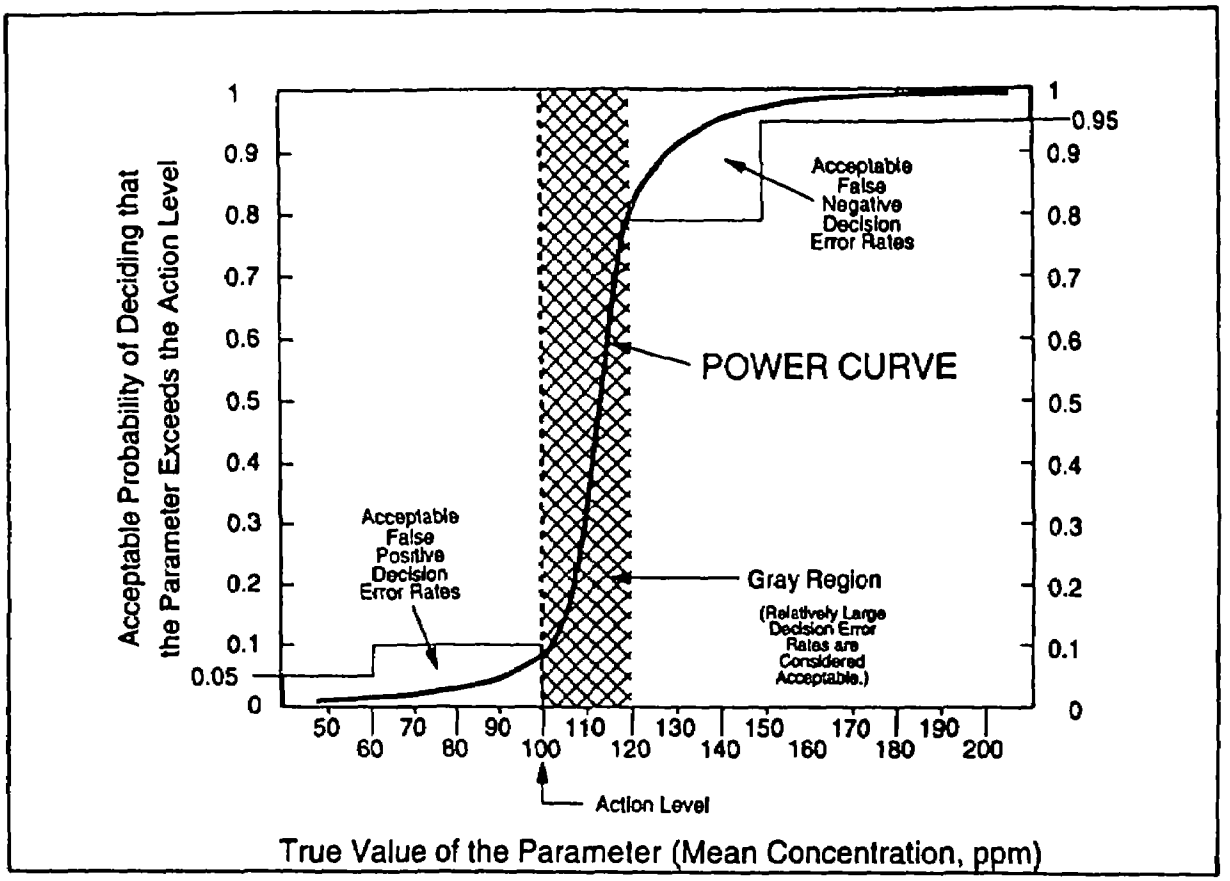

Figure 7-1. An Example of a Power Curve

- general collection techniques (e g , split spoon vs. core drill, or activated charcoal media vs. evacuated canister);
- sample support (i.e., the amount of material to be collected for each sample);
- sample locations (surface coordinates and depth) and how the locations were selected;
- timing issues for sample collection, handling, and analysis;
- analytical methods (or performance standards); and
- quality assurance and quality control needs.

For probabilistic sampling designs, the statistical model and assumptions must also be documented. This item is often omitted, yet it can be one of the most important aspects of the design documentation. If the theoretical basis for the design is documented, then the project team has a basis for handling unexpected problems that inevitably arise in the field. This will help maintain the overall validity of the study in the face of unavoidable deviations from the original design.

7.3 OUTPUTS

The outputs for this step include the optimal (most resource-effective) sampling design for the field investigation, along with documentation of the key assumptions underlying the design. The data collected using this design are expected to be "adequate" for the site manager's or other decision maker's needs.

7.4 SUPERFUND DATA CATEGORIES

During the sampling design step, the design team identified design elements that relate to QA/QC procedures. As explained later in Chapter 8, these QA/QC-related design elements are combined with other required QA/QC procedures, and the complete set of QA/QC requirements for the project are incorporated into the quality assurance project plan (QAPP). The DQO Process provides a logical basis for linking QA/QC procedures to the intended use of the data, primarily through the decision maker's acceptable limits on decision errors. The translation of the site manager's acceptable limits on decision errors into specific QA/QC requirements is done during Step 7: OPTIMIZE THE DESIGN and completed in the QAPP development process.[4]

To assist in the interpretation of data, the Superfund program has developed the following two descriptive data categories:

- Screening data with definitive confirmation;
- Definitive data.

These two data categories are associated with specific quality assurance and quality control elements, and may be generated using a wide range of analytical methods. The particular type of data to be generated depends on the qualitative and quantitative DQOs developed during application of the DQO Process. The decision on the type of data to be collected should not be made prior to completion of the entire DQO Process.

Screening Data with Definitive Confirmation

Definition of Screening Data

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, instead of elaborate extraction/digestion and cleanup. Screening data provide analyte identification and quantification, although the quantification may be relatively imprecise. At least 10% of the screening data are confirmed using analytical methods and QA/QC procedures and criteria associated with definitive data. Screening data without associated confirmation data are not considered to be data of known quality.

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[4] For more information about the QAPP development process, see *Guidance for Preparing, Reviewing, and Implementing Quality Assurance Project Plans for Environmental Programs*, EPA/QA/G-5 (Draft).

Screening Data QA/QC Elements

- Sample documentation (location, date and time collected, batch, etc.);
- Chain of custody (when appropriate);
- Sampling design approach (systematic, simple or stratified random, judgmental, etc.);
- Initial and continuing calibration;
- Determination and documentation of detection limits;
- Analyte(s) identification;
- Analyte(s) quantification;
- Analytical error determination:[5] An appropriate number of replicate aliquots, as specified in the QAPP, are taken from at least one thoroughly homogenized sample, the replicate aliquots are analyzed, and standard laboratory QC parameters (such as variance, mean, and coefficient of variation) are calculated and compared to method-specific performance requirements specified in the QAPP;
- Definitive confirmation: at least 10% of the screening data must be confirmed with definitive data as described below. As a minimum, at least three screening samples reported above the action level (if any) and three screening samples reported below the action level (or as non-detects, ND) should be randomly selected from the appropriate group and confirmed.

Definitive Data

Definition of Definitive Data

Definitive data are generated using rigorous analytical methods, such as approved EPA reference methods. 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.

Definitive Data QA/QC Elements

- Sample documentation (location, date and time collected, batch, etc.);
- Chain of custody (when appropriate);
- Sampling design approach (systematic, simple or stratified random, judgmental, etc.);
- Initial and continuing calibration;
- Determination and documentation of detection limits;
- Analyte(s) identification;
- Analyte(s) quantification;
- QC blanks (trip, method, rinsate);
- Matrix spike recoveries;
- Performance Evaluation (PE) samples (when specified);

[5] The procedures identified here measure the precision of the analytical method, and are required when total measurement error is not determined under confirmation step.

- Analytical error determination (measures precision of analytical method): An appropriate number of replicate aliquots, as specified in the QAPP, are taken from at least one thoroughly homogenized sample, the replicate aliquots are analyzed, and standard laboratory QC parameters (such as variance, mean, and coefficient of variation) are calculated and compared to method-specific performance requirements defined in the QAPP;
- Total measurement error determination (measures overall precision of measurement system, from sample acquisition through analysis): An appropriate number of co-located samples as determined by the QAPP are independently collected from the same location and analyzed following standard operating procedures. Based on these analytical results, standard laboratory QC parameters such as variance, mean, and coefficient of variation should be calculated and compared to established measurement error goals. This procedure may be required for each matrix under investigation, and may be repeated for a given matrix at more than one location at the site.

Impact of Data Categories on Existing Superfund Guidance

These Data Categories replace references to analytical levels, quality assurance objectives, and data use categories. The major documents impacted by the Data Categories are:

- *Data Quality Objective Guidance for Remedial Response Activities: Development Process and Case Studies*: EPA/540/G-87/003 and 004, OSWER Directive 9355.0-7B;
- *Quality Assurance/Quality Control Guidance for Removal Activities: Sampling QA/QC Plan and Data Validation Procedures:* EPA/540/G-90/004, OSWER Directive 9360.4-01 April 1990; and
- *Guidance for Performing Site Inspections Under CERCLA*, OSWER Directive 9?[illegible] August 1992.

CHAPTER 8

BEYOND THE DQO PROCESS:
The Sampling and Analysis Plan and Data Quality Assessment

8.1 OVERVIEW

This chapter explains some important QA management steps that occur after the DQO Process has been completed. The DQO Process is part of the planning phase of the data collection life cycle, as illustrated in Figure 8-1. At the completion of the DQO Process, the site manager will have documented the project objectives and key performance requirements for the data operations in the DQOs, and will have identified a sampling design that is expected to achieve the DQOs. The sampling design and DQOs are used to develop the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan (FSP), both of which are included in the Sampling and Analysis Plan (SAP). The SAP provides the detailed site-specific objectives, specifications, and procedures needed to conduct a successful field investigation. During the implementation phase of the data collection life cycle, the SAP is executed and the samples are collected and analyzed. During the assessment phase, Data Quality Assessment (DQA) is performed on the data to determine if the DQOs have been satisfied. The relationships between the DQO Process and these subsequent activities is explained in more detail below.

8.2 SAMPLING AND ANALYSIS PLAN DEVELOPMENT

The SAP is a formal Superfund project document that specifies the process for obtaining environmental data of sufficient quantity and quality to satisfy the project objectives. The DQO Process can be viewed as a preliminary step in the SAP development process, since it logically precedes the actual development of the SAP document, as shown in the right half of Figure 8-1. The outputs of the DQO Process feed directly into the development of the QAPP and the FSP, which are the two main elements of the SAP. Thus, the SAP is a single document that integrates the DQOs, QAPP, and FSP into a coherent plan for collecting defensible data that are of known quality adequate for the data's intended use.

The Quality Assurance Project Plan

The QAPP is required for all EPA data collection activities. The QAPP contains information on project management, measurement and data acquisition, assessment and oversight, and data validation and useability. DQOs are a formal element of the QAPP, yet information contained in the DQOs relates indirectly to many other elements of the QAPP. In essence, the DQOs provide statements about the expectations and requirements of the data *user* (such as a site manager). In the QAPP, these requirements are translated into measurement performance specifications and QA/QC procedures for the data *suppliers*, to provide them with the information they need to satisfy the data user's needs.

The Field Sampling Plan

The FSP specifies how to conduct field activities to obtain the environmental data needed for the project. Whereas the DQO Process generates a sampling design based on the data user's needs, the FSP provides the operational plan for executing that sampling design. The FSP identifies

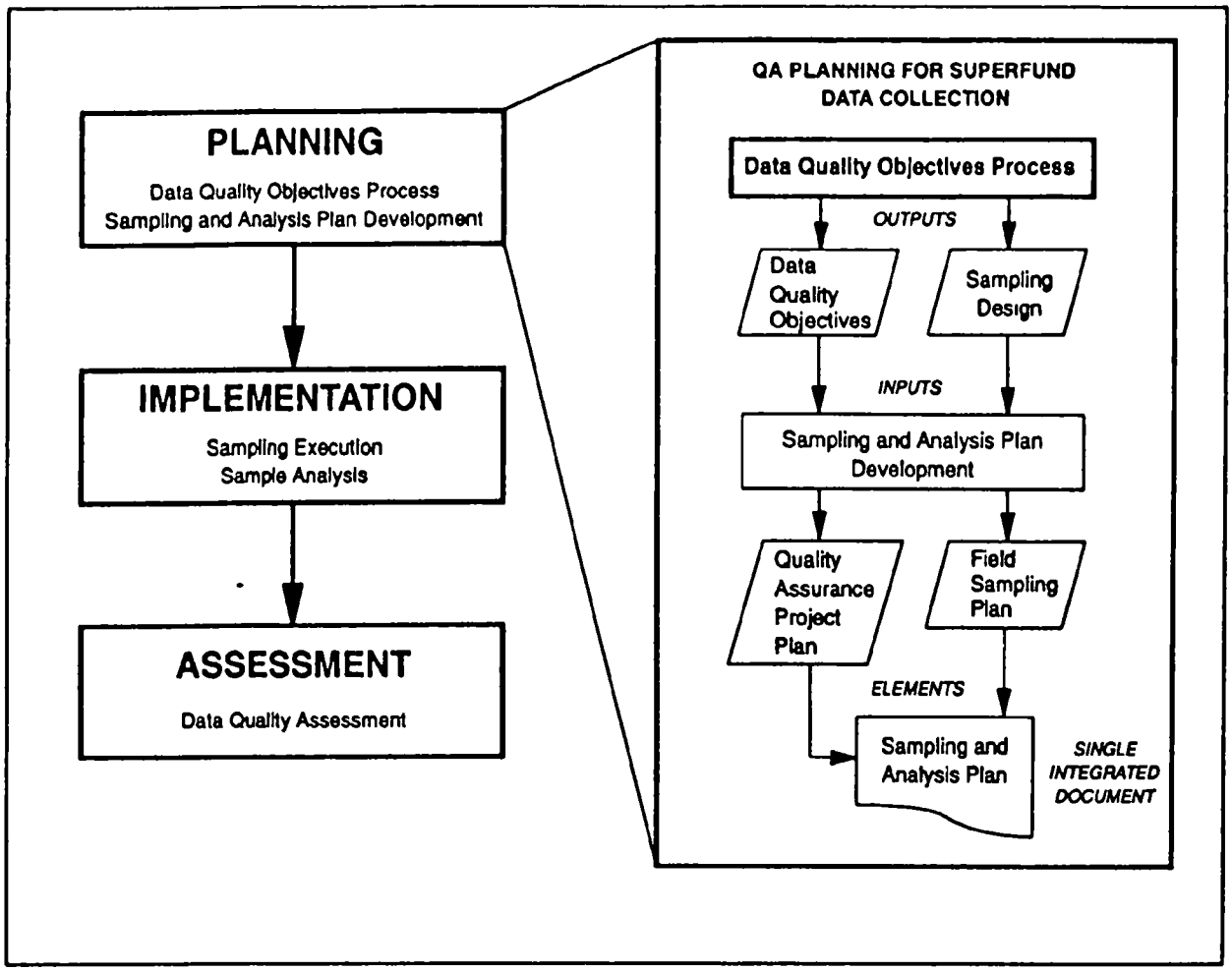

Figure 8-1. QA Planning and the Data Life Cycle

procedures for collecting samples in a manner that is consistent with the underlying theory and assumptions upon which the sampling design is based. This, along with the QA/QC procedures specified in the QAPP, helps ensure that the resulting data will be valid and appropriate for their intended use.

8.3 DATA QUALITY ASSESSMENT

After the environmental data have been collected and validated in accordance with the SAP, the data must be evaluated to determine whether the DQOs have been satisfied. EPA has developed guidance on Data Quality Assessment (DQA) to address this need.[1] DQA involves the application of statistical tools to determine whether the variability and bias in the data are small enough to allow the site manager to use the data to support the decision with acceptable confidence. The five main steps of the DQA process are illustrated in Figure 8-2.

[1] U. S. Environmental Protection Agency (EPA). 1993. *Guidance for Conducting Environmental Data Quality Assessments* EPA/QA/G-9

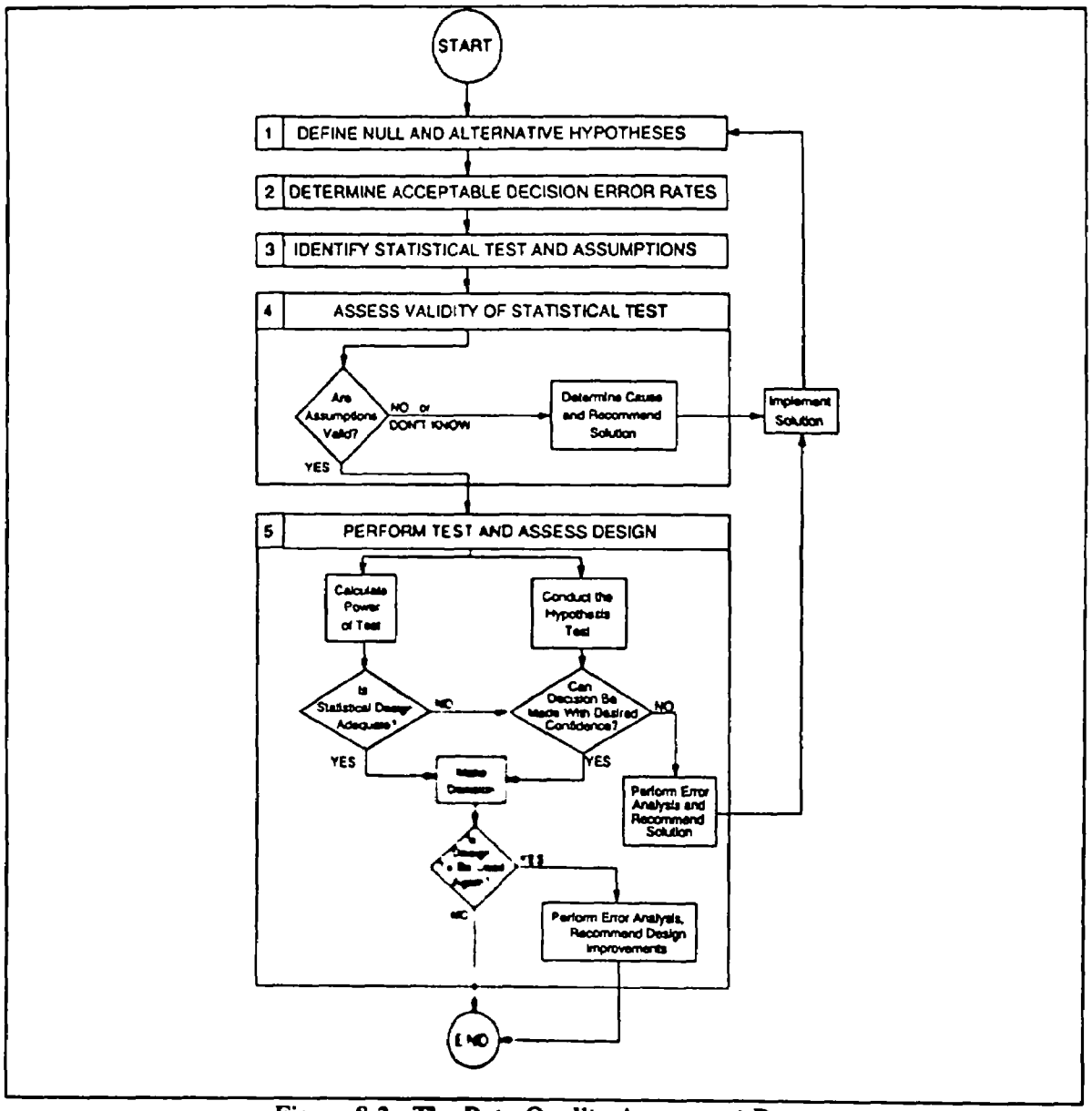

Figure 8-2. The Data Quality Assessment Process

For DQA to be effective and efficient, the crucial groundwork must have been laid in the planning phase. The DQOs provide the evaluation criteria by which the data will be assessed, and the SAP provides the blueprint by which the data will be generated. If the planning has been carried out thoughtfully, and the plans are executed successfully, then the DQA will provide answers that are useful for the site manager.

APPENDIX I

TECHNICAL SUPPLEMENT TO THE DATA QUALITY OBJECTIVES PROCESS

SECTION A: STATE THE PROBLEM

THE CONCEPTUAL SITE MODEL AND THE DQO PROCESS

This discussion focuses on the relationship between the conceptual site model (CSM) and the DQO process for Phase I of the advanced assessment decision. The DQO process involves a series of steps that gradually narrows, focuses, and divides a potentially complex problem into manageable pieces. Site problems can be very complex, especially in cases where contamination is present in several media or when cross-media contamination exists.

The CSM is developed using readily available (existing) data and illustrates the relationship between contaminants, retention/transport media, and receptors. The relationship between contaminants, retention/transport media, potential receptors, and the possibility for exposure to occur is central to a description of the problem, which is required in the first step of the DQO process.

The CSM also facilitates understanding of why new environmental data may be needed to resolve the contamination problem. The need for new environmental data may be confirmed by using the DQO process.

The CSM also serves as a framework for identifying data gaps. Data gaps identified in the CSM can be addressed by listing them as inputs to the decision in the third step of the DQO process. Information in the CSM about the location of contamination and potential receptors, as well as contaminant fate and transport, can be used to establish spatial and temporal boundaries for the field investigation in the fourth step of the DQO process. In summary, the development of the CSM directly influences the generation of the outputs of the first four steps of the DQO process.

The following discussion provides more information on developing the CSM and on defining exposure scenarios.

DEVELOP/REFINE THE CONCEPTUAL SITE MODEL

The following series of tasks are most appropriate for scoping site inspections and Phase I remedial investigations. In the later phases of the Superfund process, it is most important to confirm the exposure scenarios and generate a diagram depicting contaminant concentrations superimposed on a site map.

(1) **Collect existing site data.** Gather all historical site data and other pertinent information and compile an up-to-date data base on the site. Use this information to prepare written descriptions and graphic illustrations (diagrams) of contaminant sources, migration and exposure pathways, and potential physical and environmental targets or receptors. These illustrations and diagrams condense and document the important elements of exposure, and facilitate identification of the data needed to assess the potential risks of exposure associated with the site.

(2) **Organize, analyze, and interpret existing site data.** Organize site data according to:

- information on sources and source types (e.g., landfills, impoundments, lagoons, or ditches);
- affected media;
- site's physical and waste characteristics that can influence migration or containment; and
- potential migration and exposure pathways and receptors.

Summarize the analytical results of previous data collection activities with respect to:

- contaminants of interest,
- contaminant concentrations in each media and the practical concentration ranges of concern;
- anticipated analytical methods, and
- analytical method performance characteristics such as precision, bias, and method detection limits.

Perform a site reconnaissance with photographic equipment to document and gather current information to determine whether observations are consistent with the current understanding of the site. During the site visit, search for signs of contamination, such as the appearance of surface water, stressed vegetation, or discolored soil. Use topographic maps to mark well locations and estimate the extent of source areas or the presence of sensitive environs. Try to uncover information that will help assess the apparent stability of the site, such as leaking containment structures or weakening beams. Conduct limited sampling with portable equipment and gather additional anecdotal information from local sources that may reveal disposal areas or practices that were previously unknown and may affect contaminant migration

(3) **Determine if existing data can support the conceptual site model.** Assess whether a limited field investigation is needed to adequately define the conceptual site model. This assessment helps determine whether or not samples need to be collected and, if so, if they will be used to supplement or verify existing data.

(4) **Define the conceptual site model.** The compilation, organization, and interpretation of historical site data now can be used to develop a diagram that illustrates the conceptual site model. Representing the linkages among contaminant sources, release mechanisms, pathways, exposure routes, and receptors in a diagram is a very useful and efficient technique for summarizing the current understanding of the contamination problem.

The written description should be supported with maps and cross-sections depicting contaminants and contaminant distribution, as appropriate.

DEFINE EXPOSURE SCENARIOS

(1) **Identify media of concern.** Use historical site data including analytical data to identify media that is currently contaminated or that can become contaminated through migration.

(2) **Identify the contaminants of concern.** Develop a broad list of contaminants known or suspected to be at the site. A comprehensive approach to identifying contaminants minimizes missing chemicals that may contribute to overall risk at the site or those that may not contribute to risk significantly, but are present in large quantities.

(3) **Define future land use.** Currently, a formula for determining the probable future land use for a site is unavailable. Therefore, begin by considering the current site land use and determine if factors such as zoning laws, renovation projects, and anticipated population growth may influence the future land use for a site. The "Risk Assessment Guidance for Superfund (RAGS) Human Health Evaluation Manual, Part A" (U.S. EPA, July 1989) provides more detailed support for defining future land use.

(4) **Define Applicable or Relevant and Appropriate Requirements (ARARs).** Identify the ARARs for the site. Start with the current list of contaminants and list all the chemical-specific ARARs from all the environmental statutes. Along with the standard, note the jurisdictional prerequisites under which the ARAR was established. This information will be used to determine the applicability, relevancy, and appropriateness of the standard for CERCLA. The search continues beyond chemical-specific ARARs. It should also include location- and action-specific ARARs. Further assistance in identifying ARARs for the site is provided in the "CERCLA Compliance with Other Laws Manual" (U.S. EPA, August 1988).

(5) **Assemble exposure scenarios.** Identify all available exposure pathways associated with the site. An exposure pathway describes a unique mechanism by which a receptor is exposed to site-related contaminants. Each exposure pathway includes:

- a source and release mechanism,
- a retention and transport medium;
- an exposure point; and
- an exposure route.

For each medium and land-use combination, identify the most appropriate exposure scenarios.

At this point, several components of an exposure scenario have already been identified and should be brought forward. One of these components is the potential receptor identified in the conceptual site model. Use the potential receptors and characterize the exposure setting as it relates to receptor locations and average daily activity patterns. The scoping team also considers those physical site characteristics and waste characteristics that influence contaminant migration. Other components of the conceptual site model that assist this effort are the

identified sources and affected or potentially contaminated media. Once these exposure-related elements have been identified, consider receptor locations and activity patterns and any point of potential contact with these media. After defining all potential exposure points, identify probable exposure routes (i.e., ingestion, inhalation, dermal contact).

Next, assemble all of the information collected above into complete exposure pathways and combine exposure pathways as appropriate.

SECTION B: IDENTIFY THE DECISION

RELATIONSHIPS BETWEEN THE DECISION STATEMENTS AND PRE-SACM SUPERFUND PROCESS

The purpose of the following information is to help users correlate the first three decisions presented in the guidance to the pre-SACM Superfund process.

Superfund site assessment encompasses identification, evaluation, and response to uncontrolled releases of hazardous substances and determination of the level of post-cleanup risks to human health and the environment. To evaluate a site efficiently and minimize unnecessary expenditure of resources, site assessment activities are performed in stages or tiers.

According to the Office of Solid Waste and Emergency Response Interim Guidance on "SACM Regional Decision Teams" (Publication 9203.1-0-51, December 1992), site response action options that are based on information or data generated in the early assessment stage (i.e, site inspection[1]) include recommending the initiation of RI activities. Therefore, in general, site inspection and removal data collection activities and the decisions they support occur in the early assessment stage timeframe. A statement of the early assessment decision is, "Determine whether the release (or potential release) poses a threat to human health or the environment." Recognize that a removal action can occur at any time during site assessment.

The Advanced Assessment Stage activities follow the early assessment. As stated in the previous paragraph, a remedial investigation[2]data collection activity and the decision it supports occurs in the Advanced Assessment Phase I timeframe. A statement of the Advanced Assessment Phase I decision is, "Determine whether contaminant of concern concentrations exceed ARARs or contaminant concentrations corresponding to the target risk level for the site."

The Advanced Assessment Phase II data collection activity is conducted only if a determination is made that contaminant concentrations exceed ARARs or concentrations corresponding to the target risk level and, as a result, the site warrants a further response action. The Advanced Assessment Phase II data collection activity occurs in the remedial investigation/feasibility study timeframe.

SACM Decisions in the Context of the DQO Process

This guidance specifically discusses four site decisions that often require field investigations. Three are site assessment decisions and the fourth is the cleanup verification decision after the remedial response action has been completed. This subsection discusses these SACM decisions in the

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[1]The Interim guidance also references Preliminary Assessment/Removal Assessment as part of the Early Assessment Stage activities However, this guidance focuses on activities that involve collection of new environmental data. Typically, new environmental data are not collected during the preliminary assessment. Therefore, this guidance is most concerned with data collection activities in support of site inspections and removal assessment during the early assessment stage

[2]A combined focused or expanded SI/RI data collection can also be conducted during the advanced assessment Phase I

context of the DQO process, along with notations that relate the SACM decisions to the corresponding phase of the pre-remedial and remedial programs.

Early Assessment (Pre-Remedial) Stage

The early assessment (i.e., removal preliminary assessment or remedial preliminary assessment) allows site managers to screen sites and select those that warrant further assessment and possible response action using either the removal and/or remedial authorities.[3] These preliminary assessments typically are executed without the collection of waste or environmental samples. Instead, they rely on the collection of readily available information and therefore are unlikely to realize the full benefit of DQO application. The assessment may result in a decision to recommend the site evaluation accomplished (SEA) designation or to recommend further assessment and possible response action for the site. The further assessment recommendation may involve collection of additional data to perform a focused site inspection (SI) or an expanded site inspection/remedial investigation (ESI/RI), if the site has a high likelihood of remedial action. The SI and ESI/RI field investigations usually require the collection of waste or environmental samples and would benefit from a full application of the DQO process. A possible response action recommendation may involve an emergency/time-critical removal action, a non-timecritical early action (removal or early/interim remedial), the initiation of the NPL listing process concurrent with the early response action or ESI/RI, and/or initiation of enforcement activities. Generally, it may not be expedient to apply the DQO process to emergency/time-critical removal action field investigations. On the other hand, DQOs should be developed for non-time-critical early action field investigations.[4]

Advanced Assessment Stage (Remedial Investigation Phase I)

The field investigations in the advanced assessment stage field investigations are conducted in phases. The primary purpose of the first phase is to support the risk assessment, which is an input to the decision on whether the site warrants an additional response action. In this advanced site assessment stage, the response action recommendation typically involves a non-time-critical removal or early and/or long-term remedial action. Sites that require a response action enter the second phase of the advanced assessment.

Advanced Assessment (Remedial Investigation Phase II)

The purpose of the second phase of the advanced assessment is to determine the extent of contamination that exceeds ARARs or contaminant concentrations corresponding to the target risk level. Consistent with SACM and streamlining initiatives, this extent of contamination determination is performed concurrently with the first phase of the advanced assessment.[5] The extent of contamination determination supports alternative development processes of both removal engineering evaluation and cost analysis (EE/CA) and remedial feasibility studies (FS).[6]

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[3]SACM Publication 9203 1-051, September 1992 "SACM Program Management Update, Assessing Sites Under the SACM," page 2.

[4]SACM Directive 9203 1-051, September 1992 "SACM Program Management Update, Early Action and Long-Term Action Under SACM"

[5]SACM Publication 9203 1-051, September 1992 "SACM Program Management Update, Assessing Sites Under the SACM," page 3.

[6]The extent of contamination decision may also support presumptive remedy and lightning ROD streamlining initiatives

Cleanup Attainment Stage

The final SACM decision that will require new data and be the focus of DQO development is the cleanup attainment decision. This decision addresses whether final response actions achieved final remediation levels or removal action levels.

SECTION C: IDENTIFY THE INPUTS TO THE DECISION

DECISION-SPECIFIC ACTIVITIES

EARLY ASSESSMENT DECISION

The objective of this field investigation is to evaluate the degree to which the site presents a threat to human health and the environment.

List the Inputs Needed to Support the Decision

Gather the following information during this phase:

- historical waste generation and disposal practices;
- hazardous substances associated with the site;
- potential sources of hazardous substances;
- important migration pathways and affected media;
- a comprehensive survey of targets;
- critical sample locations for the SI;
- contaminants or waste; and
- PA results.

Identify Informational Sources for Each Decision Input

Compile any readily available information about the site and its surroundings. PA documentation, records that indicate the contaminants at the site, site photographs, and anecdotal evidence are all potential informational sources. For more involved assessments, documentation of observed releases, observed contamination, and levels of actual contamination at the site will be required.

Identify the Inputs that will Require New Environmental Measurements

Some of the information identified in the previous activity may require environmental measurements. List those inputs requiring environmental measurements that cannot be satisfied by existing data from previous field investigations.

The following lists summarize the outputs for each decision.

List of Early Assessment Inputs

(1) List of Inputs Needed to Support the Decision:

- contaminant or waste migration pathway
- waste
- contaminants

- action level[1]

(2) List of Inputs That Require New Environmental Measurements:

- contaminant concentrations
- background concentrations[1]

ADVANCED ASSESSMENT DECISION: PHASE I

List the Inputs Needed to Support the Decision

This stage of the cleanup process will involve determining the nature and magnitude of contamination. To do so, it is necessary to identify potential contaminants and determine whether or not their concentrations exceed ARARs or levels that pose an unacceptable risk. Therefore, the relevant information includes:

- records indicating the contaminants that might be found at the site;
- information that identifies contaminants actually present at the site;
- information about how contaminant concentrations are distributed among media across the site;
- ARARs (if they exist) or exposure assumptions that will be used in the preliminary remediation goal (PRG) calculation;
- toxicity information for each contaminant;
- fate and transport information to be used in assessing exposure; and
- a target risk that provides a preliminary definition of the threshold of unacceptable risk.

Determine whether or not contaminant concentrations exceed ARARs or concentrations corresponding to the target risk level. If ARARs exist, the decision involves determining if the site complies with explicit regulatory criteria, such as a Maximum Concentration Limit (MCL) for ground water near a drinking water well. If ARARs do not exist, and the decision will be based on estimates of the risks posed by the site, then there may be several alternative methods by which site risks can be estimated. Each method will require different informational inputs. The following suggested activities apply to this latter, more complicated case.

- Consider each exposure pathway of concern.
- Identify the variables in the risk calculation for each pathway.
- Decide which variables will be estimated using site-specific information and which variables will be assigned default values.
- For each variable that will be estimated using site-specific information, determine whether the estimate will be based primarily on modeling or direct measurement, or both.

[1]This applies when a comparison of site contamination levels to background levels is the basis for decision making

List the sampling and analysis action level.[1] If the decision is based on ARARs, then list the ARARs; if the decision is based on site-specific risk, then list the target risk level.

List all of the decision inputs needed to determine if the site fails to comply with ARARs or exceeds the acceptable target risk. In both cases, information on concentrations of contaminants will be required. If the decision is based on site-specific risk, then information on each input to the PRG calculation for each exposure pathway will be needed (the work done in developing the decision support strategy should provide a good starting point). This will include the contaminant potency factors, exposure pathways, fate and transport information, receptor types and activity levels or patterns, and intake parameters.

Identify Informational Sources for Each Decision Input

For ARARs, identify the specific regulation. For risk-based decisions, identify informational sources for the target risk and each input to the PRG calculation. Sources may include default values derived from written guidance, historical records, census data, field measurements or observations, or professional judgement. If the decision support strategy requires site-specific modeling to estimate any of the variables in the risk calculation, then identify any key model parameters that need to be estimated using site-specific information.

Determine if existing data from this site or similar sites exist. If the data do exist, evaluate them qualitatively to see if they appear to be the type that are appropriate for the decision.

List the Inputs That Will Require New Environmental Measurements

Some of the sources identified in the previous activity will include field measurements. List those inputs that require environmental measurements and that cannot be satisfied by existing data from previous field investigations.

List of Advanced Assessment Decision, Phase I, Inputs

(1) List of Inputs Needed to Support the Decision:

- potential contaminants
  - concentrations in space and perhaps time
  - potency factors or dose/response relationships
- exposure pathways
  - media (e.g., soil, surface water, ground water, air)
  - rates of migration (within and between media)
  - rates of dispersion/accumulation

[1]This is the contaminant concentration that corresponds to the target risk level, given various assumptions about exposure and contaminant fate, transport, and dispersion mechanisms

- receptors
  - types/subpopulations
  - sensitivities
  - numbers/densities
  - activity levels/patterns
- target risk/ARARs
- site's physical and chemical characteristics that influence technology applicability (e.g., presence of organic components, soil permeability, and depth to impervious formation)

(2) List of Inputs That Require New Environmental Measurements:

- contaminant concentrations in space (and perhaps time) for each media of concern
- small- and large-scale variability in potential contaminant concentrations
- other measurements related to risk assessment, such as fate and transport model parameters

ADVANCED ASSESSMENT DECISION: PHASE II (EXTENT OF CONTAMINATION)

Much of the information developed at this stage of the cleanup process builds on the foundation laid in the previous stage (if DQOs were not developed for Advanced Assessment Phase I, then it will be necessary to develop some of that information as part of Phase II). This decision addresses the extent of contamination that will require remediation. Consequently, the information at this stage will be similar in character to Phase I, but will be more specific or refined.

List the Inputs Needed to Support the Decision

To calculate the volume of media that will require remediation, information will be needed about the specific locations where contaminant concentrations exceed ARARs or the sampling and analysis action levels. Information on remedial alternative effectiveness, efficiency, and cost also will be needed.

- List the contaminants with concentrations that exceed ARARs or the target risk. If the decision is based on ARARs, then confirm the list of information required to determine compliance with the ARARs for each contaminant. If the decision is based on site-specific risk, then confirm the list of inputs to the PRG calculation that will be required to determine the extent of contamination that exceeds the PRG.

- List the engineering information required to determine the effectiveness, efficiency, and cost of each remedial alternative

- If the removal action level or final remediation level differs from the sampling and analysis action level,[3] then identify the new inputs required to determine the location and volume of media that exceed the removal action level or final remediation level.

[3]If decision inputs were not developed for the Phase I advanced assessment decision, then conduct the activities described above for that phase, except use the final remediation level and the selected remedy in place of the preliminary action level and remedial alternatives, respectively

- List the inputs needed to determine the volume of media that exceeds ARARs or the sampling and analysis action level.

- This phase focuses on the extent of contamination that will require remediation. The approach for determining contaminant concentrations usually will follow directly from the approach taken in Phase II. For decisions based on site-specific risks, the approach to estimating risk variables also should be consistent with the approach taken in Phase II.

Identify Sources for Each Decision Input

These sources should be similar to those identified in Phase I, unless the removal action level or final remediation level differs greatly from the sampling and analysis action level.

Identify the Inputs that will Require New Environmental Measurements

Examine the inputs derived from environmental measurements and list those inputs that will not be satisfied by existing data.

List of Advanced Assessment Decision, Phase II, Inputs

(1) List of Inputs Needed to Support the Decision:

- removal/remedial technologies or alternatives
- contaminants
- refined exposure assumptions or baseline risk assessment assumptions
- sampling and analysis action level or final remediation level

(2) List of Inputs That Require New Environmental Measurements:

- contaminant concentrations

CLEANUP ATTAINMENT DECISION

This stage addresses a question much different than the previous two stages: Do contaminant concentrations remaining after the remedial action exceed the final remediation level? Nonetheless, the information required to answer this question closely parallels the information required in the first two stages.

List the Inputs Needed to Support the Decision

The removal action level or the final remediation level serves as the criterion for deciding if the response action is complete; hence the scope of information needed at this stage is less than that

required in previous stages.[4] For the cleanup attainment decision, the primary focus is on the distribution of contaminant residual concentrations across the site.

- List the removal action level or final remediation level for each contaminant and identify any other decision criteria that may be specified in the Engineering Evaluation/Cost Analysis (EE/CA) or the ROD (for example, the ROD may require that a specific statistical test be performed to determine if the site has attained the final remediation levels).

- List the inputs required to determine if the contaminant concentrations exceed the removal action level or final remediation levels.

- Identify any special concerns, such as the desire to ensure that no hot spots above a certain size and concentration are left behind.

- List the cleanup attainment decision inputs that require field measurements that will not be satisfied by existing data.

Identify Sources for Each Decision Input

Identify the information sources for each of the cleanup attainment decision inputs. It is unlikely that any existing data will satisfy this need, unless the data were collected during the remedial action timeframe (such as monitoring data).

List the Inputs that will Require New Environmental Measurements

List the cleanup attainment decision inputs that require field measurements that will not be satisfied by existing data.

List of Cleanup Attainment Decision Inputs

(1) List of Inputs Needed to Support the Decision:

- removal action levels or final remediation levels for each contaminant
- distribution of contaminant (or surrogate) concentrations

(2) List of Inputs That Require New Environmental Measurements:

- contaminant (or surrogate) concentrations

[4]In previous stages, information about the risk calculation may have been included, however, this information is now subsumed within the removal action level or the final remediation level. Likewise, Advanced Assessment Phase I required information about remedial technologies and alternatives, after the ROD, the remedy has been selected, which reduces the scope of information required to make subsequent decisions.

SECTION D: DEFINE THE STUDY BOUNDARIES

Section D provides the scoping team with relevant information about how to develop risk-based, technology-based, and other scales of decision making. In addition, this section will focus on defining spatial boundaries and scales of decision making for four media of concern: surface soil, subsurface soil, surface water, and ground water.

1. SCALES OF DECISION MAKING

The following section provides relevant information about how to develop risk-based, technology-based, and other scales of decision making.

RISK-BASED SCALES OF DECISION MAKING

Development of risk-based scales requires substantial input from and relies on the professional judgement of the risk assessment member of the scoping team. In order to develop risk-based scales of decision making, the scoping team must evaluate: (1) the daily activity and behavior pattern of the most sensitive receptor; (2) the exposure pathway and route(s); (3) the current and future media use designation; and (4) contaminant toxicity values. In some cases, ARARs or a target risk level may be required to define the scale of decision making.

To make a risk-based decision, the sampling data should be representative of well-defined areas, volumes, and time periods which the scoping team determines a receptor could be exposed to given the anticipated use of the site. Since this scale is based on exposure assumptions, they are referred to as "Exposure Units" (EUs). If possible, the EU should represent a direct correlation between the area of contamination and the exposure that the receptor is likely to receive. Each media will have its own unique type of EU. As an example, surface soil has an EU that is defined by length, width, and depth of the surface soil layer.

TECHNOLOGY-BASED SCALES OF DECISION MAKING

If the Advanced Assessment Decision (Phase I) has already been made, the scoping team may define a scale of decision making based on the technology that was chosen to remediate the site. Scales of decision making that correspond to these areas are called Remediation Units (RUs). An RU is defined as the subset of a medium that can reasonably be remediated with the selected remediation technology (e.g., the minimum volume of soil that can be efficiently removed with a backhoe). RUs are defined by the scoping team in order to design the most cost-effective remediation design. The size of the RU will determine the scale of resolution that will be necessary for the sampling plan and also the amount of material that will ultimately be remediated. For each medium, the optimal size of an RU can be determined using a relative cost analysis and an estimate of (or assumptions about) the variability and distribution of contaminants in the media. When the "relative cost" of remediation is high compared to sample and analysis costs, and the variability of contaminants is fairly high (e.g., a patchy distribution), studying each RU and remediating only those that are contributing to risk may substantially reduce costs without decreasing the level of protection of the public. When the level of variability is very low, the optimal RU size will most likely be the same as the EU.

OTHER SCALES OF DECISION MAKING

In some instances it will be difficult or impossible to directly relate the size or volume of the media to the exposure of a receptor and there may not be a technological approach that can be translated into RUs. In these cases, the scoping team must select the scale of decision making that combines the consideration of risk from exposure with practical considerations about an EU or RU size. Again, the evaluation of the size or volume of an EU should be based on the future use of the site (residential, light industrial, recreational, etc.) and the receptors' activity pattern at the site.

EXAMPLES OF SCALES OF DECISION MAKING

In order to explain the process of setting a scale of decision making, three short examples have been provided. These examples are only meant to illustrate the concept of the scale of decision making.

Example #1: Risk-Based Scale of Decision Making

> *Background — The fictitious site is situated in Montana where a lead smelter has operated over the past 25 years and contaminated a site of approximately 35 acres with lead tailings and ash from the smelter. The smelter site is surrounded by residential homes and it seems likely that the site could be used as residential lots in the future. The primary contaminant of concern on the site is lead in the soil. The exposure pathway is ingestion of soil and the primary target receptor is small children. One of the primary activities of children that exposes them to soil is playing in their backyard around areas that are devoid of vegetation. In this case the risk assessor postulates that the majority of the soil exposure received by a small child is in an area of the backyard that encompasses the sandbox and swing set.*

Given this scenario, it would be reasonable for the scoping team to want to control uncertainty in the sampling data related to the area or volume where children get the majority of their exposure. Therefore the scoping team would set the scale of decision making to the 14'-14' area which is equal to the average size of a backyard play area. This is a risk based scale of decision making because it is possible to correlate the scale of decision making with the exposure of the most sensitive receptor.

Example #2: Technology-Based Scale of Decision Making

> *Lagoon Remediation — A Midwestern Coke Plant discharged process waste water into lagoons on their property. This resulted in the contamination of sediments with organic chemicals. Solid wastes from the same process were disposed of in several other lagoons and landfill areas. These contained organic chemicals as well as inorganic contaminants. The lagoons and landfill areas are surrounded by a wetland area which is the primary concern as a receptor for the contamination. There are no human receptors nearby. The site manager recognizes that the cleanup of the lagoons will involve more than one type of remediation practice and is most likely to involve bioremediation and incineration to reduce the influence of the organic chemicals.*

The scoping team at this site choose to evaluate each lagoon separately based on the assumption that each lagoon would have homogeneous contamination which could be remediated by a single, but possibly separate, remediation process. Therefore, each lagoon is considered to be a distinct RU.

Example #3: Other Scales of Decision Making

Carolina Transformer — The soil at an abandoned transformer production and reclamation facility has been contaminated with PCBs (polychlorinated biphenyls). The expected future use of the site is light industrial and the major route of exposure is through soil ingestion. The RPM is most concerned with exposure to children trespassers who play on the site.

In this scenario, the scoping team does not believe that there is a strong correlation between the size of a soil area and the relative "amount" of exposure that the children will receive. However, from the anticipated site activities of the children, they can select a size area (scale) that would be protective under the RME if that area had an average concentration of PCBs below the sampling and analysis action level. For this site, the scale of 1/2 acre was chosen as the Scale of Decision Making. While this decision was based on some assumptions or risk and the consideration of the receptor's activities, the scoping team had to finally make an estimate of the size area that would be protective of the children rather than rely on a direct correlation between soil area and risk. This is what differentiates this example from example #1, the risk-based scale of decision making.

2. MEDIA-SPECIFIC BOUNDARY DEVELOPMENT

This section provides specific information or considerations that are useful for the development of boundaries for specific media. Each medium is treated as a separate chapter. It is useful to have defined the geographic area of the investigation before using this section.

Surface soil and subsurface soil are treated separately in this guidance. Direct contact exposure to contaminants in surface soil through ingestion, inhalation of airborne particulate and dermal absorption exposure routes is the primary focus of the subsequent discussion. Subsurface soil discussions, on the other hand, primarily focus on indirect exposure routes through other media such as ground water.

(a) SURFACE SOIL

The media-specific boundary development for surface soil will provide relevant information to help the scoping team define spatial boundaries and the scale of decision making for surface soil.

DEFINING THE MEDIA

The physical attributes that define surface soil include grain size, depth, relationship to water (i e., sand or sediment), organic material content, etc. The scoping team should consider how to classify objects that appear in surface soil, such as rocks or debris, and whether or not they should be sampled and/or remediated. The depth of soil that is classified as "surface soil" may be regulated or standardized in some states or regions. Be sure to check with the proper offices and obtain the necessary approval before making this decision.

DEFINE THE SCALE OF DECISION MAKING FOR SURFACE SOIL

Below are descriptions of how to define the scale of decision making for surface soil.

Risk-Based Scales of Decision Making

(1) Identify the future land-use designation and exposure route and determine if it provides a basis for defining an exposure area or volume.

(2) Define an area or volume of media within which the receptor is expected to limit his daily activities or to which the receptor is expected to come into contact during the period of exposure.

(3) Integrate the information from Steps 1 and 2 with the professional judgement of the risk assessor in order to define an exposure area or volume. For example, for residential land use where soil ingestion is determined to be the primary pathway of exposure, young children may get the majority of their exposure from a typical yard area. A case where a typical plot size was recommended as such an exposure area can be found in the *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual* (EPA July 1989) in Chapter 6, Section 6.5.3, page 6-28. If the site-specific plot size is ⅓-acre, then the ⅓-acre should be considered an estimate for the scale of decision making.

(4) Modify any estimated scales of decision making with information collected during the site visit and information that may have been collected by the Agency for Toxic Substances and Disease Registry if human monitoring was conducted. These scales may provide additional clues about the activity patterns of the receptors.

Where it is difficult to establish a scale of decision making based on land use and receptor behavior patterns, rely on standard default exposure area values that are available for media-specific pathways in the *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part A.* Contact the Risk Assessment Workgroup in the Toxics Integration Branch of EPA for their current work on this topic or use a technology-based approach to define the scale of interest.

Technology-Based Scales of Decision Making

There are two types of technology-based scales of decision making. The first relies on physical features of a site to suggest the scale. These may be features that divide the site into smaller units, such as roads, buildings, or other physical impediments, or features that suggest the location of contaminants, such as lagoons, trenches, or waste pits.

The second technological approach for defining the scale of decision making is driven by the technology used to remove or clean up the contamination. This approach involves the identification of the most efficient subset of media or minimum volume of contaminated material that can be removed (i.e., the minimum amount of soil that can be removed with a backhoe) or remediated with the selected technology during an operation of the equipment or treatment cycle.

(b) SUBSURFACE SOIL

This section will describe relevant information to aid the scoping team to develop spatial boundaries and scale of decision making for subsurface soil.

Because subsurface soil has the potential to distribute contaminants along several exposure pathways, the development of boundaries must be based on exposure pathways that have been defined in Step 1: STATE THE PROBLEM. This section will evaluate methods of developing boundaries for subsurface soil by concentrating on two exposure pathways: 1) Direct Exposure — when the subsurface soil becomes surface soil through routine building and landscaping operations; and 2) Indirect Exposure — when the contaminants from the subsurface soil leach into the ground water and present an exposure through surface or drinking water.

Subsurface soil boundaries must be defined in three dimensions. They should be defined based on the possible exposure scenario. For example, if exposure to subsurfaces soil is expected to occur as a result of routine building or landscaping, the scoping team may define the subsurface boundary as the average depth and width of a building foundation. In other cases, the regional Superfund office may have a standard definition for subsurface soil that includes dimensions and other attributes. This definition should be reviewed by the scoping team to determine if it is appropriate for its circumstances.

DEFINING THE MEDIA

The physical features that describe subsurface soil are similar to those that define surface soil. Refer to the section on surface soil. The depth of soil that is classified as "subsurface soil" may be regulated in some states or regions. Be sure to check with the proper offices and to obtain the necessary approval before making this decision.

DEFINE SCALE OF DECISION MAKING FOR SUBSURFACE SOIL — EVALUATION OF SURFACE SOIL CONTAMINATION BY SUBSURFACE SOIL

Risk-Based Scales of Decision Making

Currently the Risk Assessment Group of the Toxics Integration Branch of EPA is developing risk-based approaches for studying subsurface soil. Contact their office for the latest developments in this area.

Technology-Based Scales of Decision Making

The scale of decision making for subsurface soil brought to the surface during building or landscaping operations is equal to the volume of subsurface soil that could potentially reach the surface. In order to determine a scale of decision making for subsurface soil, the scoping team must understand what potential building and landscaping operations might occur based on the future use of the site. This information, along with the size and depth of the foundation, basement, or soil removal will give the scoping team a good estimate of the volume of soil that will be removed. This subsurface volume becomes the scale of decision making. The scoping team will then evaluate the potential health risks that this volume of soil presents when it is removed.

Once the scale has been set, the scoping team will evaluate how each volume presents exposure as surface soil based on possible exposure scenarios. For example, the scoping team would evaluate the possible exposure that the contaminated soil presents by evaluating the range of surface soil contamination (thickness and extent) and possible contact of receptors spread on the surface.

DEFINE THE SCALE OF DECISION MAKING FOR SUBSURFACE SOIL — EVALUATION OF GROUND WATER CONTAMINATED BY SUBSURFACE SOIL

Risk-Based Scales of Decision Making

Currently the Risk Assessment Group of the Toxics Integration Branch of EPA is developing risk-based approaches for studying subsurface soil. Contact their office for the latest developments in this area.

Technology-Based Scales of Decision Making

A technology-based scale of decision making would be one that is defined as the smallest unit of subsurface soil that could efficiently be remediated to limit the contamination of ground water using current technology.

(c) SURFACE WATER AND ASSOCIATED MEDIA

Developing boundaries for surface water is particularly difficult because a surface water body may be either static or dynamic. The dynamic systems can have inputs from non-contaminated and contaminated sources. Under dynamic or static conditions, the concentration of contaminant of the water body can be reduced due to dilution or increase through contaminant inputs from other media such as surface soil, sediment, and ground water. Defining the boundaries of surface water will not only involve defining the bodies that are contaminated, but also defining the media that have the potential to contaminate surface water in the future.

This section will describe relevant information to aid the scoping team to develop spatial and temporal boundaries and scales of decision making for surface water bodies.

DEFINE THE MEDIA

Some of the physical features that describe surface water are depth, breadth, width, and volume. In the case where a flowing body of water is being evaluated, the scoping team should determine the extent (run) where they feel contamination is possible. Use historical information and existing analytical data to divide the surface water into areas that are relatively homogeneous within the geographic area of the investigation. Consider making separate decisions about surface water based on the sources of contamination or concentration of contamination. Surface water such as lakes and ponds may be stratified based on depth where contaminants may concentrate. Alternatively, flowing bodies such as rivers and streams may be stratified based on their proximity to contaminant sources.

DEFINE THE SCALE OF DECISION MAKING FOR SURFACE WATER

The scale of decision making for surface water is defined as the smallest unit (volume, depth, etc.) of surface water or associted media for which the scoping team wishes to limit the probability of a decision error. For surface water, there are many potential sources of contamination from associated media. Therefore, this section will help the scoping team define the scale of decision making for the associated media as well as the surface water.

Risk-Based Scales of Decision Making

Currently the Risk Assessment Group of the Toxics Integration Branch of EPA is developing risk-based approaches for studying surface water. Contact their office for the latest developments on this topic.

Technology-Based Scales of Decision Making

The technology scale of decision making for surface soil is defined as the smallest unit of surface water or other contaminated media that could efficiently be remediated to limit contaminant exposure to the receptor.

Scales of Decision Making for Surface Water By Source of Contamination

Surface Soil Contamination of Surface Water

It may be useful to delineate watershed areas within the site in order to define areas where soil contamination may impact the surface water quality. Evaluate both the dissolved and suspended portions of soil (runoff as well as leachate). In order to evaluate contaminant leaching, it is essential to have a good understanding of the physical and chemical properties of both the soil and the contaminant(s). In addition, the scoping team should evaluate the normal and the extreme conditions on the site such as extreme rain events, flooding, spring runoff, etc.

Ground-Water Contamination of Surface Water

Ground-water contamination of surface water is particularly difficult to study because contaminant concentration and flow volume are difficult to measure or model with accuracy. In addition, these parameters may vary over time. It may not be possible in this case to develop a scale of decision making. In this event, the goal of the scoping team will be to locate the sources of contamination and to estimate the extent of ground-water contamination.

Sediment Contamination of Surface Water

In evaluating sediment contamination of ground water, the goal of the scoping team is to determine the quantity of sediment that already exists in the river or lake that could possibly contaminate the surface water through leaching, or the mobilization of the sediment into the surface water.

(d) GROUND WATER

Ground water is the most difficult media to evaluate primarily because it exists within a soil matrix which is difficult to sample and evaluate. In addition, many of the techniques that are used in the boundary section such as exposure units do not apply well to the ground-water system.

DEFINE THE MEDIA

This guidance defines boundaries of ground water to include the overall spatial features of ground-water depth and range, and the temporal aspects of flow, including rate, water table height, and variation.

DEFINE THE SCALE OF DECISION MAKING

Consult the hydrogeologist and ground-water specialist when considering scales of decision making for ground water.

SECTION E: DEVELOP A DECISION RULE

CHOOSING A POPULATION PARAMETER

The first activity in developing a decision rule is choosing the parameter to characterize the population of interest. Choosing the parameter of interest involves several considerations that are discussed below.

AVOIDING PREMATURE CONCLUSIONS ABOUT THE STATISTICAL DESIGN

It is important to remember in the discussion that follows that the decision rule is not intended to constrain the statistical design. Therefore, the decision maker need only specify the population parameter that corresponds to the decision, instead of specifying a summary statistic. For instance, instead of specifying "a geometric average", the decision maker should only specify "a mean". This will allow the statistician to choose a summary statistic, either to conform to the assumptions of the statistical model that underlies the design, or in response to an analysis of the actual data if the design assumptions are not supported by the data.

CLARIFYING WHAT THE DECISION MAKER REALLY WOULD LIKE TO KNOW

When specifying an appropriate population parameter, the best guideline to follow is to ask the question, "What would the decision maker really like to know?" If it is an 'average' condition across an area or time interval at the site, then this will be important information in developing the sampling design. If it is a peak value at the site, then the sampling strategy may be quite different. If the decision maker wants to know where the "hot spots" exist, then yet another sampling design may be appropriate. Clarifying what the decision maker would like to know if the true conditions at the site could be known will help focus the discussion on matters most relevant to the decision rule.

UNDERSTANDING THE IMPLICATIONS OF DIFFERENT STATISTICAL PARAMETERS

Data may be summarized in a variety of ways, and each statistical parameter will have certain implications regarding the site. Consequently, it is important to specify a parameter that logically corresponds to the decision at hand. The following examples illustrate this point.

Mean

The mean is a measure of central tendency of a distribution. The mean concentration of a contaminant often is used by risk assessors as a mathematical model of long-term exposure. It usually requires fewer samples than other parameters to achieve a similar level of confidence, and is useful when the contaminated medium is relatively uniform with a small variance. The mean may be sensitive to extreme values; hence a few high concentrations can significantly raise a mean, while a number of low values (such as "non-detects") can reduce the mean. This sometimes gives rise to concerns about "averaging away" a contamination problem at a site. In addition, the mean is not representative of a site when there are a large proportion of non-detects.

Median

The median is another measure of central tendency that is used to estimate the 50th percentile of a distribution. The median is less sensitive to extreme values, and may be appropriate to use when the contaminants are distributed in a manner that violates the usual assumptions of a bell-shaped (normal) or lognormal curve.

Percentiles

Percentiles describe conditions where x percent of the distribution is less than or equal to the percentile value. For example, if a 95th percentile of a contaminant distribution is equal to 400 parts per million, then 95% of the concentration levels are less than or equal to 400 ppm. Percentiles may be used to ensure that the "tails" of a distribution are factored into a decision so that, for instance, "almost all" of the contamination falls below a certain threshold value.

SECTION F: SPECIFY LIMITS ON DECISION ERRORS

ESTABLISHING PROBABILITY LIMITS ON DECISION ERRORS

After defining the gray region, the decision maker will need to determine the acceptable probabilities of each decision error. In some non-Superfund applications, one or more of these probabilities will be established by regulation. For example, the RCRA rule for determining whether a waste is hazardous because of lead contamination specifies that an upper 90% confidence limit on the mean lead concentration be compared to the standard; this is comparable to specifying a 0.10 probability limit for the false positive decision error. In the Superfund program, however, these types of explicit standards usually are not pre-set.

If the acceptable probabilities for decision errors are not established by regulation, the decision maker will need to set them. Setting the probability limits on decision errors will depend on two main factors: the relative consequences of each decision error, and the cost of attaining the decision error rates. When setting the decision error rates, the decision maker must keep in mind that the cost of attaining the decision error rates should not exceed the consequences of the decision error. Usually this will require professional judgments about the likelihood of different consequences and the magnitudes of their corresponding costs and benefits. By using judgment to balance the costs and benefits of reducing the probability of decision errors versus the costs and benefits of their potential consequences, the decision maker establishes how definitive or conclusive the data must be in supporting the decision.

By defining the limits on decision errors for both the null hypothesis and alternative hypothesis, the decision maker is actually setting limits on two different aspects of the problem. One of the limits will restrict the decision errors that could cause risk of exposure to inhabitants and the environment. The other limit will restrict the decision error that would cause unnecessary cleanup of the site when the actual risks are below regulated standards.

SECTION G: OPTIMIZE THE DESIGN

This appendix discusses some basic concepts involved in creating a sampling design. Probability sampling designs and statistical models are discussed and examples of these concepts are included in the DQO applications at Superfund sites contained in Appendix II. In addition, a discussion on confidence intervals and hypothesis tests is also included to demonstrate the difference in these techniques. However, methods for creating and analyzing sampling designs and building statistical models are beyond the scope of this guidance. The reader is referred to Cochran (1977), Gilbert (1987), and U.S. EPA (1989) for more information. It is recommended that those unfamiliar with statistical sampling techniques consult a statistician or someone familiar with statistical sampling designs If certain critical statistical design assumptions are violated, the data may become unusable for the specified purpose.

1. SAMPLING DESIGNS

NON-PROBABILISTIC SAMPLING

Non-probabilistic sampling (judgmental sampling) involves an expert selecting sample locations based on experience and knowledge of the site. The results from these samples cannot be extrapolated to the entire site, and it is difficult to measure the accuracy of any estimates using the data. However, judgmental samples can be used subjectively to provide information about specific areas of the site, which is generally useful during the preliminary assessment and site investigation stages if there is substantial information on the contamination sources and history. For instance, judgmental sampling is useful when the sampling objective is to confirm specific locations of contamination that have already been identified through visual or historical information. If any statistical conclusions are desired, however, judgmental sampling is not applicable.

PROBABILISTIC SAMPLING

Probability sampling designs allow the results from a set of samples to be generalized to the entire site. All probability sampling designs have an element of randomization which allows probability statements to be made about the quality of estimates derived from the data. Every potential sampling point within the sampling unit has a positive probability of being sampled. Therefore, probability samples are useful for testing hypotheses about whether a site is contaminated, the level of contamination, and other common problems that occur with Superfund sites.

There are many different probability sampling designs, each with advantages and disadvantages. A few of the most basic designs include simple random sampling, sequential sampling, systematic sampling, and stratified sampling Other probability designs, such as multistage probability sampling and search sampling, are too complicated to be explained in this guidance. It is recommended that a statistician be consulted to determine the best design and the most appropriate analysis.

Simple Random Sampling

The simplest probability sample is the simple random sample. With a random sample, every possible sampling point has an equal probability of being selected and each sample point is selected independently from all other sample points. Random sample locations are usually generated using a random number table or through computer generation of pseudo-random numbers. Simple random

sampling is appropriate when little or no information is available for a site, and the population does not contain any trends. If some information is available, simple random sampling may not be the most cost-effective sampling design available.

Sequential Random Sampling

Sequential random sampling is a variation of simple random sampling. As before, every possible sampling point has an equal probability of being selected, and sample locations are selected randomly. However, instead of conducting a hypothesis test with all the data, a decision is made after each sampling round is collected and measured. This decision can have three possible results: reject the hypothesis, accept the hypothesis, or continue collecting data. Therefore, it may not be necessary to collect and analyze all the samples required for a simple random sample.

Sequential sampling designs are useful when analyses are very expensive and not much information is known about sampling and/or measurement variability. However, this method can only be used when the contaminant distribution is stable over the sampling time frame.

Systematic Sampling

Systematic sampling achieves a more uniform spread of sampling points than simple random sampling by selecting sample locations using a spatial grid, such as a square, rectangle, or triangle, in two or three dimensions. To determine sample locations, a random starting point is chosen, the grid is laid out using this starting point as a guide, then all points on the grid (grid nodes) are sampled.

Since sampling locations are located at equally spaced points, they may be easier to locate in the field than simple random samples or other probability samples. However, a systematic sampling design should not be used if the contamination exhibits any cyclical patterns.

Stratification

Stratified random sampling is used to improve the precision of a sampling design. To create a stratified sample, divide the study area into two or more non-overlapping subsets (strata) that cover the entire site. Strata should be defined so that physical samples within a stratum are more similar to each other than to samples from other strata. Sampling depth, concentration level, previous cleanup attempts, and confounding contaminants can be used as the basis for creating strata. Once the strata have been defined, each stratum is then sampled separately using one of the above methods.

A stratified sample can control the variability due to media, terrain characteristics, etc., if the strata are homogenous. Therefore, a stratified random sample may provide more precise estimates of contaminant levels than those obtained from a simple random sample. Even with imperfect information, a stratified sample can be more cost-effective. In addition, stratification can be used to ensure that important areas of the site are represented in the sample. However, analysis of the data is more complicated than for other sampling designs.

The purpose of defining strata for a stratified random sample is different from the purpose of defining strata for a scale of decision making. The strata in a stratified random sample are sampled separately, then the data are combined to create estimates for the entire site or scale of decision making. Stratum estimates are also available; however, decisions based on individual stratum estimates will not have the same decision error rates as those defined in Step 6: SPECIFY LIMITS

ON DECISION ERRORS.

Composite Sampling

If analysis costs are high compared to sampling costs and the parameter of interest is the mean, then the use of composite samples should be considered. Composite sampling involves physically mixing two or more samples before analysis. This method must be used in conjunction with a sample design in order to determine sample locations (for instance, random composite sampling). Compositing samples can be a cost-effective way to select a large number of sampling units and provides better coverage of the site without analyzing each unit.

Composite sampling is useful for estimating or testing the mean when information about variability is not necessary. It is also useful if the samples are to be used as a screening device. Additionally, since the amount of contamination in a composite sample should be larger than in an individual sample, there are times when a contaminant may be more easily detected in a composite sample. However, information on extreme values and variability is lost with composite data. The population of interest must be relatively homogeneous for compositing to be feasible. Sometimes individual samples are changed by the mixing process; for instance, volatile chemicals may evaporate. In addition, when the action level is close to the limit of detection, the potential dilution caused by compositing makes the use of composite sampling infeasible. Therefore, composite sampling designs should be considered with caution.

2. STATISTICAL MODELS

Statistical models describe how the observed responses are expected to behave by relating a measured value to the true parameter of interest and any sources of uncontrolled variation. Estimates can then be derived for the parameter of interest and these sources of variation using the model. The model is very important for understanding the assumptions underlying a proposed test statistic and sampling design. Thus, it will later serve as the basis for the data quality assessment.

A statistical model consists of fixed components and random components. What is regarded as fixed or random will be determined by the test of interest and by the inherent structure of the survey design. Usually, the parameter of interest (for instance, a mean) is considered fixed while the sources of uncontrolled variation are considered random. These sources include analytic/measurement errors, temporal and spatial components, and any other factors that may affect the data collection.

The model should:

1. Specify distributional characteristics of the random components; for instance, their means are usually assumed to be zero and the variances are assumed to be stable.

2. Identify which components are independent of one another. This information is usually based on historical information, pilot data, or professional judgement.

3. Specify the relationship between the various components; for instance, if they behave in an additive or multiplicative fashion (or some combination).

4. Identify any correlation structure if temporal or spatial autocorrelations are considered present.

3. CONFIDENCE INTERVALS AND HYPOTHESIS TESTS

Confidence intervals and formal hypothesis tests are two statistical methods that can be used for decision making. A hypothesis test controls both the false positive decision error rate (α) and false negative decision error rate (β). A confidence interval only controls the probability of making a false positive decision error (α) (for example, concluding that a site is clean when it is truly dirty). However, the probability of making a false negative decision error (β) is fixed at 50% for confidence intervals (i.e., $\beta = .5$).

A confidence interval and a hypothesis test can be very similar. Consider the problem of determining whether the mean concentration (μ) of a site exceeds a cleanup standard (CS), where the contaminant is normally distributed. A confidence interval could be constructed for the mean, or a t-test could be used to test the statistical hypothesis:

$$H_0: \mu > CS \quad \text{vs.} \quad H_a: \mu < CS.$$

If the site manager's false negative decision error rate is .5 (i.e., β=.5) then these methods are the same. Additionally, with a fixed α, the sample size of a confidence interval only influences the width of the interval (since β=.5). Similarly, the sample size of a t-test influences β and δ (where δ = upper value of the gray region minus the lower value of the gray region). However, by solving for the sample size using a t-test, one can substitute back into the sample size equation for a confidence interval and compute a width corresponding to this sample size. Then the results of the two methods will be identical.

Although the results of the hypothesis test and the confidence interval may be identical, the hypothesis test has the added advantage of a power curve. The power curve is defined as the probability of rejecting the null hypothesis. An ideal power curve is 1 for those values corresponding to the alternative hypothesis (all $\mu <$ CS, in the example above) and 0 for those values corresponding to the null hypothesis (all $\mu >$ CS, in the example above). The power curve is thus a way to tell how well a given test performs, and can be used to compare two or more tests. Additionally, if the null hypothesis is not rejected, the power curve gives the decision maker some idea of whether or not the design could actually reject the null hypothesis for a given level (μ).

There is no corresponding idea of a power curve in terms of confidence intervals. To derive a power curve, one would need to translate the confidence interval into the corresponding test (i.e., a t-test) and then compute the power curve. Additionally, whereas a statistical test accounts directly for the false negative decision error, a confidence interval does not ($\beta = .5$). Finally, a confidence interval and a statistical test almost always are based on distributional assumptions, independence assumptions, etc. If these assumptions are violated, it may be easier to select an alternative test (for example, a non-parametric test) than it is to derive an alternative confidence interval. For these reasons, this document concentrates its discussion on hypothesis testing.

SECTION H: THE DQO PROCESS AND THE SUPERFUND ACCELERATED CLEANUP MODEL

OVERVIEW OF THE SUPERFUND ACCELERATED CLEANUP MODEL

The Office of Solid Waste and Emergency Response has introduced an initiative that is designed to streamline and accelerate Superfund cleanups. This initiative is called the Superfund Accelerated Cleanup Model (SACM). The goals of SACM are to make hazardous waste cleanups more timely and efficient through better planning and integration of all Superfund programs (within existing statutory and regulatory requirements). The DQO process provides a framework for planning field investigations under SACM.

SACM eliminates certain distinctions between the remedial and removal programs and views them as separate legal authorities under one program: the Superfund program.[1] Response actions are divided into early actions and long-term actions based primarily on the length of time the response action will take. Early actions can be taken under either removal or remedial authorities. Long-term actions will be taken under remedial authority. SACM provides a streamlined approach for non-timecritical removals and all remedial actions. This approach has six aspects:

- a continuous process for assessing site-specific conditions and the need for action;
- cross-program coordination of response planning;
- prompt risk reduction through early action (removal or remedial);
- appropriate cleanup of long-term environmental problems;
- early public notification and participation; and
- early initiation of enforcement activities.[2]

THE ROLE OF THE DQO PROCESS IN IMPLEMENTING SACM

To produce data that can be used for multiple purposes, careful planning is required. Site managers need to define the objectives of their field investigations and coordinate among different existing programs (e.g., the removal, site assessment, and remedial programs). They also will need to document planning activities well so that if the site manager or Regional Decision Team (RDT) determines later that a further assessment or different response action is appropriate, the planning information and data collected in the earlier field investigation can be used by others within Superfund.

The DQO process provides a framework for planning multiple field investigations and documenting those planning activities. The DQO process encourages the participation of all those people involved in generating or using site data. If there is a reasonable chance that the site could require response actions under different legal authorities (removal/remedial) or different programs under the same authority (site assessment/remedial), then representatives from these programs are encouraged to participate on the DQO planning team The DQO process provides a logical, step-by-step procedure for organizing the complex issues that cut across different programs and project phases and for keeping the team focused on the issues most relevant to planning the field investigation.

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[1] U S EPA, "Superfund Accelerated Cleanup Model (SACM)," Publication No 9203 1-01, Memo from Don R Clay, April 7, 1992, p 3.

[2] OSWER Publication 9203 1-051, *Status of Key SACM Program Management Issues — Interim Guidance*, December 1992, p 1

APPENDIX II

APPLICATION OF DATA QUALITY OBJECTIVES TO SUPERFUND SITES

EXAMPLES

SECTION A

GROUND-WATER EXAMPLE

THE WATERVILLE MUNICIPAL LANDFILL SUPERFUND SITE

1.0 BACKGROUND

The Waterville Municipal Landfill was in operation from 1967 to 1985. During this time, the facility accepted residential and commercial waste. Historical information indicates that waste solvent was disposed of at the Waterville Municipal Landfill. One chemical in particular, perchloroethylene (PCE), was disposed of in large quantities. PCE is a class C, possible human carcinogen which mainly targets the kidney. Ingestion and inhalation of drinking water from contaminated ground water are considered viable exposure routes.

The Waterville Municipal Landfill is situated in the Atlantic coastal plain overlying an unconfined aquifer that serves as a drinking water source for nearby residents via domestic wells (see Figure A-1). Local residents are concerned that the landfill may be releasing contaminants into the ground water. EPA has initiated an Expanded Site Investigation (ESI) because of the potential for exposure to PCE through drinking water.

The aquifer underlying the landfill site was previously contaminated by PCE from a leaking tank at a dry cleaning facility, which is hydraulically upgradient from the landfill site. The leaking tank was removed in 1990. PCE was detected during quarterly sampling in 1991 and 1992, but was detected below levels of concern. Well A is hydraulically upgradient from the landfill and is located at the site boundary. Two drinking water wells — wells B and C — are within ¼ mile and are hydraulically downgradient from the site (see Figure A-2). Any leakage from the landfill will affect only the downgradient wells.

2.0 DQO DEVELOPMENT

The following is an example of the output from each step of the DQO process.

Step 1: State the Problem — a description of the problem and specifications of available resources and relevant deadlines for the study.

(1) Identify the members of the DQO scoping team — The members of the scoping team will include the Site Assessment Manager (SAM), a field sampling expert, a chemist, a hydrogeologist, a QA Officer, and a statistician. The SAM is the decision maker.

(2) Define/refine the conceptual site model — Figure A-1 illustrates some of the main elements of the conceptual site model, such as the source of contamination, routes of migration, and potential receptors (humans living in households connected to the domestic water supply fed by wells B and C). Additional information needed to

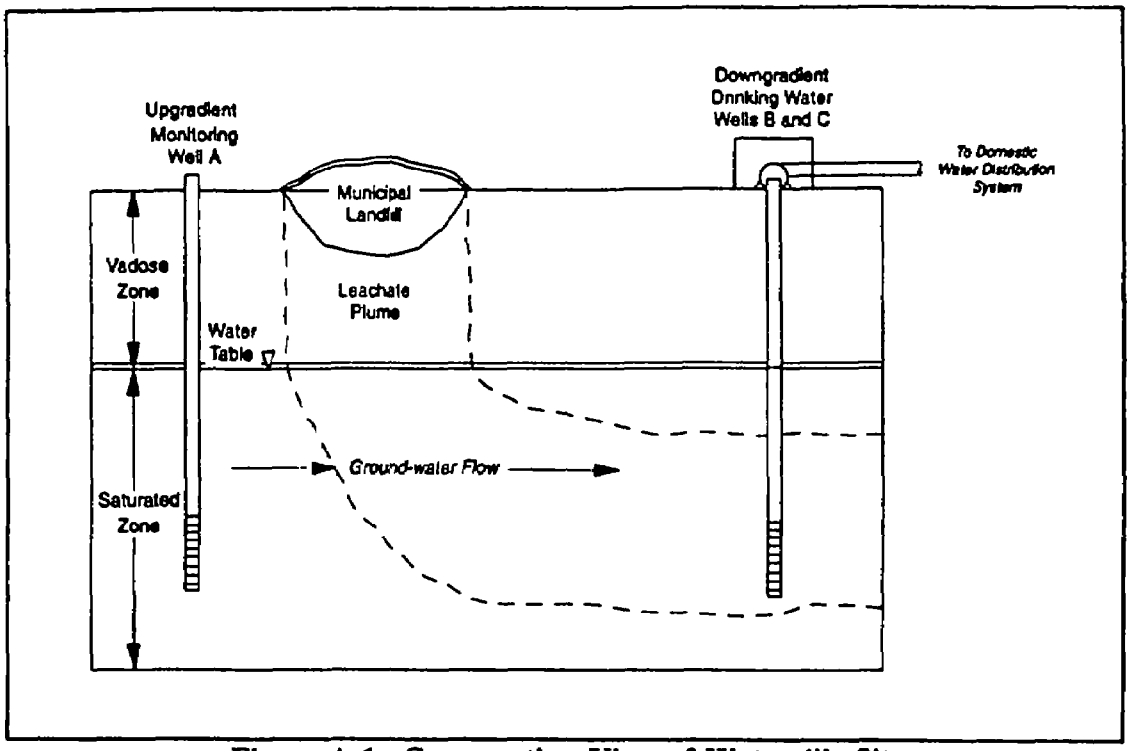

Figure A-1. Cross-section View of Waterville Site

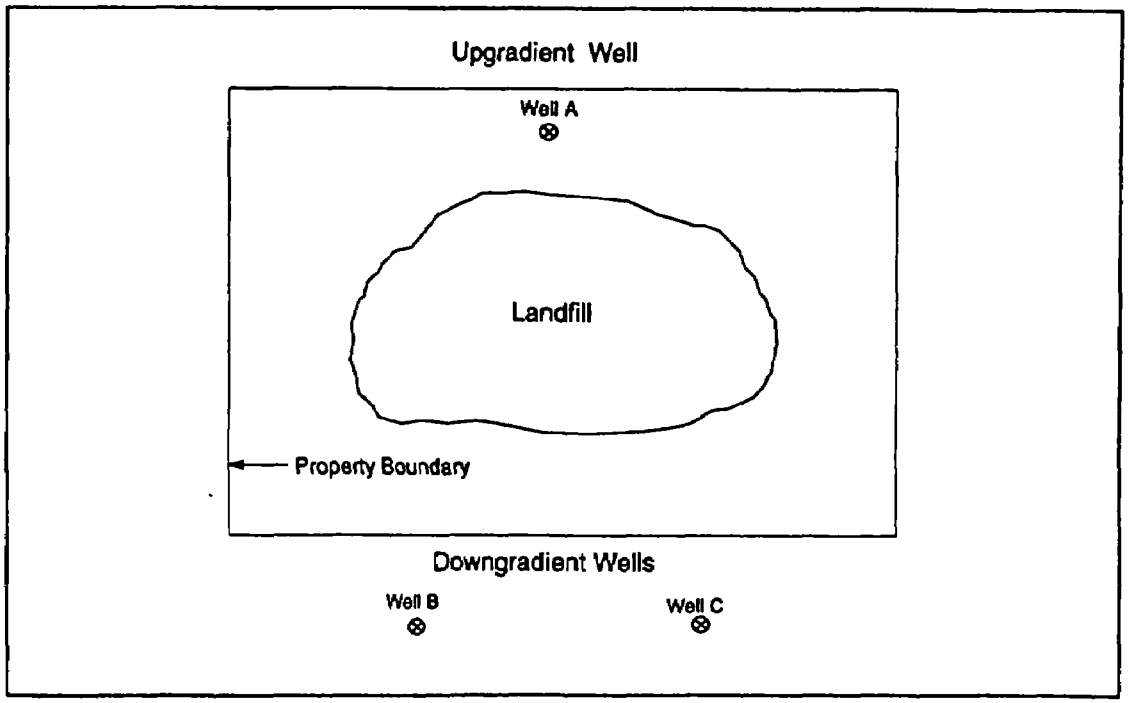

Figure A-2. Plan View of Waterville Site

complete the conceptual site model includes the type of contaminant (PCE) and a range of expected concentrations.

(3) Define exposure scenario — PCE located in the landfill can be released from decaying containers, escape from the unlined landfill, and migrate into the ground-water aquifer which is the drinking water supply for the town. Residents may be exposed to PCE contamination through dermal contact, inhalation, and ingestion of drinking water during routine daily activities in their homes, such as cooking and showering.

(4) Specify the available resources — EPA would like to take the minimum samples necessary that would still provide adequate data quality to support a defensible decision. There are adequate resources to collect and analyze a few samples from each of the three wells.

(A) *Time* — Residents with wells near the site are concerned about the safety of their drinking water. Local representatives would like this problem addressed within 6 months.

(B) *Identify project constraints* — In the pre-remedial phase of the Superfund process, financial resources are limited.

(5) Write a brief summary of the contamination problem — The Waterville Municipal Landfill is known to have accepted large quantities of PCE, and now residents of the town are concerned that the PCE may be leaking and contaminating their domestic water supply via two drinking water wells located near the landfill.

Step 2: Identify the Decision — a statement of the decision that will use environmental data and the actions that could result from this decision.

(1) State the decision — Determine whether there has been a release of PCE from the Waterville Municipal Landfill into the drinking water aquifer of Waterville.

(2) State the actions that could result from the decision —

(a) Recommend Site Evaluation Accomplished (SEA); or
(b) Recommend further assessment or a response action.

Step 3: Identify the Inputs to the Decision — a list of the environmental variables or characteristics that will be measured and other information needed to make the decision.

(1) Identify the informational inputs needed to resolve the decision — Concentrations of PCE in ground water are needed from at least one upgradient location and at least one downgradient location near the landfill.

(2) Identify sources for each informational input — The information on PCE concentrations in ground water can be obtained through analytical measurements performed on water samples drawn from upgradient well A and downgradient wells B and C. There are existing data for well A gathered during 1991 and 1992.

During 1991 and 1992, quarterly PCE data were collected from well A, the upgradient well. The SAM is concerned that the upgradient level of PCE contamination may have changed over the course of the sampling which began two years ago. If the contamination problem has changed during the two years, the previously collected data may not be appropriate and new data may need to be collected. Therefore, the SAM needs to verify that there are no temporal trends in the data for well A. A plot of the eight observations shows no visible trends. The SAM, however, has decided to compare the data from 1991 and 1992 to verify that the distribution of PCE contamination has not changed.

	Observations of PCE Concentrations (ppb)						
Year	*Jan. 1*	*April 1*	*July 1*	*Oct. 1*	*Mean*	*Std. Dev.*	*Variance*
1991	0.406	0.399	0.340	0.383	0.382	0.0296	8.767E-04
1992	0.434	0.347	0.422	0.383	0.397	0.0395	1.563E-03
Differences (1991 minus 1992)	-0.028	0.052	-0.082	0.0	-0.0145	0.0559	3.124E-03

Evaluation of changes in the PCE concentration over the sampling period 1991-1992

Comparison of Sample Variance: An F-test can be used to test the uniformity of two variances by comparing the ratio of the two variances with critical values from an F-distribution. The ratio of 1991 and 1992 variances is:

$$F = \frac{1.563E\text{-}03}{8.767E\text{-}04} = 1.783$$

Since the SAM wishes to test $H_0 : \sigma^2_{1991} = \sigma^2_{1992}$ versus $H_1 : \sigma^2_{1991} \neq \sigma^2_{1992}$, the critical region (with $\alpha = .1$) is given by:

$$F < F_{(1-\alpha/2)} = 0.1078$$

$$F > F_{(\alpha/2)} = 9.28$$

Since $1.783 \not< 0.1078$ and $1.783 \not> 9.28$, the SAM cannot conclude that the variance in 1991 is different from the variance in 1992. Therefore, the SAM may assume these variances are equal.

Comparison of Sample Means: A t-test can be used to test the equivalence of two sample means. Since it has already been concluded that the variances are not different, a pooled t-test of the form:

$$t = \frac{|mean_1 - mean_2|}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} = \frac{.0145}{.0346 \cdot \sqrt{\frac{1}{4}+\frac{1}{4}}} = .593$$

$$where \quad S_p = \frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}$$

may be used. This value will be compared to the critical value of a t-distribution with 6 degrees of freedom. Since 0.593 is less than the critical value, 1.943, the SAM cannot conclude that the yearly means are different. As a result, the SAM has determined that the sampling data from 1991 and 1992 are adequate for use in the comparison with downgradient wells.

(3) Define the basis for establishing contaminant-specific action levels — The action level for this problem is the lowest possible PCE concentration that demonstrates a significant increase in comparison to the upgradient concentration.

(4) Identify potential sampling techniques and appropriate analytic methods — The bottom valve bailer (teflon or stainless steel 316) has been identified as a potential sampling technique. A dedicated sampler will be used for each well. GC/MS is the proposed analytical technique.

Step 4: Define the Boundaries of the Study — a detailed description of the spatial and temporal boundaries of the decision; characteristics that define the environmental media, objects, or people of interests; and any practical considerations for the study.

(1) Define the spatial boundaries —

(A) *Define the domain within which all decisions must apply.* The study will focus on ground water within the unconfined aquifer below the landfill.

(B) *Specify the characteristics that define the population of interest.* PCE concentrations in ground-water monitoring wells B and C. For the purposes of this study, these wells are assumed to be representative of the aquifer below the landfill.

(C) *Define the scale of decision making.* Samples will be taken from the two downgradient ground-water monitoring wells (B and C). A separate decision will be made for each drinking water well.

(2) Define the temporal boundaries —

(A) *Determine what timeframe the sampling data must represent.* Because the study is not intended to determine health risks posed by PCE, there is no specific timeframe to which the results will apply.

(B) *Determine when to collect data.* EPA is interested in characterizing the contamination at this site quickly because of the potential adverse health effects of exposure to PCE in drinking water. Because the data from the three wells will be compared, samples will be collected on the same day. Past experience at similar sites indicates that there are no systematic variations in PCE concentration over time, so samples may be taken at any time of day.

(3) Identify practical considerations that may interfere with the study — EPA does not expect to encounter any practical constraints while sampling.

Step 5: Develop a Decision Rule — an "if...then .." statement that defines the conditions that would cause the decision maker to choose among alternative actions.

(1) Specify the parameter of interest — The study is trying to quickly determine whether the downgradient concentration of PCE is significantly greater than the upgradient concentration, so the SAM has decided to specify the parameter as an observation of PCE concentration in each of the downgradient wells.

(2) Specify the action level for the study — The action level for this problem is the lowest possible PCE concentration that demonstrates a significant increase when compared with the upgradient concentration. The specific concentration will be identified during the Optimize the Design step.

(3) Develop a decision rule (an "if...then..." statement) — If any downgradient sample yields a PCE value significantly greater than the upgradient well, then there is actual contamination of the ground water and further assessment or response is required; otherwise recommend SEA.

Step 6: Specify Limits on Decision Errors — the SAM's acceptable decision error rates based on a consideration of the consequences of making an incorrect decision.

(1) Determine the possible range of the parameter of interest — The scoping team has estimated the range of the parameter of interest to be 0-10 ppb PCE in the ground water, based on the evaluation of similar PCE releases from other sites.

(2) Define both types of decision errors and identify the potential consequences of each —

(A) *Define both types of decision errors and establish which decision error has the more severe consequences.* The two decision errors are:

Decision Error 'a': Deciding that the downgradient well PCE concentration is greater than the upgradient well when it is not. The consequences of this decision error include the unnecessary costs of further study, and the possibility of unnecessary remedial or emergency removal action. Treating ground water is usually a lengthy and resource-intensive process. Other remedial options such as providing an alternate drinking water supply can be very costly also. A positive consequence of taking unnecessary action is that some environmental improvement may occur (e g , through

removing very low levels of PCE and other contaminants), even though the improvement may be of little value when compared to the costs.

Decision Error 'b': Deciding that the downgradient well PCE concentration is not greater that the upgradient well when it is. Some consequences of this decision error include environmental damage, increased future health costs, and increased cancer illness and deaths. A positive consequence is that resources are conserved. While the resource savings may be of small consequence when weighed against the negative consequences, it is important to consider them here. A complete, balanced picture of the problem can only be developed if both positive and negative consequences of the decision error are considered. Decision Error 'b' is the more severe decision error.

(B) *Establish the true state of nature for each decision error.* The true state of nature for decision error 'a' is that the downgradient well does not have a higher concentration of PCE than the upgradient well. The true state of nature for decision error 'b' is that the downgradient well has a higher concentration of PCE than the upgradient well.

(C) *Define the true state of nature for the more severe decision error as the baseline condition (null hypothesis) and define the true state of nature for the less severe decision error as the alternative hypothesis.*

Null hypothesis, H_0 = The downgradient well has a higher concentration of PCE than the upgradient well.

Alternative hypothesis. H_A = The downgradient well does not have a higher concentration of PCE than the upgradient well.

(D) *Assign the terms "false positive" and "false negative" to the proper errors.*

False positive error = decision error 'b'
False negative error = decision error 'a'

(3) Identify Acceptable Decision Error Rates —

False Positive Error: If the downgradient concentration of PCE is greater than the upgradient concentration due to a release, the SAM desires at least a 95 percent probability of finding that a release has occurred (5% probability of a false positive error). In this example, the SAM becomes increasingly concerned the higher the downgradient PCE concentration is in comparison to the upgradient well.

False Negative Error: If there truly has been no release, the SAM wants at most a 5 percent probability that the data indicate a release.

(4) Specify the Gray Region — There will be no gray region for this problem since the decision is to determine a "significant difference" between the concentration of the downgradient wells and background concentrations rather than a fixed point (action level).

Step 7: Optimize the Design — the decision maker will analyze existing data and select the lowest cost sampling design that is expected to achieve the DQOs.

(1) Develop general sampling and analysis design alternatives — Existing data from well A were found to be useful in determining the contamination level upgradient of the site. New data will be generated for the downgradient wells and tested to determine whether they belong to the same population as the upgradient data. If the downgradient values are significantly higher, then it will be concluded that the upgradient and downgradient concentration levels come from different populations. An upper 95% tolerance limit on the population (with 95% probability that at least 95% of the distribution will be less than the limit) will be used to make this determination.

A tolerance interval may be used to prove that a well is contaminated; however, it cannot conclusively determine that a well is not contaminated; The scoping team believes, based on the past history of the site, that wells B and C are contaminated. Thus, a tolerance interval will be used to quickly verify that the wells are contaminated. If data from wells B and C fail to exceed the upper tolerance limit, then this method is inconclusive and an alternative sampling design should be developed.

The tolerance interval used will be based on a normal distribution. Hence, the assumption that the eight observations from well A follow a normal distribution should be tested. Due to the small sample size, Geary's Test for Normality will be used to test this assumption. The test statistic will be

$$a = \frac{\sum_{i=1}^{n} |x_i - \bar{x}|}{\sqrt{n\left[\sum x_i^2 - (\sum x_i)^2/n\right]}}$$

and an approximate test for normality will be

$$Z = \frac{(a - 0.7979)}{\left(\frac{0.2123}{\sqrt{n}}\right)} \sim N(0,1)$$

If $Z > 1.96$, the assumption of normality at a 5% level of significance will be rejected

For the data from well A,

$$a = \frac{0.248829}{\sqrt{8 \cdot 0.007739}} = 0.835914$$

$$Z = \frac{(0.835914 - 0.7979)}{\left(\frac{0.2123}{\sqrt{8}}\right)} = 0.506459$$

Since $Z < 1.96$, the idea that the data are normally distributed cannot be rejected. Therefore, it will be assumed that the upgradient data are normally distributed and can be used to construct a tolerance interval.

Using the eight observations from well A, an upper tolerance interval (TL) can be constructed by:

$$TL = \text{mean} + K * \text{Std. Dev.}$$

where K is a one-sided normal tolerance factor. A table of tolerance factors can be found in the *Guidance Document on the Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities*, EPA, 1993. In this case, K(0.95, 0.95, 8) = 3.188, and

$$TL = 0.389 + 3.188 * 0.03325 = 0.495$$

Any one observation over 0.495 will cause the SAM to conclude that additional contamination above the upgradient level has been observed. In other words, any one observation from either downgradient well that exceeds 0.495 will be cause for deciding that there has been a release from the landfill.

Statistical Models

For each observation y_i from the upgradient well A,

$$y_i = \mu + e_i$$

where μ represents the mean PCE concentration for the upgradient well and the e_i's represent sampling and measurement error which are assumed to be distributed with a mean of 0 and a variance equal to σ^2. Unless the data demonstrate otherwise, the observations from the downgradient wells B and C should also follow this model.

Sample Size

Ideally the SAM would like to collect just one sample from each of the two downgradient wells. Collection of one additional sample from the upgradient well is recommended to ensure that the direction of the plume from the dry cleaning facility has not changed.

(2) Select the most resource-effective design that satisfies all of the DQOs — This design is resource-effective because it requires a small number of samples (one from each well). However, if neither sample exceeds 0.495, then an alternative sampling design will be developed which would satisfy the scoping team's limits on decision errors. (A tolerance interval will only satisfy the limits of a false-positive error.)

(3) Document the details and assumptions of the selected design — This design assumes that the purpose of sampling is to verify that a release has occurred. If the data do not demonstrate that a release has occurred, the decision maker cannot conclude that the wells are not contaminated and an alternative sampling design will be developed.

SECTION B

REMOVAL PROGRAM EXAMPLE

THE LEADBURY SUPERFUND SITE

1.0 BACKGROUND

The Leadbury Superfund Site covers a large area in two counties within the State of Oklahoma. The soil within this area has elevated levels of lead. The site surrounds the town of Leadbury where the Lead Smelter Co. has been mining and smelting lead since 1933. Currently, the area of surface soil contamination extends for approximately 36 square miles surrounding the town. The lead has allegedly originated from stack emissions or possibly from improper disposal of waste materials from the smelting and mining processes. Lead concentrations exceed 500 ppm at some portions of the site.

The Environmental Protection Agency (EPA) has decided to conduct the Remedial Investigation/Feasibility Study (RI/FS) and the remedial design for this site concurrently with the removal action in observance of the Superfund Accelerated Cleanup Model (SACM) guidance. Therefore, all data collected during the removal phase will be used in later phases of the study.

The predominant threat to the public from this site comes from the inhalation and/or ingestion of lead-contaminated soil particles. Lead is known to produce many adverse health effects in humans ranging from reproductive system disorders, delays in neurological and physical development, cognitive and behavioral changes, and increased blood pressure. The main exposure pathway for lead is inhalation. Inhalation exposure is most likely to occur during dry and windy conditions that are prevalent during the summer months. Children are at special risk from lead exposure because their behavior traits result in greater intake of soil per body weight. In addition, children are more likely than adults to have nutrient deficiencies which increase the metal absorption and retention. It has also been indicated that adverse neurological effects occur at lower blood lead level thresholds in children.

An Emergency Removal Branch (ERB) assessment of the site was conducted in two phases. During Phase I, an area of 36 miles surrounding the town was sampled to determine the contaminants of concern. The samples were analyzed for 24 target compound metals and the results identified lead as the contaminant that should be addressed in more extensive sampling. In Phase II, additional surface soil locations were sampled within the Phase I area from 53 locations that were determined to be "high-access" areas for children, the target population at risk. These included school yards, playgrounds, day care centers, and church yards. Twenty-six of the high-access areas were determined to have concentrations of lead in excess of the removal program's action level of 500 ppm. These 26 areas were considered to present imminent and substantial endangerment to the public.

As part of the sampling done in Phase II, the removal program determined that the lead contamination was distributed bimodally (i.e., a graph of the distribution of lead concentrations shows two distinct peaks). The concentration of the low mode is 30 ppm while the concentration of the high mode is 700 ppm. The lower concentration of lead is thought to have come from aerial deposition

associated with the lead smelter and other mining operations. The higher concentrations are thought to be due to the use of contaminated fill material. The fill most likely came from mining tailings. It was therefore decided that a sampling plan should be initiated to locate the portions of the high-access areas that had lead contamination in excess of 500 ppm. The contaminated soils would then be removed and clean fill would replace it. The removal program has decided to use the DQO Process to help them develop the sampling plan to locate areas of excess lead contamination.

As a precursor to the DQO Process, the ERB estimated the cost of disposal for the contaminated soil. They subjected soil samples to the Toxicity Characteristic Leaching Procedure (TCLP) to determine if the contaminated soil was considered a "hazardous substance" under RCRA regulations and would therefore need to be disposed of at a more expensive hazardous waste facility. The tests showed that the contaminated soil was considered non-hazardous and could therefore be disposed of at a less costly municipal landfill.

2.0 DQO DEVELOPMENT

Step 1: State the Problem — a description of the problem(s) and specifications of available resources and relevant deadlines for the study.

(1) Identify the members of the DQO scoping team — The members of the scoping team will include the On-Scene Coordinator (OSC), the manager of the Lead Smelter Co., a Quality Assurance Officer, a representative of the Leadbury town council, a statistician who has experience with sampling design, and a chemist with field experience. The decision maker will be the OSC of the removal program.

(2) Define/refine the conceptual site model — The source of contamination is from lead found in surface soil at 26 "high-access" areas around the city. The lead has been deposited through air deposition at the high-access areas from lead smelter operations in the region over a period of 60 years. The concentration of lead is expected to be from 0 - 1000 ppm based on site preliminary site investigations. The receptors are children between the ages of 1-12 years.

(3) Define the exposure scenario — EPA is concerned about the secondary source of lead contamination existing in the surface soil at 26 high-access areas throughout the city, so the original release mechanism from the smelter is not directly relevant. However, lead will be released from the surface soil in the form of dust. The lead will be bound to soil particles. Children will be exposed through inhalation of the dust particles and through ingestion of contaminated soil at each site. The future land use is assumed to be the same as the current mixed uses.

(4) Specify available resources — The total budget for sampling, removal, and disposal is $5,560,000. Therefore approximately $200,000 is available for each of the 26 high-access areas.

(A) *Time.* All removals should be completed within 6 to 8 months.

(B) *Identify project constraints.* The OSC has requested that all stages of the operation be performed in a manner that minimizes the time and cost of sampling, analysis, and disposal.

(5) Write a brief summary of the contamination problem — Surface soil in high-access areas of Leadbury are contaminated with relatively high concentrations of lead. EPA needs to determine what portions of soil within the high-access areas need to be removed.

Step 2: Identify the Decision — a statement of the decision that will use environmental data and the actions that could result from this decision.

(1) State the decision(s) — Determine what areas within the 26 high-access areas have concentrations of lead in the soil that exceed the removal program's regulated standard.

(2) State the actions that could result from the decision —

(a) Further study will take place to delineate contamination, the surface soil will be removed, and clean fill will replace it.
(b) The surface soil will be left intact.

Step 3: Identify the Inputs to the Decision — a list of the environmental variables or characteristics that will be measured and other information needed to make the decision.

(1) Identify the informational inputs needed to resolve the decision — Concentration of lead in the soil within the 26 high-access areas.

(2) Identify sources for each informational input — The concentration of lead can be measured from soil samples.

(3) Define the basis for establishing contaminant-specific action levels — The action level for lead in soil has been set for the removal program by the Agency for Toxic Substance Disease Registry (ATSDR), based on the risk of exposure and the possibility of adverse health consequences. The action level is 500 ppm.

(4) Identify potential sampling techniques and appropriate analytic methods — The analytical method will be atomic absorption. The tulip bulb planter has been identified as a potential sample collection device.

Step 4: Define the Boundaries of the Study — a detailed description of the spatial and temporal boundaries of the decision; characteristics that define the environmental media, objects, or people of interest; and any practical considerations for the study.

(1) Define the spatial boundaries —

(A) *Define the domain within which all decisions must apply.* The boundaries of the study will be limited to the property boundaries of each separate high-access area that has been identified as having soil contamination that exceeds the removal program standard of 500 ppm for lead. Each of the 26 high-access areas will be evaluated and sampled separately.

(B) *Specify the characteristics that define the population of interest.* Surface soil (0-6 inches) associated with the site. Each of the 26 high-access areas will be considered subpopulations.

(C) *Define the scale of decision making.* Because the contaminated soil is thought to come from fill material, the sampling plan should be adequate to detect the smallest area that would reasonably have been filled within the high-access areas. The scoping team has chosen a circle with a diameter of 40 feet to a depth of 6 inches to represent the area that corresponds to the smallest area that could reasonably have been filled. This is the area that corresponds to four dump truck loads (8 tons) of fill material, spread 6 inches thick. Therefore the sampling plan must adequately detect contaminated circular areas of contaminated soil that have a diameter of 40 feet.

(2) Identify temporal boundaries — The EPA is facing public pressure to reduce the exposure risks from the site quickly.

(A) *Determine what timeframe the sampling data must represent.* Because the study is not intended to determine risk, there is no specific timeframe to which the results will apply.

(B) *Determine when to sample.* Lead in soil is stable. It will not degrade or migrate from the "high-access areas". Therefore lead can be sampled at any time. For best results, soil samples should be taken when the soil moisture is relatively low (less than 30%) so that the core samples will hold their form.

(3) Identify practical considerations that may interfere with the study — Two of the high-access areas provide a passageway between elementary school buildings. For students to avoid possible exposure, a walkway built of plywood will be installed. Additionally, it will not be possible to perform removals on these areas during regular school hours (8:00 am - 2:30 pm).

Step 5: Develop a Decision Rule — an "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative actions.

(1) Specify the parameter of interest — A hot spot can be considered as a maximum concentration. Therefore the parameter of interest is the maximum concentration.

(2) Specify the action level for the study — The removal program's action level for lead in soil is 500 ppm. The action level has been set by the ATSDR.

(3) Develop a decision rule (an "if...then..." statement) — If the maximum concentration of lead in any high-access area is greater than 500 ppm, then a second round of sampling will be implemented to delineate the extent of soil contamination. Otherwise, no action will take place.

Step 6: Specify Limits on Decision Errors — the decision maker's acceptable decision error rates based on a consideration of the consequences of making an incorrect decision.

(1) Determine the possible range of the parameter of interest — The possible range of lead concentrations is expected to be from 0-1000 ppm.

(2) Define both types of decision errors and identify the potential consequences of each —

(A) *Define both types of decision errors and determine which decision error has the more severe consequences.* The two decision errors are:

Decision Error 'a': Determining that circular areas of contaminated soil with a radius of 40 feet or greater do not exist when they actually do; i.e., determining there are no hot spots when a hot spot actually exists. The consequence of this error is that contaminated soil will not be removed and human health will be endangered. Decision Error 'a' is the more severe decision error.

Decision Error 'b': Determining that the soil is contaminated when in reality it is not; i.e., determining that a hot spot exists when in reality there are no hot spots. The consequence of this error is that time and energy will be spent on additional sampling. The public will view this error positively in that it shows that the overriding concern is for protecting human health. The consequences, therefore, are far less severe than the consequences of the other decision error.

(B) *Establish the true state of nature for each decision error.* The true state of nature for decision error 'a' is that a hot spot exists. The true state of nature for decision error 'b' is that there are no hot spots.

(C) *Define the true state of nature for the more severe decision error as the baseline condition or null hypothesis and define the true state of nature for the less severe decision error as the alternative hypothesis.*

Null Hypothesis, H_0 = A hot spot exists. (The concentration of an individual sample is above 500 ppm.)

Alternative Hypothesis, H_a = A hot spot does not exist. (The concentration of an individual sample is less than 500 ppm.)

(D) *Assign the terms "false positive" and "false negative" to the proper errors.*

False positive error = decision error 'a'
False negative error = decision error 'b'

Specify the Gray Region — The scoping team has set the gray region, which spans 100 ppm, to the left of the action level.

(4) Identify Acceptable Decision Error Rates —

(a) False Positive Error: The scoping team can accept a rate of 20% for the probability of a false positive (see Figure B-1).

(b) False Negative Error: The scoping team has set the acceptable rate of making a false negative error at 30% (see Figure B-1).

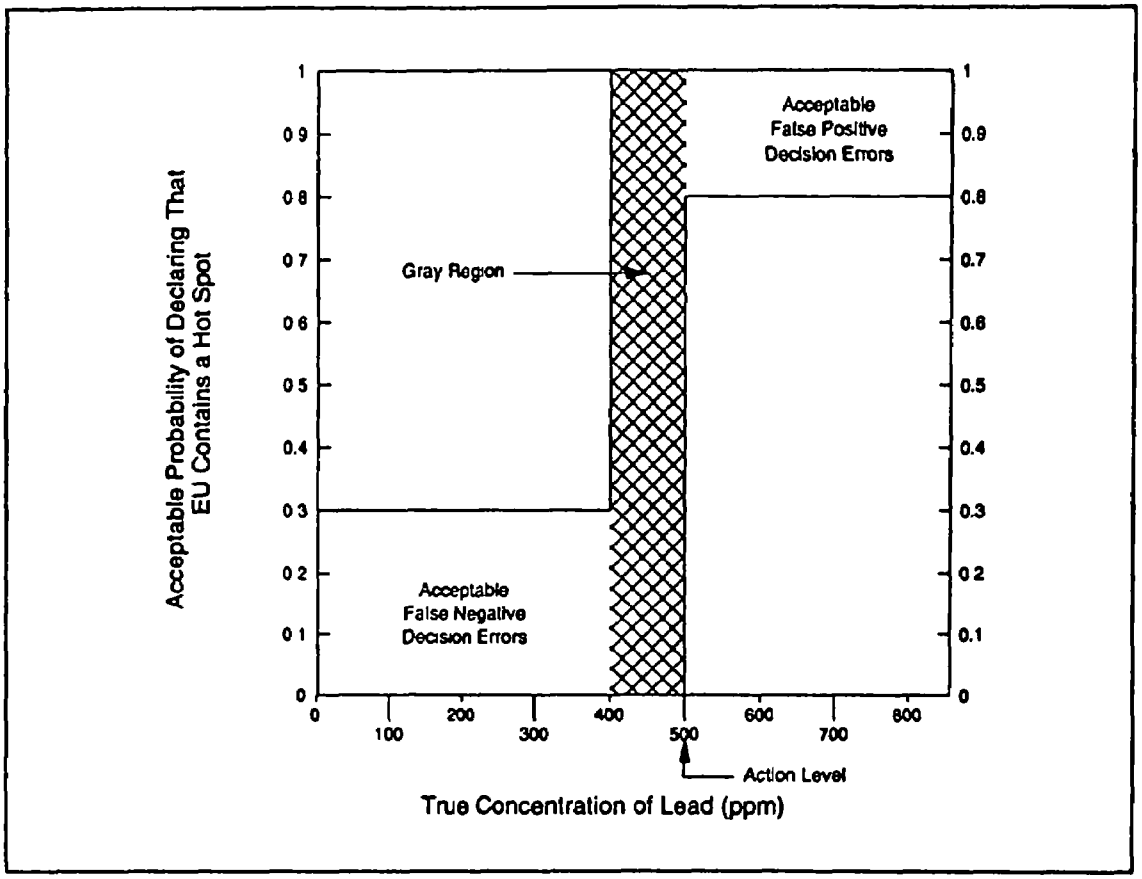

Figure B-1. Design Performance for Soil Lead Testing

Step 7: Optimize the Design — the decision maker will select the lowest cost sampling design that is expected to achieve the DQOs.

(1) Develop general sampling and analysis design alternatives — For each design alternative, the statistician must formulate a statistical model (i.e., a mathematical expression) that tests the hypothesis and select the optimal sample size that satisfies the decision maker's limits on decision errors.

A search sampling method using systematic (or grid) samples will be used to determine whether or not a "hot spot" of contamination exists. If the concentration of lead in any sample within the boundaries is significantly greater than 500 ppm, then a second round of sampling will be implemented to determine the extent of soil contamination. Otherwise, no action will take place.

The second round of sampling, sequential sampling, will characterize the extent of the area that requires removal. Additional soil samples will be taken at a point one-half the distance to the next non-contaminated sampling point. If any sample in the second round is contaminated, additional samples will continue to be collected one-half the distance to the nearest non-contaminated sampling point until a sample shows no contamination. Once this occurs, contaminated soil will be removed up to and including the last clean sample. The soil will be removed to a depth of 8 inches because this is the maximum depth that children are expected to receive exposure from soil during normal activity. Clean fill will be used to fill the depressions made during removal activity.

Samples will be taken in a triangular-shaped grid pattern. The distance between samples will be 42.5 feet (see Figure B-2). Six-inch core samples will be taken at the grid nodes, homogenized, and analyzed at each sampling location.

Because of the extreme bimodal distribution of the lead concentration, the design assumes that when a hot spot is sampled, it will not be mistaken for background and vice versa.

Statistical Models

For each observation y_i:

$$y_i = v_i + e_i$$

where v_i = true value of the i_{th} observation and
e_i = sampling error for the i_{th} observation.

The e_i's are independently and identically distributed with the mean equal to 0 and variance equal to σ^2_s.

Sample Size

Below is an explanation of a procedure that is used to determine the number of samples needed to detect hot spots of contamination within a pre-specified confidence limit. The procedure employs three common sampling patterns (square, rectangular, and triangular) to determine the optimal sample spacing and distance between samples. To determine the minimum spacing between samples that will detect an elliptical hot spot of a pre-specified size and shape with a specified confidence, the following procedure is used:

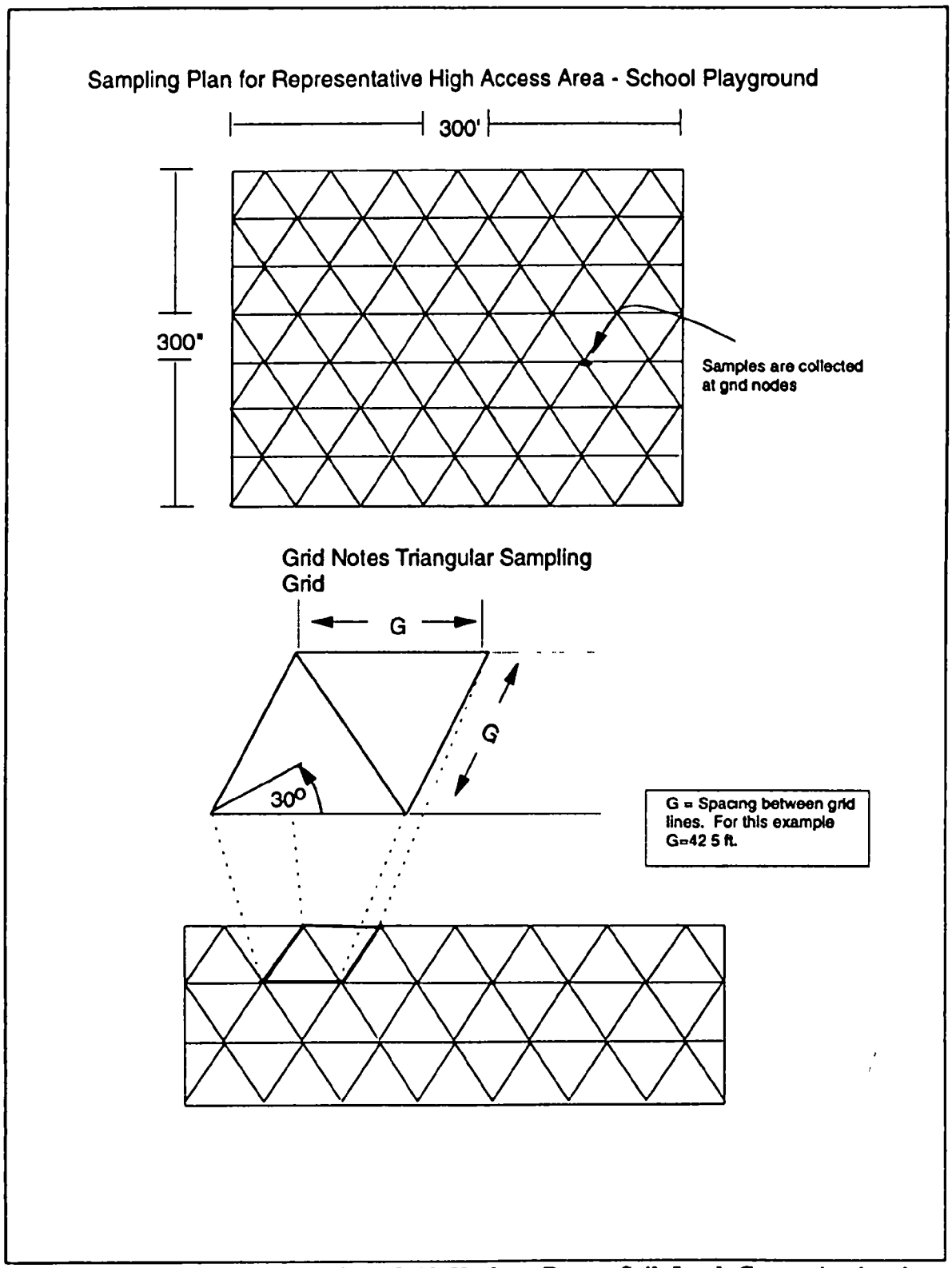

Figure B-2. Triangular Sampling Grid Used to Detect Soil Lead Contamination in a 300′ x 300′ School Playground

(A) Specify the length (L) of the long axis of the hot spot ellipse: L = 20 ft.

(B) Specify the length (R) of the short axis of the hot-spot ellipse: R = 20 ft.

(C) Divide the length of the short axis by the length of the long axis. The solution, S, is called the shape:

$$S = \frac{\text{Length of the short axis of the hot-spot ellipse}}{\text{Length of the long axis of the hot-spot ellipse}} = 1$$

(D) Specify the acceptable probability of not finding the hot spot. In our example the probability of not finding the hot spot corresponds to $\beta = .2$. (In this case, a false positive error.)

(E) Determine the distance between samples (G) using the nomograph (see Figures 2-3 and 2-4) to meet the constraints specified in the first four steps. For a square playground area with a size of 300 ft. x 300 ft., the distance between samples and the number of samples needed to meet the DQOs will be:

Using a square sampling pattern, G = 39.2 feet : 64 samples.

Using a triangular sampling pattern, G = 42.5 feet : 49 samples.

(2) Select the most resource-effective design that satisfies all of the DQOs — Sampling costs include both the cost of collecting and analyzing samples. Each soil sample tested for lead will cost $75.00. The total cost of sampling will depend on the total number of samples.

(3) Document the details and assumptions of the selected design —

- The target (hot spot) is circular. For subsurface targets, this applies to the projection of the target to the surface.
- Samples or measurements are taken on a triangular grid.
- The distance between grid points is much larger than the area sampled, measured, or cored at grid points — that is, a very small proportion of the area being studied can actually be measured.
- The definition of "hot spot" is clear and unambiguous. This definition implies that the types of measurement and the levels of contamination that constitute a hot spot are clearly defined.
- There are no measurement misclassification errors — that is, no errors are made in deciding when a hot spot has been hit.

The most efficient sampling plan is one that uses a triangular sampling grid (see Figure B-2) because it meets the constraints of the DQOs with the fewest number of samples and therefore has the lowest total cost.

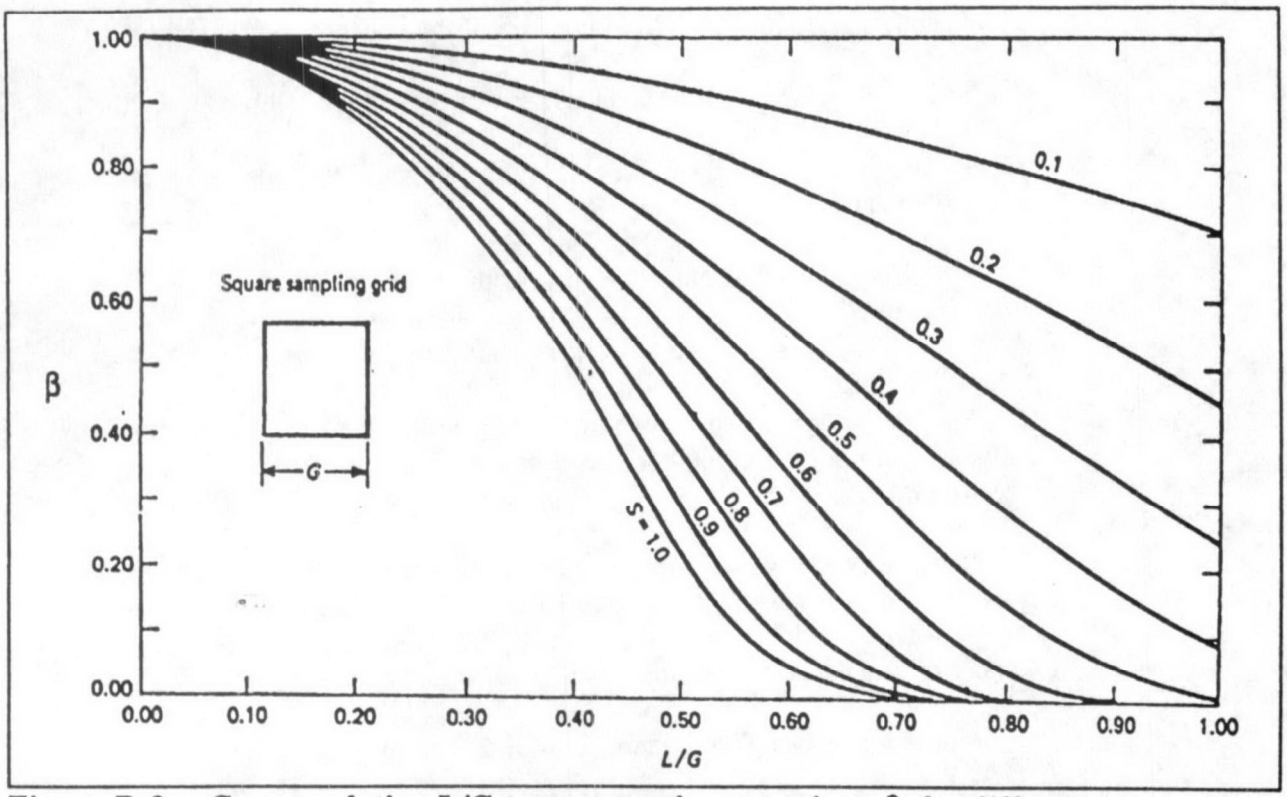

Figure B-3. Curves relating L/G to consumer's uncertainty, β, for different target shapes using a square grid (from Zirschky and Gilbert 1984, with permission)

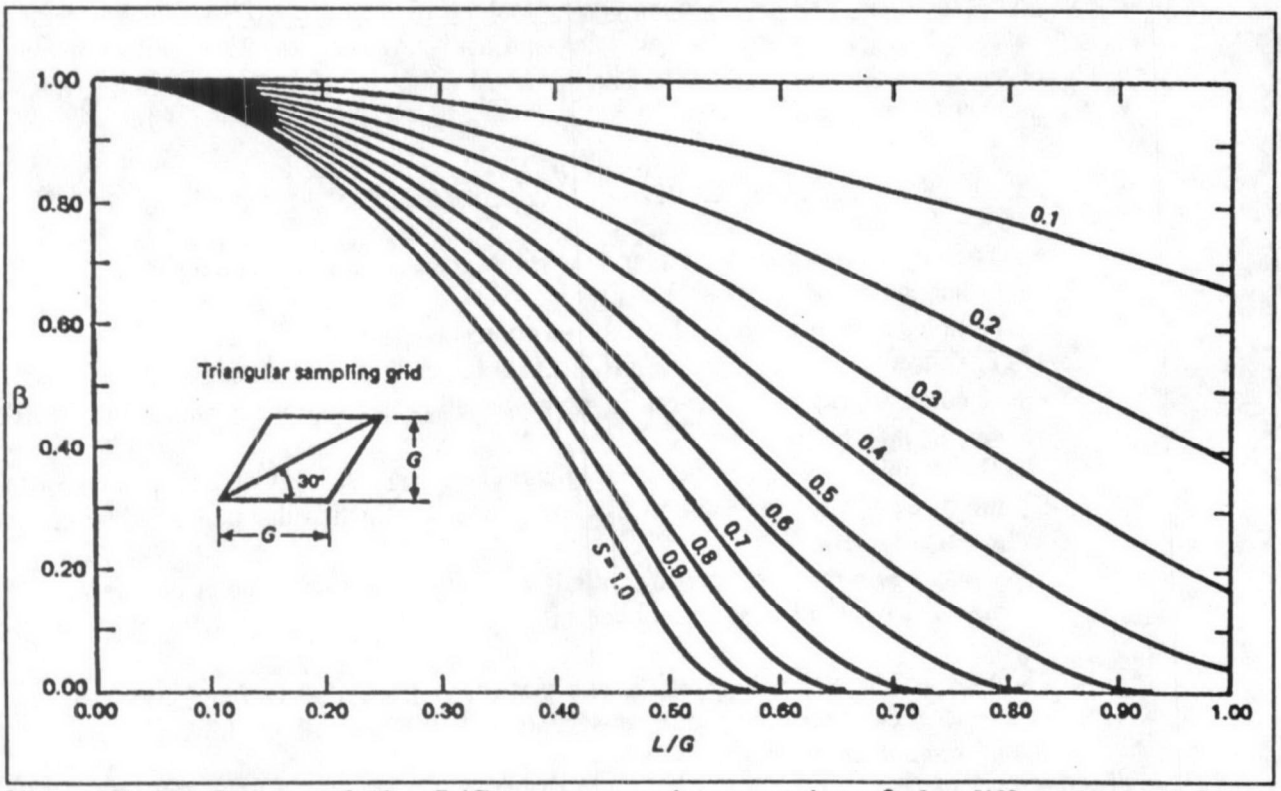

Figure B-4. Curves relating L/G to consumer's uncertainty, β, for different target shapes using a triangular grid (from Zirschky and Gilbert 1984, with permission)

SECTION C

REMEDIAL PROGRAM EXAMPLE

THE RAWHIDE SUPERFUND SITE

1.0 BACKGROUND

The Rawhide Superfund Site is a former leather tannery. Between 1982 and 1985, tannery waste sludge was landfarmed over part or all of a 29-acre pasture (see Figure C-1). "Landfarming" refers to a process of waste disposal that involves spraying or pouring waste onto the soil and then disking the waste into the soil. At this site, the sludge containing high levels of chromium compounds was disked into the soil to a depth of approximately 8 inches. Historical site information indicates that several portions of the landfarm area have received little or no waste.

High concentrations of chromium III and VI have been detected in surface soil samples at the landfarm. This may indicate that wastes were dumped on the ground, but not disked into the soil. Ground-water sampling in wells and springs within three miles of site have shown the presence of chromium and lead at levels below maximum contaminant levels (MCLs). Due to the high levels of chromium in the surface soil, the site has been placed on the National Priorities List (NPL).

The site is currently used to graze cattle. Several residences are located adjacent to the site. Potential human exposure routes identified by the site risk assessor include ingestion and inhalation of soil particulates and ingestion of ground water. Chromium VI compounds are suspected human carcinogens through the inhalation pathway only. Chromium III compounds are not considered carcinogenic. Direct contact with chromium compounds can cause a hypersensitivity reaction.

The scoping team has decided to employ the DQO process to help them determine if there are any areas of the landfarm that pose an unacceptable risk to human health and the environment and thus require further assessment or a response action. By using the DQO process, the team plans to generate a statistically valid sampling design, generate results of known confidence, make defensible decisions, and save time and resources.

2.0 DQO DEVELOPMENT

Following is an example of the output from each step of the DQO process.

Step 1: State the Problem — a description of the problem(s) and specifications of available resources and relevant deadlines for the study.

(1) Identify the members of the DQO scoping team — The members of the DQO scoping team include the RPM, a field sampling expert, a chemist, an engineer, a risk assessor, a QA Officer, a hydrogeologist, a DQO facilitator, and a statistician. The RPM is the decision maker.

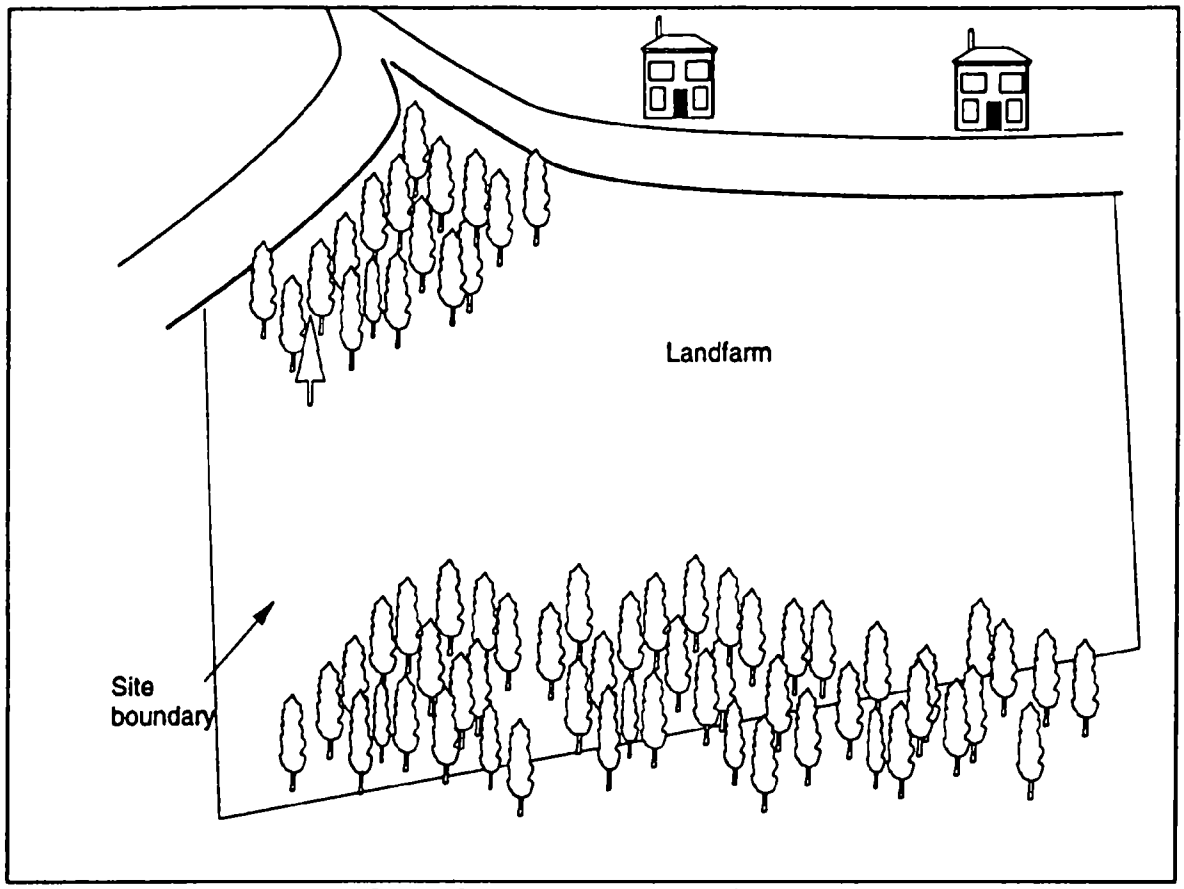

Figure C-1. Site Map of Rawhide Superfund Site

(2) Define/refine the conceptual site model — The source of the contamination is from landfarming waste disposal operations at a former leather tannery. High concentrations of chromium have been observed in soil associated with the site. Chromium and lead were detected in ground-water samples at levels below the MCLs. Contaminants are migrating from surface and subsurface soils to ground water. Contaminants may also become airborne primarily due to wind. The receptors are humans of all ages who live within a 2-mile radius and who derive their drinking water from ground-water wells which are connected to the ground-water aquifer below the site. Cattle who graze on the site are also potential receptors.

(3) Define exposure scenarios — The source of the contamination is the chromium-contaminated soil and the ground water associated with the site. Contaminants will be released through aerial transport and migration to ground water. Contaminants may also migrate through ground water to drinking water wells. The chromium will be bound to soil dust particles or dissolved in ground water. The exposure routes include ingestion of soil, inhalation of dust particles, and ingestion of ground water. The potential exposure points are the contaminated soils on-site and houses connected to drinking water supply. The land use for the site is residential.

(4) Specify the available resources — EPA is concerned about the cost of extensive sampling and analysis, but adequate data quality is a priority. EPA has allocated the funds necessary for a sampling crew of four people for only one week. All sampling must be done within that week.

(A) *Time.* The RPM wants this site addressed in a "reasonable timeframe." The RPM expects data validation to be the most time-consuming aspect of data generation. It may take up to three months after samples are collected before the data are available.

(B) *Identify project constraints.* The sampling team has a limited amount of time to collect samples due to budget constraints. This will be a major consideration during the development of the sampling and analysis design.

(5) Write a brief summary of the contamination problem — This site was placed on the NPL due to the discovery of chromium contaminated soil. Chromium was also detected in ground water associated with the site which is hydraulically connected to drinking water wells. Residents in the area can be exposed to contaminants in soil and ground water via ingestion. Residents can also be exposed to contaminated particulates via inhalation. The site manager has designated the soils associated with the site as an operable unit. Since the site is on the NPL, a remedial investigation will be performed to determine which areas of the soil pose an unacceptable risk to human health or the environment and require further assessment or a response action.

Step 2: Identify the Decision — a statement of the decision that will use environmental data and the actions that could result from this decision.

(1) State the decision(s) — Determine whether sections of the landfarm (soil) pose an unacceptable risk to human health or the environment or whether they exceed ARARs.

(2) State the actions that could result from the decision —

(a) No action.
(b) Recommend further assessment or a response action.

Step 3: Identify the Inputs to the Decision — a list of the environmental variables or characteristics that will be measured and other information needed to make the decision.

(1) Identify the informational inputs needed to resolve the decision — Surface soil samples need to be taken within the site boundaries.

(2) Identify sources for each information input — Total chromium will be measured in soil samples.

(3) Define the basis for establishing contaminant-specific action levels — Since a health-based non-carcinogenic value (600 ppm of total chromium) is lower than the risk-based carcinogenic PRG of 700 ppm for hexavalent chromium, the total chromium concentration value is considered more protective.

(4) Identify potential sampling techniques and appropriate analytic methods — A soil coring device has been identified as the potential sampling technique. Atomic absorption is the proposed analytical methodology.

Step 4: Define the Boundaries of the Study — a detailed description of the spatial and temporal boundaries of the decision; characteristics that define the environmental media, objects, or people of interests; and any practical considerations for the study.

(1) Define spatial boundaries —

(A) *Define the domain within which all decisions must apply.* Surface soil is defined as the top 12 inches of soil within the geographic boundaries of the 29-acre landfarm area, excluding forested areas where landfarming and disposal could not have taken place.

(B) *Specify the characteristics that define the population of interest.* Chromium concentrations in soil samples.

(C) *Define the scale of decision making.* Although the area is rural, future residential development is possible. Residential land use represents a reasonable worst-case scenario. The entire site has been divided into square areas that are approximately 200 x 200 feet. These areas are approximately one acre in size and correspond to the expected residential lot size These areas are referred to as "exposure units" (EUs). EUs which overlapped the site boundaries were combined with EUs having forested areas so that 20 EUs of approximately one acre would result. A separate decision will be made for each EU

(2) Identify temporal boundaries — EPA is facing public pressure to reduce the exposure risk from the site quickly

(A) *Determine what time frame the sampling data must represent.* Because chromium is not migrating or degrading to any significant degree, the sampling results will apply to lifetime exposure.

(B) *Determine when to collect data.* Sampling must occur within a one-week period when EPA has made funds available.

(3) Identify practical considerations that may interfere with the study — The center of each EU will be marked with a wire flag. Because the site is currently used for grazing, there is considerable concern that the cows will ingest the wire flags. This would injure the cows and impede timely sample collection. Some background investigation has indicated that it is not likely the cows will eat the wire flags. As a precaution, the farmers will be informed of the sampling activities in order to protect the welfare of the cows.

Step 5: Develop a Decision Rule — an "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative actions.

(1) Specify the parameter of interest — The mean concentration of total chromium within each EU will be compared to the action level.

(2) Specify the action level for the study — The action level for this problem will be 600 ppm of total chromium.

(3) Develop a decision rule (an "if...then" statement) — If the average total chromium concentration in the surface soil of an EU exceeds 600 ppm, then recommend further assessment or a response action will be taken. Otherwise, no action will be taken.

Step 6: Specify Limits on Decision Errors — the decision maker's acceptable decision error rates based on a consideration of the consequences of making an incorrect decision.

(1) Determine the possible range of the parameter of interest — The possible range of chromium concentrations is 0-1000 ppm.

(2) Define both types of decision errors and identify the potential consequences of each —

(A) *Define both types of decision errors and establish which decision error has the more severe consequences.*

The two decision errors are:

Decision Error 'a': One decision error occurs when the decision maker decides an EU is not contaminated when, in truth, the mean concentration of chromium is greater than or equal to 600 ppm. If an EU that poses an unacceptable risk is not remediated, some resources may be saved, but this would be at the cost of increased human health and/or environmental risk. Increased future health costs or cancer deaths may also result. This decision error is more severe.

Decision Error 'b': The other decision error occurs when the decision maker decides, based on the data, to take action when, in truth, the mean concentration of chromium is less than 600 ppm. One possible consequence of this decision error is unnecessary further study in the EU. This would result in wasted resources and time. Offsetting this to some degree would be the marginal reduction in health risk if a response action is taken.

(B) *Establish the true state of nature for each decision error.* The true state of nature for decision error 'a' is that the mean concentration of chromium is greater than 600 ppm. The true state of nature for decision error 'b' is that the mean concentration of chromium is less than 600 ppm.

(C) *Define the true state of nature for the more severe decision error as the baseline condition or null hypothesis and define the true state of nature for the less severe decision error as the alternative hypothesis.* The hypothesis test is stated as:

Null Hypothesis (H_o): Mean concentration in the EU ≥ 600 ppm

Alternate Hypothesis (H_a): Mean concentration in the EU < 600 ppm

(D) *Assign the terms "false positive" and "false negative" to the proper errors.*

false positive error = decision error 'a'
false negative error = decision error 'b'

(3) Specify the Gray Region — The gray region corresponds to the area where the decision maker considers the consequences of making a false negative decision error to be relatively minor. In this example, the gray region is set to the left of the action level between 500 ppm and 600 ppm (see Figure C-2).

(4) Identify Acceptable Decision Error Rates — The decision maker specified the probability of deciding to take action at four different total chromium concentrations.

True Concentration of Total Chromium	Acceptable Probability of Taking Action
100 ppm	less than or equal to 1%
250 ppm	less than or equal to 10%
500 ppm	less than or equal to 25%
600 ppm	greater than or equal to 95%

Based on the above table, at a true mean of 100 ppm, the decision maker can tolerate making a false negative decision error 1% of the time. At 600 ppm (the action level), the decision maker wants to be confident of taking action 95% of the time (i.e., can tolerate making a false positive decision error 5% of the time).

Step 7: Optimize the Design — the decision maker(s) will select the lowest cost sampling design that is expected to achieve the DQOs.

(1) Develop general sampling and analysis design alternatives — For each design alternative, the statistician must formulate a statistical model (i.e., a mathematical expression) that tests the hypothesis and select the optimal sample size that satisfies the decision maker's limits on decision errors.

Several alternate designs were discussed and subsequently deemed impractical by the decision maker. One design was considered possible, however. A spatially intensive design was developed which would gather composite soil samples from each EU. Samples will be taken using a systematic grid. The sampling crew is more comfortable with this type of design than with a random sampling plan. An approximate t-test is suggested for each EU by calculating

$$t = \frac{600 - M_h}{\sqrt{v} \; / \; \sqrt{2}}$$

where M_h is the mean of the h^{th} EU and v is the pooled within-EU variance. This will be compared with the critical value of a t-distribution for $\alpha = 0.05$ and 20 degrees of freedom. If the computed value exceeds the critical value, the null hypothesis will be rejected.

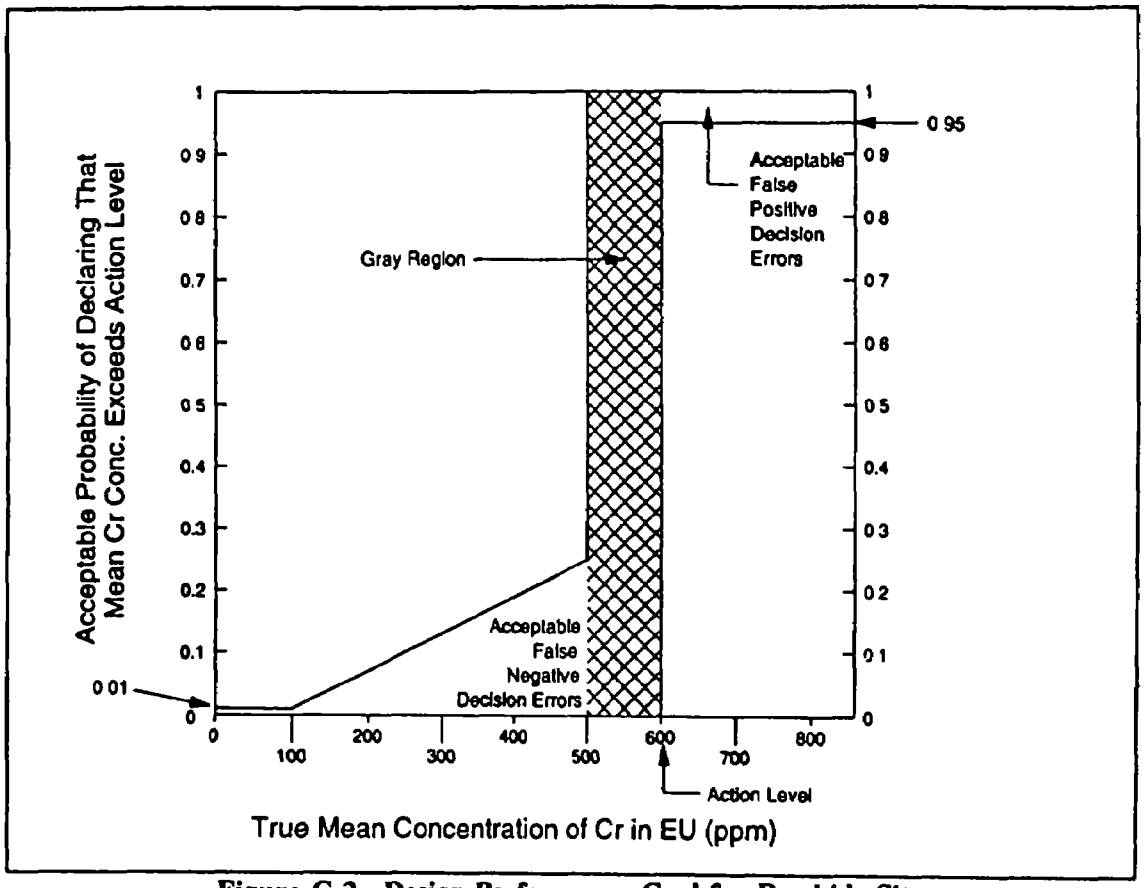

Figure C-2. Design Performance Goal for Rawhide Site

Estimate of Variance

A limited field investigation was conducted in order to develop an estimate of the expected variability of the contaminant. A preliminary estimate of the total standard deviation of the chromium is 65.70 ppm.

Statistical Model

The model proposed for the observed composite sample concentrations is

$$x_{ij} = \mu_i + \varepsilon_{ij}$$

where: x_{ij} = j^{th} composite sample of the i^{th} EU
μ_i = mean concentration of the i^{th} EU
ε_{ij} = deviation from μ_i for j^{th} composite sample of the i^{th} EU
and the ε's are distributed normally with mean zero.

Sample Size

A maximum of nine samples per composite can be realistically handled. Using this information and the prior estimate of the standard deviation, two composite samples of nine scoops each will be randomly selected from each of the 20 EUs. This sample size will provide 20 degrees of freedom, provided that the within-EU variances can be pooled.

(2) Select the most resource-effective design that satisfies all of the DQOs — Composite samples save money by reducing analysis costs, which is important for the initial study as well as for the next phase of study.

This design meets the decision maker's objectives for adequately identifying which EUs require further study or a response action. This is critical given the expected high cost of remediation.

(3) Document the details and assumptions of the selected design — Two composite samples of nine scoops each will be selected within each EU. A systematic grid with nine nodes will be used to collect the first composite sample. The second composite sample will consist of nine samples that are offset from the original grid nodes. Within each EU it is assumed that the variance is the same, regardless of the level of contamination. This assumption can be tested after the data are collected.

APPENDIX III

GLOSSARY

GLOSSARY OF TERMS

action level: the numerical value that causes the decision maker to choose one of the alternative actions (e.g., compliance or noncompliance). It may be a regulatory threshold standard, such as a Maximum Contaminant Level for drinking water, a risk-based concentration level, a technological limitation, or reference-based standard.

bias: the systematic or persistent distortion of a measurement process which causes errors in one direction (i.e., the expected sample measurement is different than the sample's true value).

boundaries: the area or volume (spatial boundary) and the time period (temporal boundary) to which the decision will apply. Samples are collected within these boundaries to be representative of the population of interest for the decision.

Data Quality Assessment (DQA): a process of statistical and scientific evaluation that is used to assess the validity and performance of the data collection design and statistical test, and to establish whether a data set is adequate for its intended use.

Data Quality Objectives (DQOs): qualitative and quantitative statements derived from the outputs of each step of the DQO Process which specify the study objectives, domain, limitations, the most appropriate type of data to collect, and specify the levels of decision error that will be acceptable for the decision.

Data Quality Objectives Process: a Quality Management tool based on the Scientific Method and developed by the U.S. Environmental Protection Agency to facilitate the planning of environmental data collection activities. The DQO Process enables planners to focus their planning efforts by specifying the use of the data (the decision), the decision criteria (action level), and the decision maker's acceptable decision error rates. The products of the DQO Process are the DQOs.

decision errors:

false positive error — The false positive error occurs when data mislead a decision maker into believing that the burden of proof in a hypothesis test has been satisfied, so that the null hypothesis is erroneously rejected. A statistician usually refers to the false positive error as alpha (α), the level of significance, the size of the critical region, or a Type I error.

false negative error — The false negative error occurs when data mislead the decision maker into wrongly concluding that the burden of proof in a hypothesis test has not been satisfied so that the null hypothesis is accepted. A statistician usually refers to this as beta (β), or a Type II error. It is also known as the complement of Power.

defensible: the ability to withstand any reasonable challenge related to the veracity or integrity of laboratory documents and derived data.

directed sampling: see judgmental sampling.

gray region: an area that is adjacent to or contains the action level, and where the consequences of making a decision error are relatively small.

judgmental sampling: a subjective selection of sampling locations based on experience and knowledge of the site by an expert.

limits on decision errors: the acceptable decision error rates established by the decision maker. Economic, health, ecological, political, and social consequences should be considered when setting limits on decision errors.

mean: the arithmetic average of a set of values.

measurement error: the difference between the true or actual state and that which is reported from measurements.

median: the middle value for an ordered set of n values; represented by the central value when n is odd or by the average of the two most central values when n is even.

medium: a substance (e.g., air, water, soil) which serves as a carrier of the analytes of interest.

natural variability: the variability that is inherent or natural to the media, objects, or people being studied.

parameter: a numerical descriptive measure of a population.

percentile: a value on a scale of 100 that indicates the percentage of a distribution that is equal to or below it.

population: the total collection of objects or people to be studied and from which a sample is to be drawn.

power curve: the probability of rejecting the null hypothesis (H_o) over the range of the population. The power function is used to assess the goodness of a test or to compare two competing tests.

probabilistic sampling: a random selection of sampling locations that allows the sampling results to be extrapolated to an entire site (or portion of the site).

quality assurance (QA): an integrated system of management activities involving planning, quality control, quality assessment, reporting, and quality improvement to ensure that a product or service (e.g., environmental data) meets defined standards of quality with a stated level of confidence.

Quality Assurance Project Plan (QAPP): a formal technical document containing the detailed procedures for assuring the quality of environmental data prepared for each EPA environmental data collection activity and approved prior to collecting the data.

quality control (QC): the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users. The aim is to provide quality that is satisfactory, adequate, dependable, and economical.

Quality Management Plan (QMP): a formal document describing the management policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation protocols of an agency, organization, or laboratory for ensuring quality in its products and utility to its users. In EPA, QMPs are submitted to QAMS for approval.

range: the numerical difference between the minimum and maximum of a set of values.

[1]sample: a single item or specimen from a larger whole or group, such as any single sample of any medium (air, water, soil, etc.).

[2]sample: a group of samples from a statistical population whose properties are studied to gain information about the whole.

sample variance: a measure of the dispersion of a set of values.

sampling: the process of obtaining a subset of measurements from a population.

sampling error: the error due to observing only a limited number of the total possible values that make up the population being studied. It should be distinguished from errors due to imperfect selection, bias in response, and errors of observation, measurement, or recording, etc.

scoping team: the group of people that will carry out the DQO Process. Members include the decision maker (senior manager), representatives of other data users, senior program and technical staff, senior managers (decision makers), someone with statistical expertise, and a QA/QC advisor (such as a QA Manager).

standard deviation: the square root of the variance.

statistic: a function of the sample measurements; e.g., the sample mean or standard deviation.

study design: a study design specifies the final configuration of the environmental monitoring effort to satisfy the DQOs. It includes the types of samples or monitoring information to be collected; where, when, and under what conditions they should be collected; what variables are to be measured; and the Quality Assurance and Quality Control (QA/QC) components that ensure acceptable sampling error and measurement error to meet the decision error rates specified in the DQOs. The study design is the principal part of the QAPP.

total study error: the sum of all the errors that are incurred during the process of sample design through data reporting. Total study error is related to decision error.

true: being in accord with the actual state of affairs.

Type I error: an error that can occur during a statistical hypothesis test. A Type I error occurs when a decision maker rejects the null hypothesis (decides that the null hypothesis is false) when it is actually true.

Type II error: an error that can occur during a statistical hypothesis test. A Type II error occurs when the decision maker accepts the null hypothesis (decides that the null hypothesis is true) when it is actually false.

uncertainty: a measure of the total variability associated with sampling and measurement that includes the two major error components: systematic error (bias) and random error (imprecision)

APPENDIX IV

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Section 3

FIELD SCREENING

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. List and give a functional description of the classes of chemicals on the Target Compound List.

2. Determine the uses and limitations of the x-ray fluorescence techniques.

3. Determine the uses and limitations of soil gas techniques.

4. Describe the theory and use of the enzyme immunoassay test.

5. Determine the uses and limitations of magnetics, electromagnetics, and ground-penetrating radar.

6. List and describe other types of inexpensive field test kits.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

FIELD SCREENING

WHY FIELD SCREENING

- Limits resources necessary
- Limits time
- Reduces large areas requiring further investigation

TARGET COMPOUND LIST

- List of 148 chemicals
- Toxic and prevalent
- Updated periodically

TARGET COMPOUND LIST (cont.)

- Volatiles
- Semivolatiles (BNA)
- Pesticides/PCBs
- Metals
- Cyanide

TARGET COMPOUND LIST

Volatile Compounds*

Acetone
Benzene
Bromodichloromethane
Bromoform
Bromomethane
2-Butanone
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
Dibromochloromethane
1,1-Dichloroethene
1,2-Dichloroethene (total)
1,1-Dichloroethane
1,2-Dichloroethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Ethylbenzene
2-Hexanone
Methylene chloride
4-Methyl-2-pentanone
Styrene
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene
Vinyl acetate
Xylenes (total)

BTEX*

Benzene
Toluene
Ethylbenzene
Xylenes (total)

* BTEX compounds are included in an analysis of volatile compounds, or they can be analyzed as a separate group.

TARGET COMPOUND LIST (continued)

Semivolatile Compounds

Base-Neutral Extractables

bis(2-Chloroethyl)ether
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
bis(2-Chloroisopropyl)ether
N-Nitroso-di-*n*-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
bis(2-Chloroethoxy)methane
1,2,4-Trichlorobenzene
Naphthalene
Hexachlorobutadiene
2-Chloronaphthalene
Dimethylphthalate
Acenaphthylene
2,6-Dinitrotoluene
Acenaphthene
2,4-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenyl ether
Fluorene
4-Bromophenyl-phenyl ether
Hexachlorobenzene
Phenanthrene
Anthracene
Di-*n*-butylphtalate
Fluoranthene
Pyrene
3,3'-Dichlorobenzidine
Benz(a)anthracene
Chrysene
bis(2-Ethylhexyl)phthalate
Di-*n*-octylphthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene
Hexachlorocyclopentadiene
N-Nitrosodiphenylamine
Butylbenzyl phthalate
4-Chloroaniline
2-Methylnaphthalene
2-Nitroaniline
3-Nitroaniline
Dibenzofuran
4-Nitroaniline

Acid Extractables

Phenol
2-Chlorophenol
2-Nitrophenol
2,4-Dimethylphenol
2,4-Dichlorophenol
4-Chloro-3-methylphenol
2,4,6-Trichlorophenol
2,4-Dinitrophenol
4-Nitrophenol
4,6-Dinitro-2-methylphenol
Pentachlorophenol
Benzyl alcohol
2-Methylphenol
4-Methylphenol
Benzoic acid
2,4,5-Trichlorophenol

TARGET COMPOUND LIST (continued)

Pesticides and PCBs

Aldrin Endrin
alpha-BHC
beta-BHC
gamma-BHC (Lindane)
delta-BHC
alpha-Chlordane
gamma-Chlordane
4,4,-DDT
4,4-DDE
4,4-DDD
Dieldrin
Endosulfan
Endosulfan II
Endosulfan sulfate
Endrin ketone
Heptachlor
Heptachlor epoxide
Methoxychlor
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260
Toxaphene

Inorganic Target Analyte List (TAL)

Metals

Aluminum
Antimony
Arsenic
Barium Nickel
Beryllium
Cadmium
Calcium
Chromium
Cobalt Thallium
Copper Vanadium
Iron Zinc
Lead Cyanide
Magnesium
Manganese
Mercury
Potassium
Selenium
Silver
Sodium

Reference: U.S. EPA Contract Laboratory Program Statement of Work for Organic and Inorganic Analysis (refer to the most current publication).

FIELD SCREENING METHODS

- X-ray fluorescence (XRF)
- Soil gas
- Enzyme immunoassay (EIA)
- Geophysics
- Inorganic test kits

X-RAY FLUORESCENCE

X-RAY FLUORESCENCE

- Field portable instrument with radioactive source
- Quantitative metals analysis

X-RAY FLUORESCENCE (cont.)

- Source irradiates sample
- Electrons excited and fluoresce
- Wavelength indicative of element
- Intensity indicates concentration

XRF USES

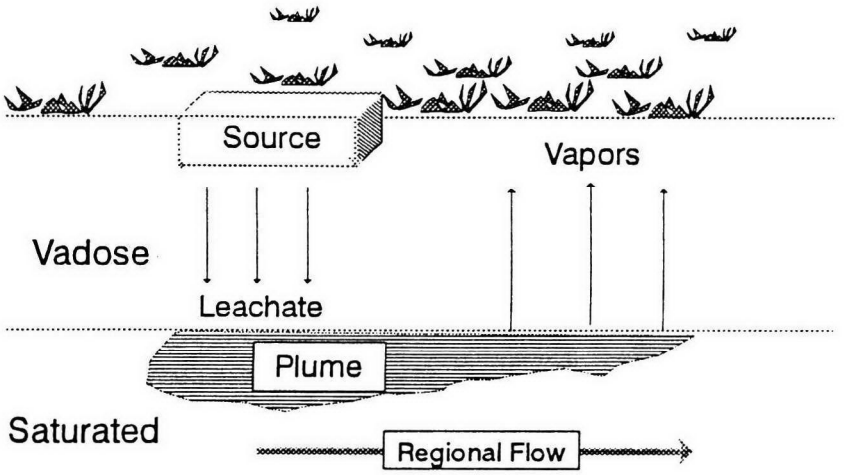
- Battery and wire burning sites
- Abandoned mines
- Lead in soil
- Lead in paint

XRF LIMITATIONS

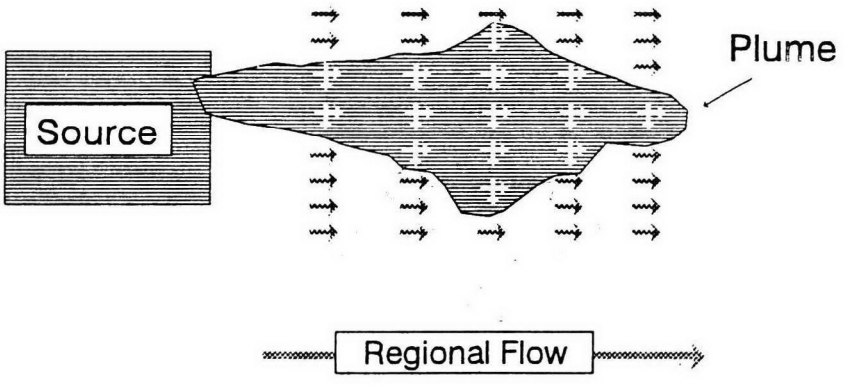
- Penetration in centimeters
- Need site-specific calibration
- Wet soil major matrix interference

SOIL GAS

CROSS SECTION



PLAN VIEW



SOIL GAS USES

- Delineate groundwater plumes
- Locate monitoring wells
- Locate soil contamination

SOIL GAS LIMITATIONS

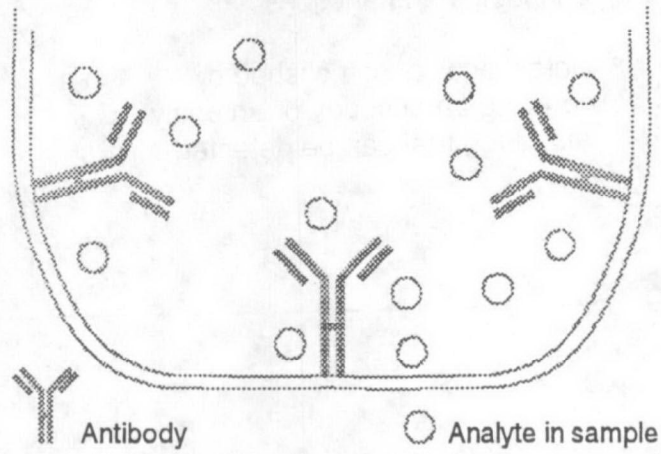
- Primarily volatile organic compound identification
- Limited use in clay
- Semiquantitative analysis

ENZYME IMMUNOASSAY (EIA)

THEORY OF OPERATION

- Immunoassay tests work by detecting the binding of chemical-specific antibodies and antigens
- Detection is accomplished by coupling an antibody or an analyte with a tag that can be detected

STEP 1: ADD SAMPLE/CALIBRATORS



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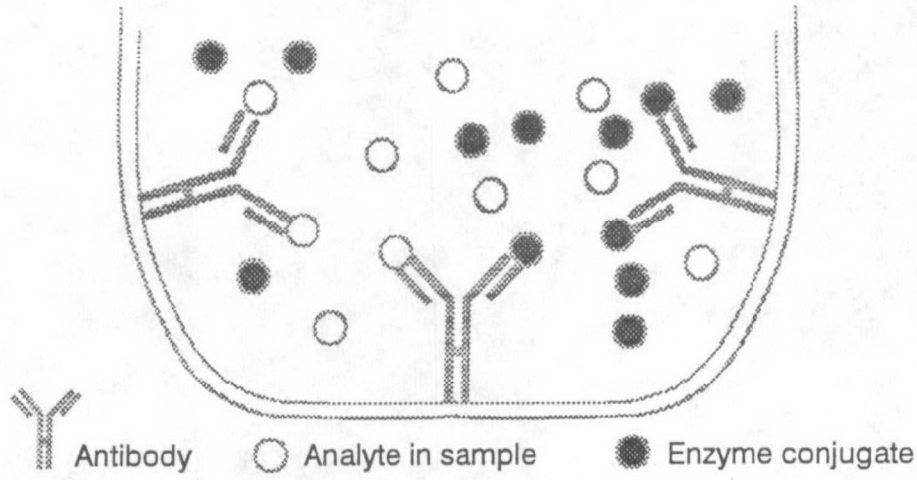
STEP 2: ADD ENZYME CONJUGATE



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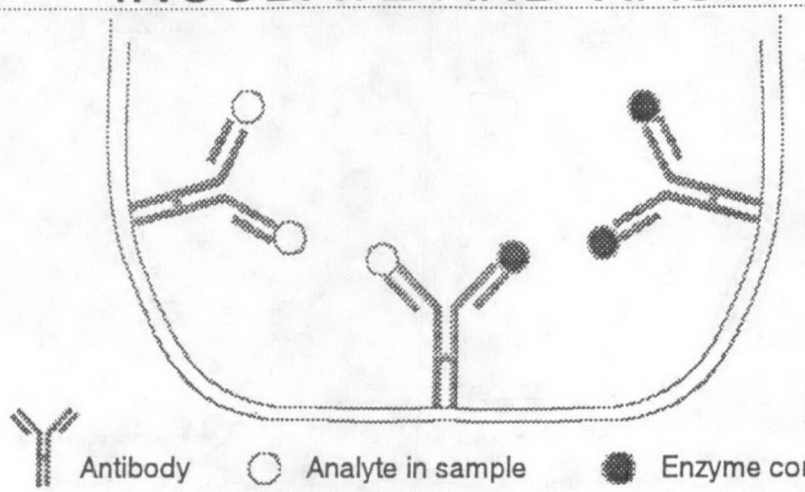
STEPS 3 AND 4: INCUBATE AND WASH



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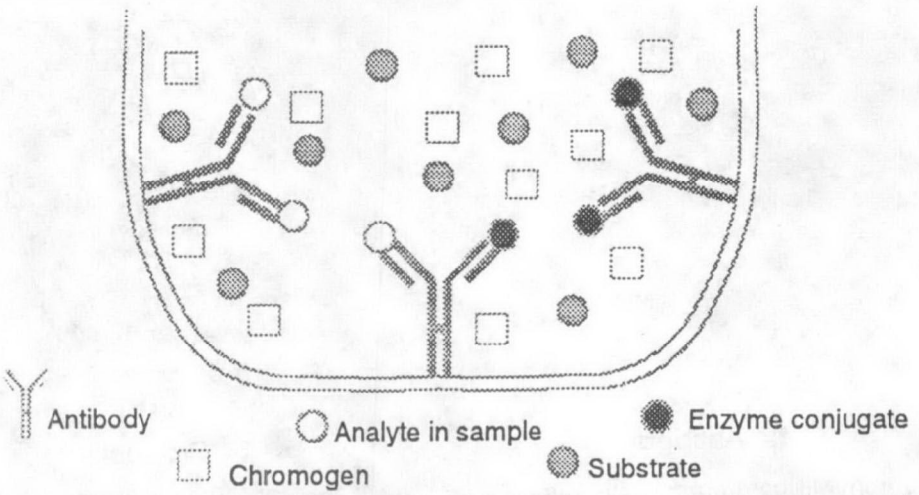
STEPS 5 AND 6: ADD SUBSTRATE AND CHROMOGEN



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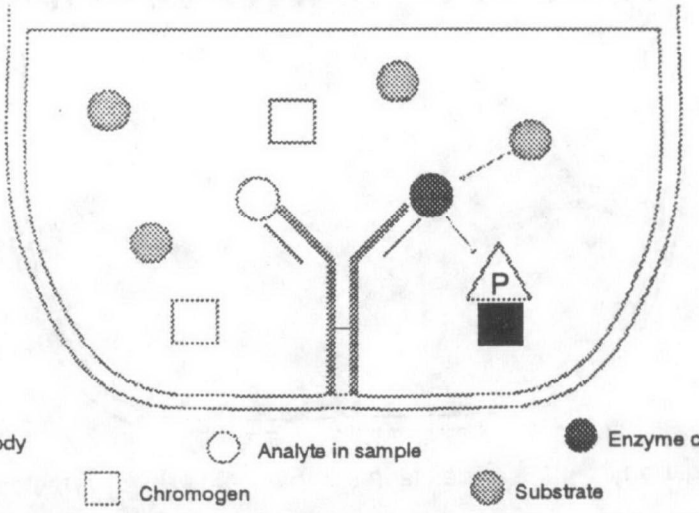
STEP 7: THE CHROMOGEN IS CONVERTED



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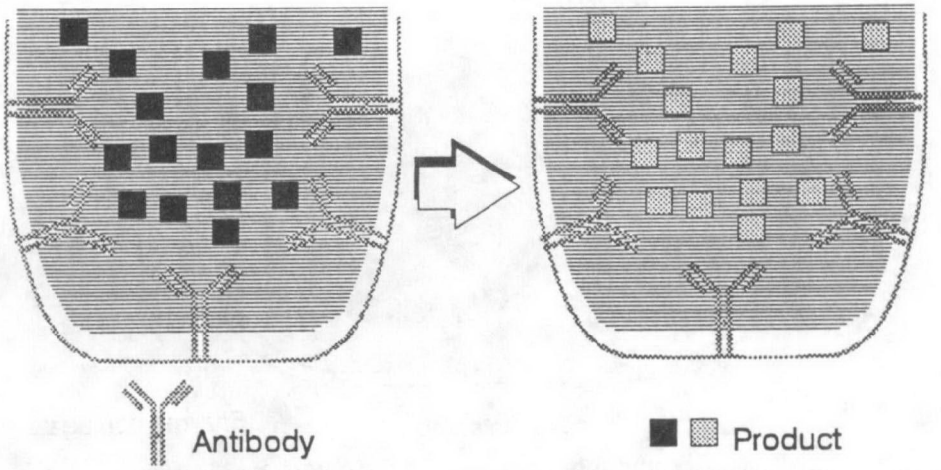
STEPS 8 AND 9: STOP REACTION AND READ RESULTS



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EIA USES
Pesticides and Herbicides

- DDT
- Atrazine
- Chlordane
- 2, 4,-D

EIA USES (cont.)
Fuels and Heavy Hydrocarbons

- Benzene
- BTEX
- Polycyclic aromatic hydrocarbons (PAHs)
- TPH

EIA USES (cont.)
Miscellaneous Compounds

- TNT/RDX
- Polychlorinated biphenyls (PCBs)
- Pentachlorophenol (PCP)
- Mercury

EIA LIMITATIONS

- Sensitivity
- Refrigeration
- Limited shelf life
- Cross-reactivity
- Draft SW-846 methods

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GEOPHYSICS

S-28

GEOPHYSICS

- Magnetics
- Electromagnetics (EM)
- Ground-penetrating radar (GPR)

S-29

MAGNETICS

- Earth's magnetic field intensity measured
- Total field or vertical component
- Ferromagnetic material detected
- Passive method

MAGNETICS USES

- Drum location
- Landfill boundaries
- Screening for drill sites

MAGNETICS LIMITATIONS

- Only detects iron and steel
- Depth determination difficult
- Interferences/false positives

ELECTROMAGNETICS (EM)

- Electric field induces secondary fields
- Secondary fields related to conductivity
- Conductivity read directly
- Active method

EM USES

- Drum location
- Conductive plumes
- Landfill boundaries
- Utilities, pipelines, etc.

EM LIMITATIONS

- Limited depth of penetration
- Operators need to be trained
- Interpretations by geophysicist

GROUND-PENETRATING RADAR (GPR)

- Electromagnetic energy transmitted and received
- Reflections at material horizons
- Metal or changes in geology detected
- Active method

GPR USES

- Drum and underground storage tank locations
- Trench/landfill boundaries
- Geologic horizons
- Water table location

GPR LIMITATIONS

- Poor penetration in clay
- Difficult to interpret
- Expensive equipment

ADDITIONAL SCREENING METHODS

ADDITIONAL SCREENING METHODS

- Chlorine detection
- Inorganic kits
- Field instrumentation

CHLORINE KITS - DEXSIL®

- Detects chlorine in compound
- Used for PCBs in oil or soil

INORGANIC TEST KITS

- Uses color change for detection
- Interpretation by color wheel or spectrophotometer
- Cyanide, copper, lead, nickel, others

FIELD SCREENING INSTRUMENTS

- Snapshot™ PID
- TCE monitor
- Others

REFERENCES

U.S EPA. 1989. Methods for Evaluating the Attainment of Cleanup Standards: Volume 1—Soils and Solid Media. EPA 230/02-89-042. U.S. Environmental Protection Agency, Washington, DC.

U S. EPA. 1991. Removal Program, Representative Sampling Guidance: Volume 1—Soil. Interim Final OSWER Directive 9360.4-10. U.S. Environmental Protection Agency, Washington, DC.

U S EPA 1992. Guidance for Data Useability in Risk Assessment (Part A). Final Report. Publication 9285 7-091A Office of Emergency and Remedial Response, Washington, DC.

DOCUMENTATION

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. List different types of field documentation.

2. Identify the components of each type of documentation.

3. Prepare documentation forms in accordance with applicable field standard operating procedures, given the proper forms of documentation.

4. Describe the elements of training required by the U.S. Department of Transportation (DOT).

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

DOCUMENTATION

SAMPLE DOCUMENTATION

- Field logbooks
- Sample labels
- Site maps

SAMPLE DOCUMENTATION (cont.)

- Photographs
- Chain of custody
- Other documentation

SAMPLE DOCUMENTATION (cont.)

Field logbooks - provide daily records

of significant events, observations, and

measurements during field investigations

FIELD DOCUMENTATION
Best Practices

- Use a bound notebook
- Record all original data in nonerasable waterproof ink
- Correct errors by crossing a single line through the error and initialing and dating the correction

FIELD DOCUMENTATION (cont.)
Best Practices

- Field records should be direct and succinct
- Documenter should sign and date each page

FIELD LOGBOOK ENTRIES

- Date and time of entry
- Purpose of sampling
- Name and address of field contacts (federal, state, and local representatives)

FIELD LOGBOOK ENTRIES (cont.)

- Description of sample
- Description of sampling point
- Date and time of sample collection

FIELD LOGBOOK ENTRIES (cont.)

- Sample identification number
- Field observations
- Field measurements (e.g , pH, flammability)

SAMPLE IDENTIFICATION

All sample containers should be labeled with the following eight categories of identifying information

1 Project code

2 CLP case and sample number

SAMPLE IDENTIFICATION (cont.)

3 Station location and number

4 Date and time of sample location

5 Preservative

SAMPLE IDENTIFICATION (cont.)

6 Requested analysis

7 Signature

8. Remarks

PHOTO DOCUMENTATION

Roll # _____ Date _____

Frame # _____ Time _____

Photographer's Name _____

Location _____

Description _____

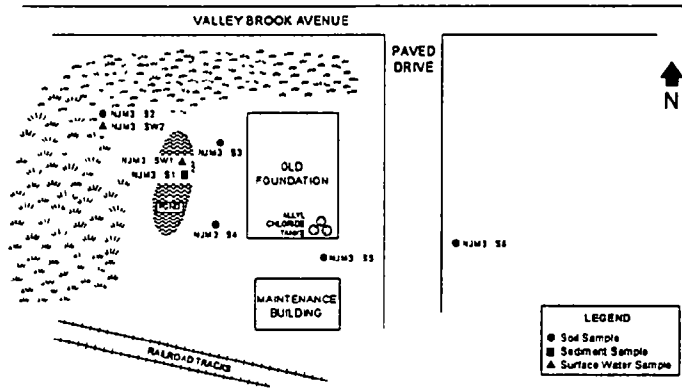
Viewing Direction _____

Signature of Photographer _____

Need to document any special lenses used (and filters)

SAMPLE LOCATION MAP

(not to scale)



SAMPLE CHAIN OF CUSTODY

A reconstruction of who had access to the sample from the time it was collected until produced in court

NEIC SAMPLE CUSTODY

A sample is under custody if

- It is in your possession
- It is in your view after being in your possession
- It was in your possession and then you locked it up to prevent tampering
- It is held in a designated secure area

RULES GOVERNING TRANSPORTATION OF SAMPLES

49 CFR 171-179

- New regulations published December 21, 1990
- Effective date: October 1, 1991

NEW RULING

- Adopts United Nations labels and placards
- Adopts UN identification numbers for hazardous materials
- Provides packing standards based on performance criteria
- Makes U S standards compatible with international standards

SCOPE OF TRAINING REQUIREMENTS

- Persons involved in transportation of hazardous materials
- Categories
  - General awareness/familiarization training
  - Function-specific training
  - Safety training
  - Driver training

TRAINING REQUIREMENTS

- Initial training before October 1, 1993 (if hired before July 2, 1993)
- Train within 90 days of employment
- Refresher training once every 3 years
- DOT, private agency, or employer can provide training (must have Section 172 704 criteria)

HAZARDOUS MATERIALS

A substance or material in a quantity or form capable of posing an unreasonable risk to health, safety, and property when transported in commerce

PROJECT NO X III X

PROJECT NAME/LOCATION SFHM OUI

PROJECT LEADER

REMARKS

SAMPLE TYPES

1 SURFACE WATER
2 GROUNDWATER
3 POTABLE WATER
4 WASTEWATER
5 LEACHATE
6 SOIL/SEDIMENT
7 SLUDGE
8 WASTE
9 AIR
10 FISH
11 OTHER _____

SAMPLERS (SIGN)

STATION NO	SAMPLE TYPE	19__ DATE	TIME	COMP	GRAB	STATION LOCATION/DESCRIPTION	TOTAL CONTAINERS	VOA	BNAs	METALS	PEST/PCBs	CYANIDE	NUTRIENTS	BOD SOLIDS	REMARKS	LAB USE ONLY

ANALYSES

RELINQUISHED BY (PRINT)	(SIGN)	DATE/TIME	RECEIVED BY (PRINT)	(SIGN)	RELINQUISHED BY (PRINT)	(SIGN)	DATE/TIME	RECEIVED BY (PRINT)	(SIGN)
RELINQUISHED BY (PRINT)	(SIGN)	DATE/TIME	RECEIVED BY (PRINT)	(SIGN)	RELINQUISHED BY (PRINT)	(SIGN)	DATE/TIME	RECEIVED BY (PRINT)	(SIGN)

DOCUMENTATION

taken from:

EPA/540/P-87/001
(OSWER Directive 9355.0-14)
December 1987

A COMPENDIUM OF SUPERFUND FIELD OPERATIONS METHODS (Section 4)

OFFICE OF EMERGENCY AND REMEDIAL RESPONSE
OFFICE OF WASTE PROGRAMS ENFORCEMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

SECTION 4

SAMPLE CONTROL, INCLUDING CHAIN OF CUSTODY

4.1 SCOPE AND PURPOSE

This section describes procedures for sample identification and chain of custody. The purpose of these procedures is to maintain the quality of samples during collection, transportation, and storage for analysis Sample control and chain-of-custody procedures specific to the Contract Laboratory Program (CLP) are presented in the *User's Guide to the Contract Laboratory Program*.

4.2 DEFINITIONS

Sample
Physical evidence collected for environmental measuring and monitoring. Evidence includes remote-sensing imagery and photographs.

Site Manager (SM)
The individual responsible for the successful completion of a work assignment within budget and schedule. The person is also referred to as the Site Project Manager or the Project Manager and is typically a contractor's employee (see Subsection 1.1).

4.3 APPLICABILITY

When environmental measuring or monitoring data are collected for the Environmental Protection Agency (EPA), workers should refer to the procedures in this section

4.4 RESPONSIBILITIES

The SM or designee is responsible for monitoring compliance with these procedures. In general, it is desirable to appoint one person to be responsible for implementing sample control procedures (i.e , field operations leader) However, each sampler is responsible for the activities described in Subsections 4.5 and 4 6.

4.5 RECORDS

The following records are kept·

- Sample identification tags (varies with the EPA region, see Subsection 4.7 and Exhibit 5-7)
- Sample traffic reports (e g , Special Analytical Services (SAS); see Exhibits 5-2, 5-3, and 5-9)
- Chain-of-custody (COC) forms and records (see Exhibits 5-4, 5-5, and 5-6)
- Receipt-for-samples forms (varies among EPA regions; see Subsection 4 7 and Exhibit 4-3)

- Field Investigation Team (FIT) receipt (for sample forms and field notebooks not serially numbered by the U.S. EPA)
- Field notebooks
- Airbills or bills of lading
- Dioxin analysis forms (as applicable)
- Photographic logs

Subsection 4.6 describes procedures for these records; Subsection 5.1.6 shows completed exhibits of the first three items.

4.6 PROCEDURES

Sample identification documents must be prepared to maintain sample identification and chain of custody. The following are sample identification documents:

- Sample identification tags
- Sample traffic reports
- Chain-of-custody records
- Receipt-for-samples forms
- Custody seals
- Field notebooks

These documents are usually numbered (serialized) by EPA. Some varieties of custody seals, field notebooks, or photographic logs may not be serialized.

The following additional forms are used for samples shipped to CLP laboratories:

- Organic traffic reports
- Inorganic traffic reports
- High-hazard traffic reports
- SAS request forms
- Dioxin shipment records (as applicable)

Completed examples of these forms are in Subsection 5 1 6 of this compendium

The organization's document control officer (designated on exhibits in this subsection as the Regional Document Control Officer or RDCO) or another designated person maintains a supply of the documents listed above, including field note books The document control officer is responsible for the inventory of serialized documents and the assignment of these documents to specific projects Unused field documents are usually returned to the document control officer at the end of the field sampling event The document control officer notes the return of these documents in the serialized document logbook In some EPA regions, unused field documents are retained by the sampler to whom they were originally assigned for use on future projects The sampler maintains a personal logbook in which is recorded the final disposition of all relevant field information. Unused, returned documents may be checked out to another project by the RDCO, as needed. A cross reference of serialized field documents is usually maintained for each project in the project files A sample cross-reference matrix is shown in Exhibit 4-1.

The document control officer orders sample identification tags, receipt-for samples forms, custody seals, and chain-of-custody records from the EPA regional offices. Traffic reports and SAS request forms are obtained through the Sample Management Office (SMO) representative.

Exhibit 4-2 shows how the sample control documents can be integrated into the document control procedures used in an EPA project. The procedures for using each document are discussed below. Subsection 4 7 discusses regional variations; however, because procedures change and vary from region to region, the EPA Regional Sample Coordinating Center (RSCC) should be contacted during the planning of field activities to obtain the most current procedures Appendix A of the *User's Guide to the CLP* contains a directory of RSCC contacts and telephone numbers.

4.6.1 Sample Identification Tags

Sample identification tags (see Exhibit 5-7) are distributed as needed to field workers by the SM (or designated representative). Procedures vary among EPA regions. Generally, the EPA serial numbers are recorded in the project files, the field notebook, 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 chain-of custody record. Sample identification tags are not to be discarded. If tags are lost, voided, or damaged, the facts are noted in the appropriate field notebook, and the SM is notified.

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 those 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 (Exhibit 4-3). Alternatively, the split samples are not tagged but are accounted for on a chain-of-custody form.

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 (see User's Guide to the CLP and Section 6 of this compendium) and is identified with a separate sample identification tag, which should indicate in the "Remarks" section that the sample is a split sample.

Exhibit 4-1

CROSS REFERENCE MATRIX FOR SERIALIZED DOCUMENTS

Sample Station	Sample Identification Tag Number	Type of Analysis	Organic Traffic Report Number	Inorganic Traffic Report Number	High Hazard Traffic Report Number	Dioxin Forms	Chain-of-Custody Record Number	Receipt-for-Samples Form Number	Airbill Number	Date Shipped

Exhibit 4-2
DOCUMENT CONTROL PROCEDURES

The following information is recorded on the tag:

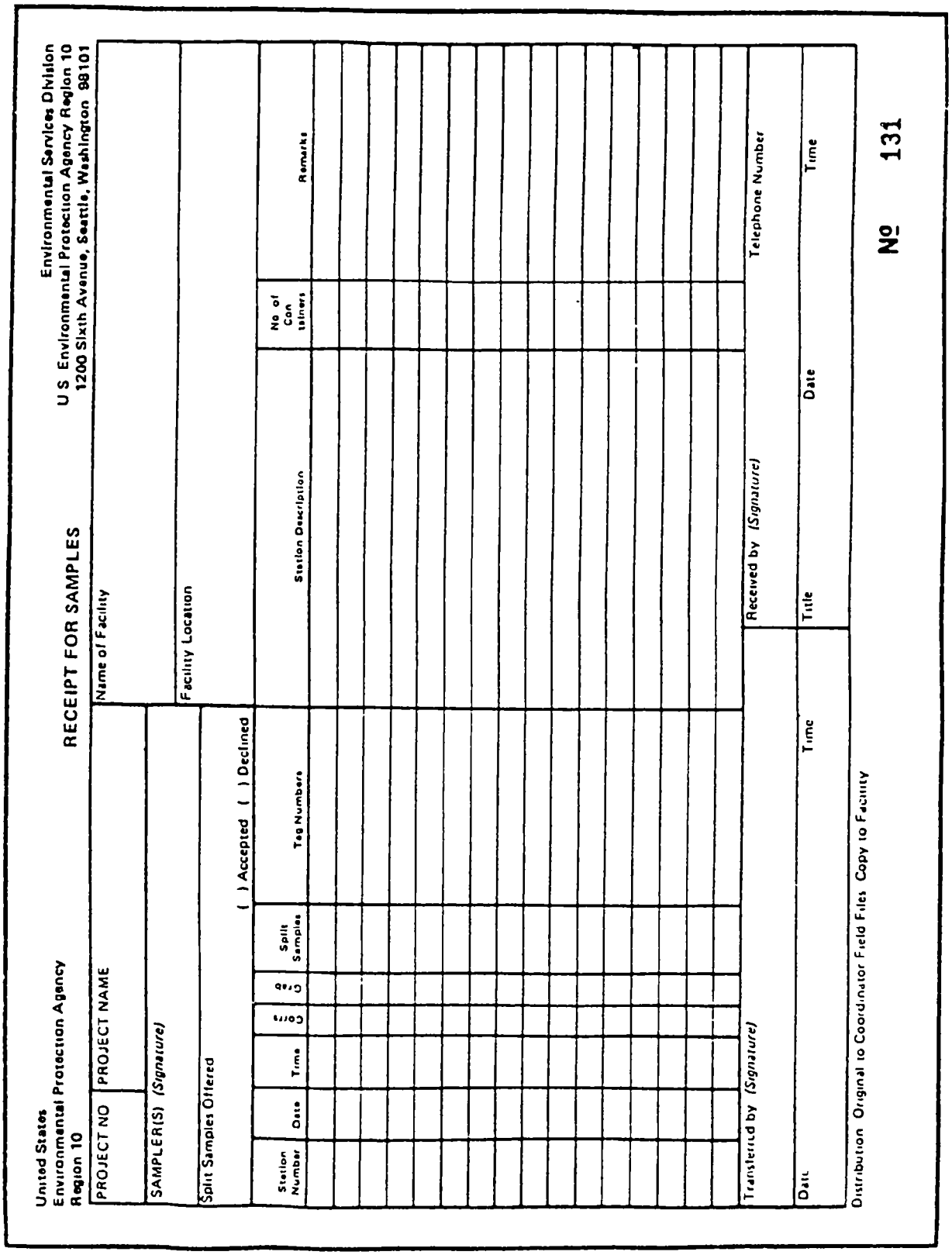
- **CLP Case / SAS Number(s):** The unique number(s) assigned by SMO to identify the sampling event (entered under "Remarks" heading)
- **CLP Sample Number:** The unique sample identification number (from the TR, DSR, or PL) used to document that sample (entered under "Remarks" heading)
- **Project Code:** An assigned contractor project number
- **Station Number:** A unique identifier assigned to a sampling point by the sampling team leader and listed in the sampling plan
- **Date:** A six-digit number indicating the year, month, and day of collection
- **Time:** A four-digit number indicating the local standard time of collection using the 24-hour clock notation (for example, 1345 for 1 45 p.m)
- **Station Location:** The sampling station description as specified in the sampling plan
- **Samplers:** Each sampler's name and signature
- **Preservative:** Whether a preservative is used and the type of preservative
- **Analysis:** The type of analysis requested
- **Tag Number:** A unique serial number, stamped on each tag
- **Batch Number:** The sample container cleaning batch number, recorded in the "Remarks" section
- **Remarks:** The sampler's record of pertinent information, such as batch number, split samples, and special procedures
- **Laboratory Sample Number:** Reserved for laboratory use

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 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 Depending on the EPA region, sample identification tags are completed and attached to each split and marked with the tag numbers of the other portions and with 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 notebook Some EPA regions require that laboratories be informed of the number of blanks and duplicates that are shipped, but not the identity of the quality assurance samples

The printed and numbered adhesive sample labels affixed to the traffic reports are secured to sample containers by the sampler Forms are filled out with waterproof ink, if weather permits. If a pen will not function because of inclement conditions, an indelible pencil may be used If a pencil is used, a note ex-

Exhibit 4-3
TYPICAL RECEIPT-FOR-SAMPLES FORM



United States
Environmental Protection Agency
Region 10

RECEIPT FOR SAMPLES

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) *(Signature)* | Facility Location

Split Samples Offered ( ) Accepted ( ) Declined

Station Number	Date	Time	Grab	Comp	Split Samples	Tag Numbers	Station Description	No of Containers	Remarks

Transferred by *(Signature)* | Received by *(Signature)* | Telephone Number

Date | Time | Title | Date | Time

Distribution Original to Coordinator Field Files Copy to Facility

No 131

plaining the conditions must be included in the field notebook. When necessary, the label is protected from water and solvents with clear tape.

The original is sent to the SMO. The first copy is retained for the project file The second and third copies are sent with the shipment to the laboratory Complete instructions for the use of traffic reports are given in the *User's Guide to the CLP.*

4.6.2 Sample Traffic Report (TR)

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 is assigned by the sampler to each sample collected. The three types of TRs currently in use include organic, inorganic dioxin, and high-concentration TRs (See *Subsection 5.1 6 for examples of completed TRs*)

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. Numbers of sample containers and volumes are entered by the sampler, beside the analytical parameter(s) requested for particular sample portions.

4.6.3 Chain-of-Custody Forms and Records

Because samples collected during an investigation could be used as evidence in litigation, possession of the samples must be traceable from the time each is collected until it is introduced as evidence in legal proceedings. To document sample possession, chain-of-custody procedures are followed.

4.6.3.1 Definition of Custody

A sample is under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession.
- It is in the sampler's view after being in possession.
- It was in the sampler's possession and then was locked up to prevent tampering.
- It is in a designated secure area

4.6.3.2 Field Custody Procedures

Only enough of the sample should be collected to provide a good representation of the medium being sampled To the extent possible, the quantity and types of samples and the sample locations are determined before the actual fieldwork As few people as possible should handle the samples

Field samplers are personally responsible for the care and custody of the samples collected by their teams until the samples are transferred or dispatched properly A person is usually designated to receive

the samples from the field samplers after decontamination, this person maintains custody until the samples are dispatched.

The SM determines whether proper custody procedures were followed during the fieldwork and decides if additional samples are required

4.6.3.3 Transfer of Custody and Shipment

Samples are accompanied by a chain-of-custody (COC) form or record (Exhibits 5-4 and 5-5) When transferring samples, the individuals relinquishing and receiving them should sign, date and note the time on the form This form documents sample custody transfer from the sampler, often through another person, to the analyst, who is in a mobile or contract laboratory

Samples are packaged properly for shipment and dispatched to the appropriate laboratory for analysis, with a separate COC record accompanying each shipment. Shipping containers are padlocked or sealed with custody seals for shipment to the laboratory. The method of shipment, courier name(s), and other pertinent information such as the laboratory name should be entered in the "Remarks" section of the COC record

When samples are split with an owner, operator, or government agency, the event is noted in the "Remarks" section of the COC record The note indicates with whom the samples are being split The person relinquishing the samples to the facility or agency requests the signature of the receiving party on a receipt-for-samples form (Exhibit 4-3) (described in the following subsection), thereby acknowledging receipt of the samples If a representative is unavailable or refuses to sign, this situation is noted in the "Remarks" section of the COC record. When appropriate, for example, when an owner's representative is unavailable, the COC record and receipt-for-samples form should contain a statement that the samples were delivered to the designated location at the designated time. A witness to the attempted delivery should be obtained The samples shall be secured if no one is present to receive them.

All shipments are accompanied by a COC record identifying their contents. The original form accompanies the shipment, the copies are retained by the sampler and returned to the sampling coordinator

If nonhazardous samples are sent by mail, the package is registered, and a return receipt is requested Note. Hazardous materials shall not be sent by mail If samples are sent by common carrier, a bill of lading is used. Air freight shipments are sent prepaid. Freight bills, postal service receipts, and bills of lading should be retained as part of the permanent documentation for the COC records

4.6.3.4 Laboratory Custody Procedures

Laboratory personnel are responsible for the care and custody of samples from the time they are received until the samples are exhausted or returned to the laboratory sample custodian for ultimate disposal Laboratory-specific variations exist, however, a generally accepted laboratory chain-of-custody procedure is presented below Any laboratory used for the analysis of samples taken in the course of EPA remedial response must have an adequate chain-of-custody procedure This procedure is required as an exhibit in the Quality Assurance Project Plan (QAPjP) if the laboratory is not in the CLP

A designated custodian of laboratory samples accepts custody of the shipped samples and verifies that the information on the sample identification tags matches that on the COC records Pertinent information on shipment, pickup, courier, and condition of samples is entered in the "Remarks" section. The custodian then enters the sample identification tag data into a bound logbook, which is arranged by project code and station number

The laboratory custodian uses the sample identification tag number or assigns a unique laboratory number to each sample; the custodian transfers the samples to the proper analyst or stores them in the appropriate secure area. A limited number of named individuals are allowed access to the sample storage area. The appropriate analysts are responsible for the samples until they are returned to the custodian

When sample analyses and necessary quality assurance (QA) checks have been completed, the unused portion of the sample and the sample containers must be disposed of properly (see Subsection 5 2 6.4). All identifying tags, data sheets, and laboratory records, are retained as part of the permanent documentation.

4.6.4 Receipt-for-Samples Form

Section 3007(a)(2) of the RCRA 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 (CERCLA), 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. The particular form used may vary between EPA regions; an example is shown in Exhibit 4-3. 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 SM 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.

4.6.5 Custody Seals

When samples are shipped to the laboratory, they must be placed in padlocked containers or containers sealed with custody seals; a completed example is shown in Exhibit 5-6. Some custody seals are serially numbered These numbers must appear in the cross-reference matrix (Exhibit 4-1) of the field document and on the COC report. Other types of custody seals include unnumbered seals and evidence tape

When samples are shipped, two or more seals are to be placed on each shipping container (such as a cooler), with at least one at the front and one at the back, located in a manner that would indicate if the container were opened in transit. Wide, clear tape should be placed over the seals to ensure that seals are not accidentally broken during shipment Nylon packing tape may be used providing that it does not completely cover the custody seal. Completely covering the seal with this type of tape may allow the label to be peeled off Alternatively, evidence tape may be substituted for custody seals.

If samples are subject to interim storage before shipment, custody seals or evidence tape may be placed over the lid of the jar or across the opening of the storage box. Custody during shipping would be the same as described above. Evidence tape may also be used to seal the plastic bags or metal cans that are used to contain samples in the cooler or shipping container. Sealing individual sample containers assures that sample integrity will not be compromised if the outer container seals are accidentally broken.

4.6.6 Field Notebooks

A bound field notebook must be maintained by the sampling team leader to provide daily records of significant events, observations, and measurements during field investigations. All entries are to be signed and dated. All members of the field investigation team are to use this notebook, which is to be kept as a permanent record. Observations or measurements that are taken in an area where contamination of the field notebooks may occur may be recorded in a separate bound and numbered logbook before being transferred to the project notebook The original records are retained, and the delayed entry is noted as such.

Field notebooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during projects and to refresh the memory of the field personnel if called upon to give testimony during legal proceedings. In a legal proceeding, notes, if referred to, are subject to cross-examination and are admissible as evidence. The field notebook entries should be factual, detailed, and objective.

4.6.7 Corrections to Documentation

Unless restricted by weather conditions, all original data recorded in field notebooks and on sample identification tags, chain-of-custody records, and receipt-for-samples forms are written in waterproof ink. These accountable serialized documents are <u>not</u> to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document.

If an error is made on an accountable document assigned to one person, that individual may make corrections simply by crossing out the error and entering the correct information. The erroneous information should not be obliterated. Any error discovered on an accountable document should be corrected by the person who made the entry. All corrections must be initialed and dated.

For all photographs taken, a photographic log is kept; the log records date, time, subject, frame and roll number, and photographer. For "instant photos," the date, time, subject, and photographer are recorded directly on the developed picture. The serial number of the camera and lens are recorded in the project notebook. The photographer should review the photographs or slides when they return from developing and compare them to the log, to assure that the log and photographs match. It can be particularly useful to photograph the labeled sample jars before packing them into shipping containers. A clear photograph of the sample jar, showing the label, any evidence tape sealing the jar, and the color and amount of sample, can be most useful in reconciling any later discrepancies.

4.7 REGION-SPECIFIC VARIANCES

Region-specific variances are common; the SM should contact the EPA RPM or the RSCC before any sampling campaign to ascertain the latest procedures. Future changes in variances will be incorporated in subsequent revisions to this compendium.

4.7.1 Region I

Region I uses a standard contractor serialized chain-of-custody form and an unnumbered chain-of-custody seal, which are placed on the outside of the shipping cooler. Numbered sample bottle labels are used for REM site work and numbered tags for FIT site work

4.7.2 Region II

Region II uses an unnumbered chain-of-custody form and numbered sample bottle labels for all site work. Custody seals are placed on the outside of the shipping cooler.

4.7.3 Region III

Region III uses a serialized chain-of-custody form and numbered sampling tags. Chain-of-custody seals used by Region III are unnumbered and placed on the outside of the shipping cooler.

4.7.4 Region IV

Region IV has a detailed procedural discussion in the *Engineering Support Branch Standards Operating Procedures and Quality Assurance Manual*, U S. EPA, Region IV, Environmental Services Division, 1 April 1986

4.7.5 Region V

Region V uses a serialized chain-of-custody seal. Region V seals are color coded; orange is used for REM and FIT work. Seals are placed on the outside of the shipping cooler only if the samples are sent the same day as collected; otherwise, seals are placed across sample jar lids. FIT does not note whether or not samples were split on the chain-of-custody record. FIT includes the corresponding Traffic Report number under the remarks section of the tag. The bottle lot numbers or "batch numbers" are not recorded here, but on the "Chain-of Custody form "

4.7.6 Region VI

Region VI does not use a serialized number control system on custody seals

4.7.7 Region VII

Region VII personnel provide onsite sample control Samples are logged into a computer by regional personnel. Although contractor personnel do not seal and log samples, chain of custody is followed as described above.

4.7.8 Region VIII

Region VIII does not use a serialized number control system on custody seals

4.7.9 Region IX

Region IX does not use a serialized number control system on chain-of-custody seals

4.7.10 Region X

Region X does not use a serially numbered custody seal. Seals are signed, and the sample ID number is written on the seal.

4.8 INFORMATION SOURCES

Superfund Amendments and Reauthorization Act (SARA). Section 104(m), "Information Gathering Access Authorities."

U S. Environmental Protection Agency. *NEIC Policies and Procedures*. EPA-330/9-78-001-R. May 1978 (Revised February 1983)

U.S. Environmental Protection Agency. *REM IV Zone Management Plan.* Contract No. 68-01-7251, CH2M HILL and U.S. EPA.

U.S. Environmental Protection Agency. *User's Guide to the Contract Laboratory Program* Office of Emergency and Remedial Response. December 1986.

U S Environmental Protection Agency. *Zone II REM/FIT Quality Assurance Manual.* Contract No 68-01-6692, CH2M HILL and Hazardous Site Control Division.

REFERENCES

U.S. EPA. 1987. Compendium of Superfund Field Operations Methods (Section 4) Documentation. EPA/540/P-87-001. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1991. NEIC Policies and Procedures. Revised Edition. EPA-33019-78-R. U.S. Environmental Protection Agency, Denver, CO.

FIELD SCREENING EXERCISE

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Screen for petroleum hydrocarbons using an enzyme immunoassay kit.

2. Conduct a test for lead using the EM Science test strips.

3. Perform tests on water samples for copper, ammonia, and dissolved oxygen.

4. Conduct a lead test using the LEADTRAK test kit.

5. Describe the operation of an x-ray fluorescence instrument.

6. Operate a pH meter to determine the pH of unknown solutions.

7. Conduct a chlorine detection test for PCB contamination.

8. Conduct a simple hazard classification using hazard classifier test strips on liquids.

9. Perform a lead test using lead test swabs on soil samples.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

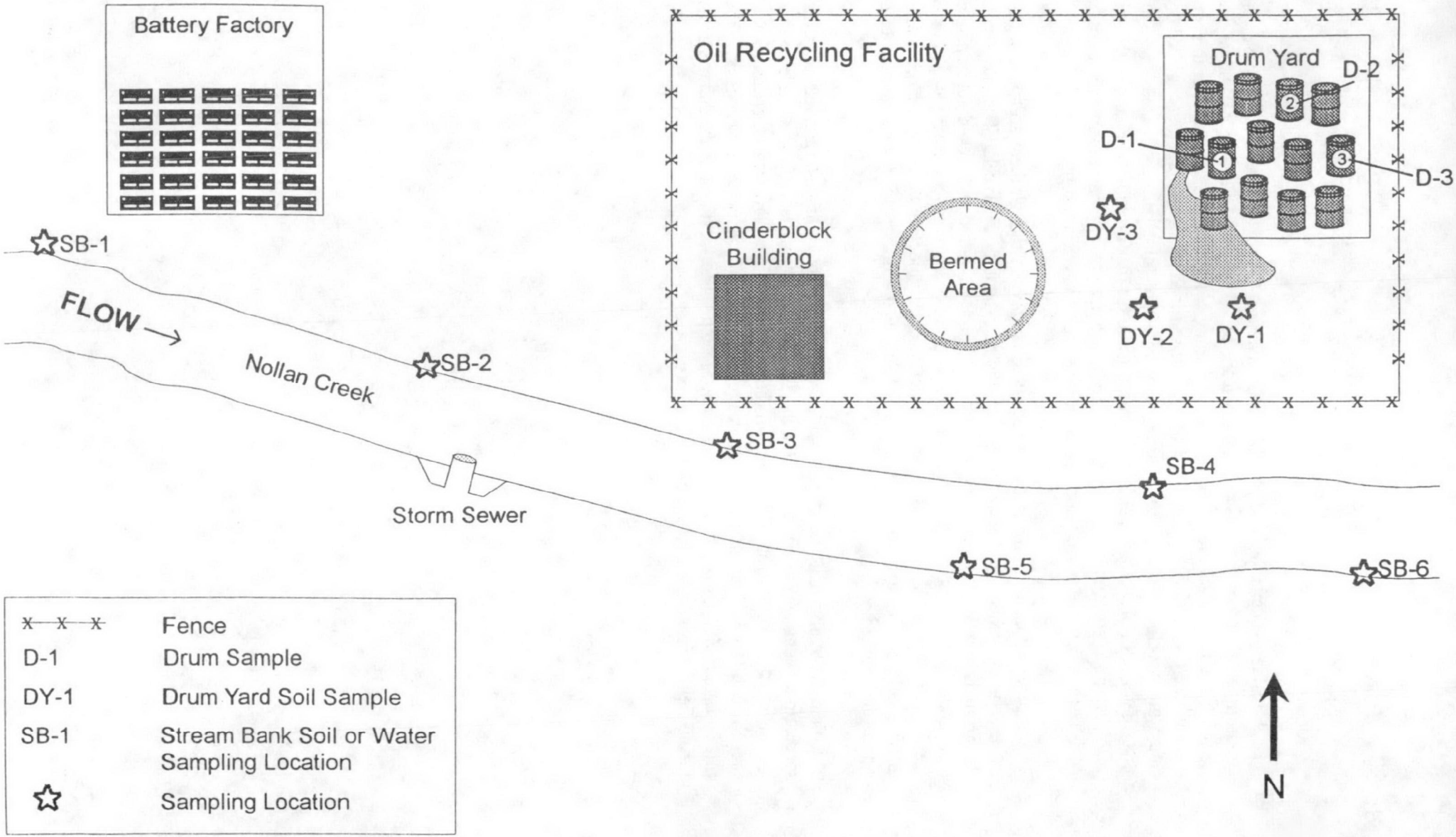
FIELD SCREENING SCENARIO

Local residents have noticed dead fish in Nollan Creek (Figure 1) and have asked the stat environmental response agency to sent a team to investigate. Because of budget constraints and ongoing site responsibilities, only a short screening session can be scheduled at this time. The area near where the dead fish were noted has two abandoned industrial facilities: an old battery factory and a oil recycling facility . Both have been closed for some period of time. There are suspicions that one or both of the facilities may be responsible for the fish kill. The task of the screening team is to determine contaminants, possible sources, and pathways. The present owners of both facilities have been called and permission has been given for entry and testing.

The battery factory is upstream of the recycling facility. Although there are outfalls from the plant, there is a marked absence of vegetation on the near bank of the creek. The site is not fenced, but the grounds have no obvious stains and the building is shuttered and locked. A concrete parking lot surrounds the building and there are no drums or other signs of contamination. The oil recycling facility is fenced. The grounds contain a locked cinder block building, a bermed area that appears to have held an aboveground storage tank (AST), and a drum yard with a number of deteriorating drums and stained soil.

The field screening plan calls for a wide variety of tests in limited numbers to achieve a broad spectrum screening of select areas. On the first day, a soil gas survey was made over the area near and inside the bermed area. The data will be made available. The sampling team will identify four sites for collection of groundwater samples to be analyzed by enzyme immunoassay. These samples will be taken with a shallow direct-push piezometer. The locations of the other samples collected during field screening are noted on the site map.

Figure 1. Site Map



FIELD SCREENING EXERCISE DESCRIPTION

BERMED AREA

Soil Gas

Teams will discuss the soil gas data results and determine the best location for the collection of groundwater samples.

Enzyme Immunoassay (EIA): Four water samples

Available equipment: Millipore EIA BTEX test kit

Using the Millipore EIA BTEX test kit, each team will analyze water samples collected from the bermed area identified on the site map. Results will be recorded on the Field Screening Data Sheet.

STREAM BANK

Lead Test Strips: Three surface water samples (SB-1, SB-3, SB-6)

Available equipment: EM SCIENCE Lead Test Strips

Using the EM SCIENCE Lead Test Strips, each team will field screen one of three surface water samples collected from the sampling locations identified on the site map. Results will be recorded on the Field Screening Data Sheet.

Chemetrics®: Three surface water samples (SB-2, SB-4, SB-5)

Available equipment: Chemetrics Copper Test Kit, Chemetrics Ammonia Test Kit, Chemetrics Dissolved Oxygen Test Kit

Using each of the three Chemetrics test kits, each team will conduct either one, two, or three of the Chemetrics field screening tests on the three surface water samples collected from the sampling locations identified on the site map. Results will be recorded on the Field Screening Data Sheet.

X-Ray Fluorescence (XRF): Three soil samples (SB-1, SB-2, SB-3)

Available equipment: XRF

Using the XRF, each team will field screen three soil samples collected from the sampling locations identified on the site map. Results will be recorded on the Field Screening Data Sheet

pH Meter: Three surface water samples (SB-1, SB-3, SB-6)

Available equipment: pH Meter

Using the pH meter, each team will field screen each of the three samples collected from the sampling locations identified on the site map. Results will be recorded on the Field Screening Data Sheet

DRUM YARD

Lead ✓™ Swabs: Three soil samples (DY-1, DY-2, DY-3)

Available equipment: Lead Check Swabs

Using the lead check swabs, each team will field screen one of the three soil samples collected from the sampling locations identified on the site map. Results will be recorded on the Field Screening Data Sheet.

Dexsil® PCB Test Kit

Available equipment: Dexsil PCB Test Kit

Using the Dexsil PCB test kit, each team will analyze one drum sample collected from one of the three drums identified on the site map. Results will be recorded on the Field Screening Data Sheet.

SPILFYTER Test Strip

Available equipment: SPILFYTER Test Strip

Using the SPILFYTER test strip, each team will field screen one drum sample collected from one of the three drums identified on the site map. Results will be recorded on the Field Screening Data Sheet.

FIELD SCREENING DATA SHEET

	Sample Number	Soil Gas Coordinates	EIA	EM SCIENCE Lead Test Strips	Chemetrics Test Kits		
					Copper	Ammonia	D.O.*
BERMED AREA							
	1						
	2						
	3						
	4						
STREAM BANK							
	SB-1						
	SB-2						
	SB-3						
	SB-4						
	SB-5						
	SB-6						
DRUM YARD							
	DY-1						
	DY-2						
	DY-3						
	D-1						
	D-2						
	D-3						

* D O = dissolved oxygen

FIELD SCREENING DATA SHEET (cont.)

	Sample Number	XRF					pH	Lead ✓	Dexsil PCB	SPILFYTER				
BERMED AREA														
	1													
	2													
	3													
	4													
STREAM BANK														
	SB-1													
	SB-2													
	SB-3													
	SB-4													
	SB-5													
	SB-6													
DRUM YARD														
	DY-1													
	DY-2													
	DY-3													
	D-1													
	D-2													
	D-3													

Section 6

CONTAINERIZED MATERIAL SAMPLING

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Collect a legally defensible sample from containerized waste.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

CONTAINERIZED MATERIAL SAMPLING

OSHA REGULATIONS

29 CFR Part 1910.120 (j) and Part 1926

General requirements and standards for storing, containing, and handling chemicals and containers

CHARACTERISTICS

- High concentrations and hazards
- Large quantities
- Multiphase layers/sludge
- Containers under pressure

METHOD SUMMARY
FSOP No. 2009

- Inventoried
- Staged
- Opened

STAGING AREA

Classify drums into:

- Radioactive
- Leaking
- Bulging
- Lab packs
- Explosive/shock sensitive

STAGING AREA (cont.)

Physically separate into:

- Liquids
- Solids
- Lab packs
- Cylinders
- Empty

DRUM SAMPLING

Under OSHA 1910.120, manual drum opening cannot be used if contents are:

- Unknown
- Flammable
- Reactive or explosive
- Shock sensitive

METHOD SUMMARY
FSOP No. 2010

- Representative sampling
  - If LEL >25%, discontinue sampling
- Can use a bailer, glass thief, sludge judge, bacon bomb, COLIWASA, or subsurface grab sampler

SUMMARY

- Use proper drum opening techniques and equipment
- Use proper levels of protection
- Use caution

Section 7

SOIL SAMPLING

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Describe the media to be sampled.

2. List the reasons for sampling the soil on the site and in the background location.

3. Determine which soil sampling strategy should be used in a particular situation.

4. List and describe appropriate methods for taking surface and subsurface samples.

5. Determine the appropriate sample container for a soil sample for a given analysis.

6. Operate the available soil sampling equipment in a manner appropriate with the media and analysis requested.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

SOIL SAMPLING

SOIL CONSTITUENTS

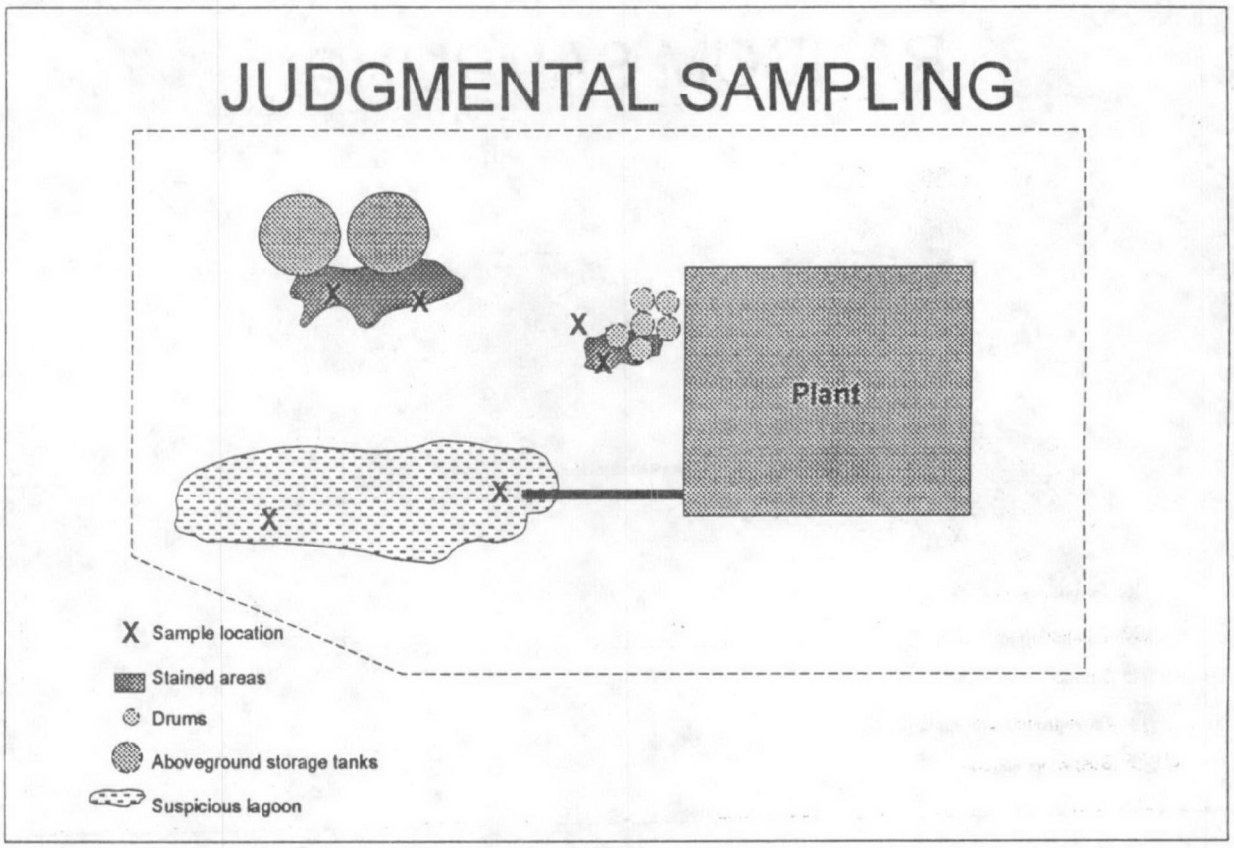
- Gravel
- Sand
- Silt
- Clay
- Organic material

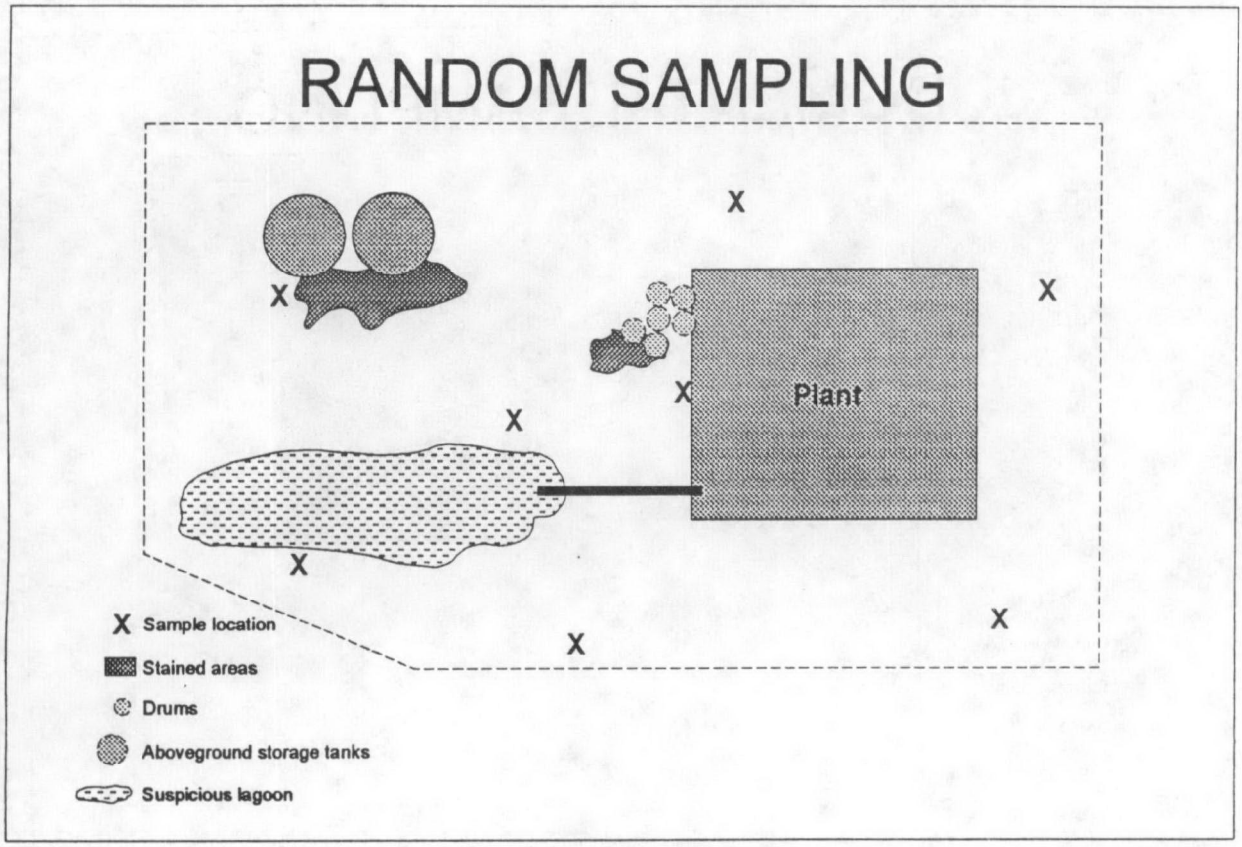
SAMPLING OBJECTIVES

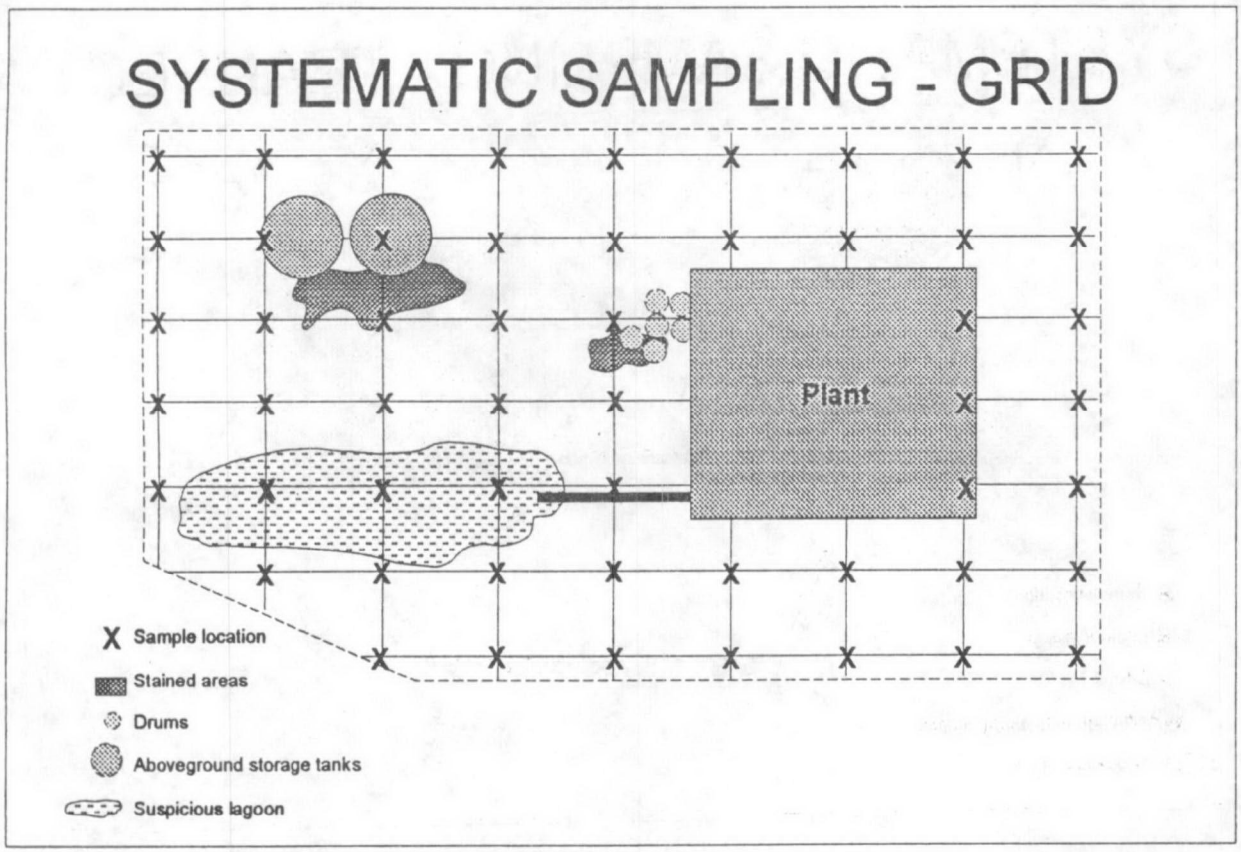
- Establish threat to health or environment
- Locate and identify sources
- Define extent
- Collect remedial option data
- Verify attainment of cleanup

SAMPLING STRATEGY

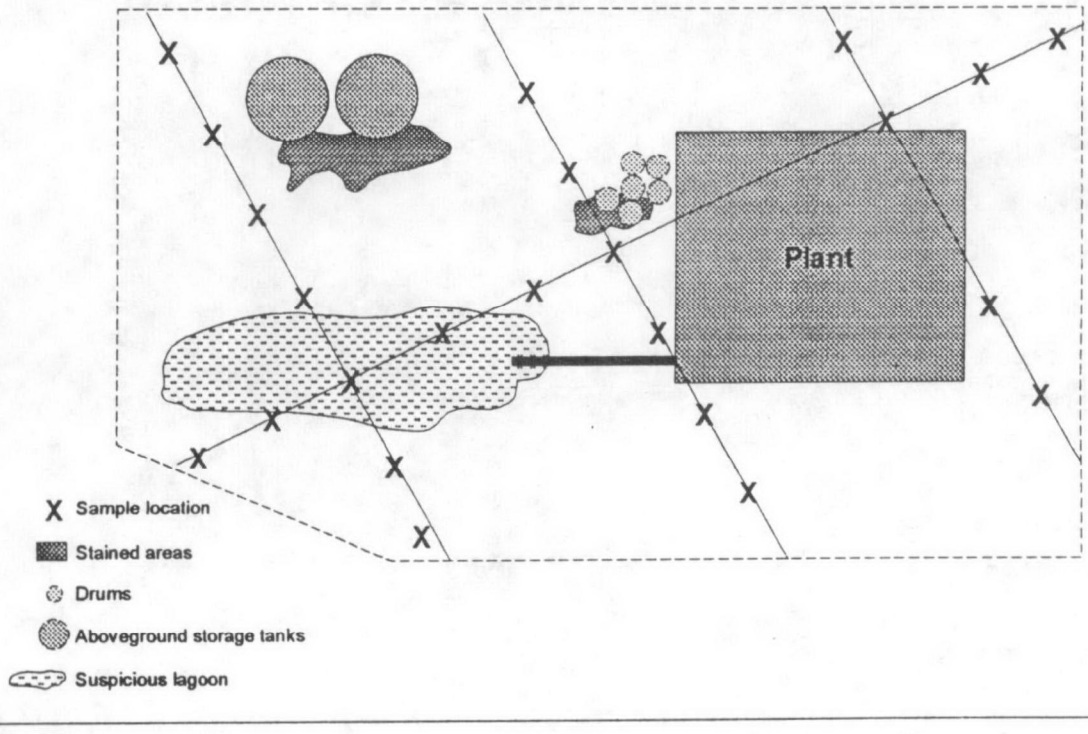
- Judgmental
- Random
- Systematic - grid
- Systematic - transect


JUDGMENTAL SAMPLING
Plant
X Sample location
Stained areas
Drums
Aboveground storage tanks
Suspicious lagoon


RANDOM SAMPLING
Plant
X Sample location
Stained areas
Drums
Aboveground storage tanks
Suspicious lagoon


SYSTEMATIC SAMPLING - GRID
Plant
Sample location
Stained areas
Drums
Aboveground storage tanks
Suspicious lagoon

SYSTEMATIC SAMPLING - TRANSECT



SAMPLING EQUIPMENT
Surface Soil

- Trowel
- Hand auger
- Push tube

SAMPLING EQUIPMENT
Subsurface Soil

- Hollow-stem auger/split spoon
- Rotosonic rig
- Direct push

SAMPLE COLLECTION
Volatiles

- 4-oz. wide-mouth glass jar
- Immediate transfer with some sorting
- Zero head space
- 4°C

SAMPLE COLLECTION
BNAs, Pesticides/PCBs, Metals, CN^-

- 8-oz. wide-mouth glass jar
- Thoroughly mixed
- 80% filled
- 4°C

SITE CROSS SECTION

DATA POSTING

HOWE VALLEY NPL SITE SAMPLING LOCATIONS FOR ORGANICS

3 ft. - tetrachloroethene conc. (mg/kg)

REFERENCES

U.S. EPA. 1989. Methods for Evaluating the Attainment of Cleanup Standards: Volume 1—Soils and Solid Media. EPA/230/02-89-042. U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, Statistical Policy Branch, Washington, DC.

U.S. EPA. 1991a. Compendium of ERT Soil Sampling and Surface Geophysics Procedures. EPA/540/P-91-006. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Environmental Response Team, Washington, DC.

U.S. EPA. 1991b. Removal Program, Representative Sampling Guidance: Volume 1—Soil. Interim Final. PB 92-963408. OSWER Directive 9360.4-10. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1992. Guidance for Data Useability in Risk Assessment (Part A). Final Report. PB 92-963356. OERR Publication 9285.7-09A. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. No date. Summary of Remedial Alternative Selection: Record of Decision, Howe Valley Landfill, Howe Valley, Kentucky. U.S. Environmental Protection Agency, Region 4, Atlanta, GA.

Section 8

SURFACE WATER AND SEDIMENT SAMPLING

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Describe the media to be sampled.

2. List the reasons for sampling the surface water and sediment on the site and in the background location.

3. Determine which surface water sampling strategy should be used in a given situation.

4. Determine which sediment sampling strategy should be used in a given situation.

5. List and describe appropriate methods for obtaining surface water samples.

6. List and describe appropriate methods for obtaining sediment samples.

7. Determine the appropriate sample container and preservative for surface water samples for a given analysis and for sediment samples for a given analysis.

8. Operate the available surface water and sediment sampling tools.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

SURFACE WATER AND SEDIMENT SAMPLING

SEDIMENT

Any inorganic and organic material transported and deposited by water

SURFACE WATER BODY TYPES

- Freshwater-flowing
- Freshwater-standing
- Saltwater
- Estuaries

PURPOSE OF SURFACE WATER AND SEDIMENT SAMPLING

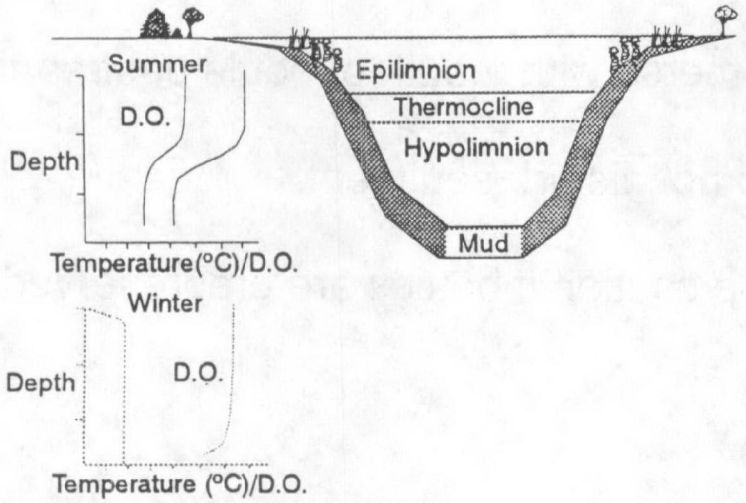
- Contaminants can be transported by surface water
- Sediment is "end of the line" for many contaminants

SURFACE WATER SAMPLING LOCATION AND EQUIPMENT

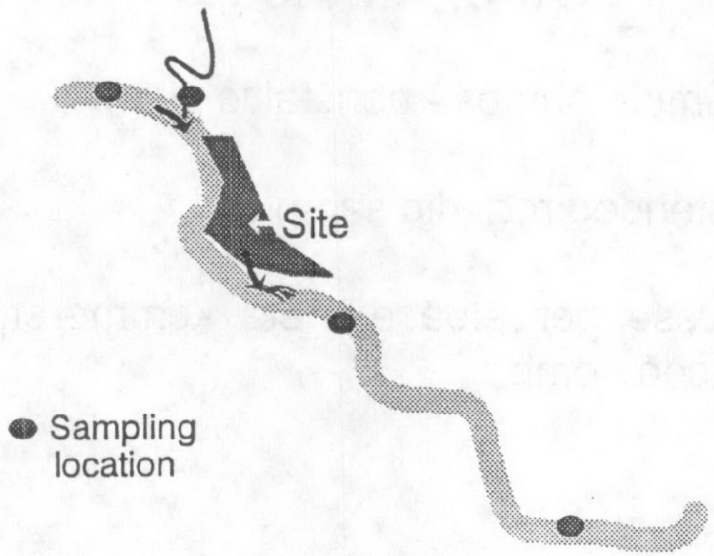
IN-SITU WATER QUALITY PARAMETERS

- Temperature
- pH
- Dissolved oxygen
- Oxidation/reduction potential
- Conductivity

LAKE STRATIFICATION



FLOWING SURFACE WATER



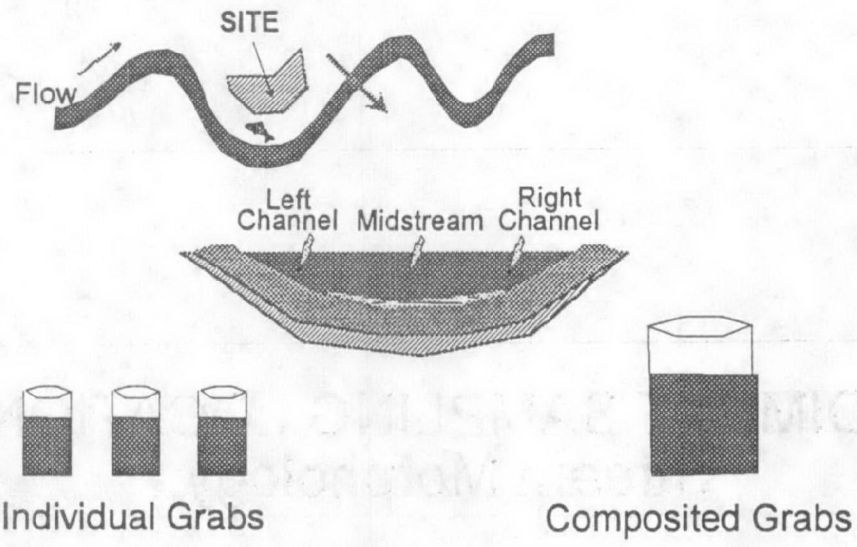
SURFACE WATER SAMPLING
Direct Method

- Immerse with mouth of bottle upstream
- Do not disturb sediment
- Use caution if bottles are prepreserved

SURFACE WATER SAMPLING
Other Methods

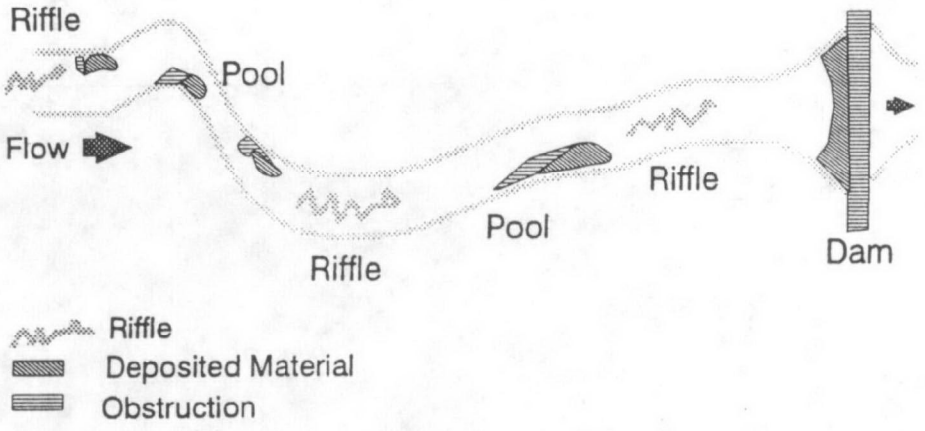
- Sample pumps - peristaltic pump
- Extended rod, dip sampler
- Messenger release - beta, kemmerer, bacon bomb

GRAB VS. COMPOSITE SAMPLING



SEDIMENT SAMPLING LOCATION AND EQUIPMENT

SEDIMENT SAMPLING LOCATIONS
Stream Morphology



SEDIMENT TRANSPORT
Variables

- Particle size distribution
- Organic carbon content

SEDIMENT TRANSPORT
Particle Size

- Boulders -Basketball or bigger
- Cobble - Grapefruit
- Gravel - Pea to orange
- Sand - Sugar to rock salt
- Silt - Flour
- Clay - Talcum powder

SEDIMENT SAMPLING EQUIPMENT
Corers

- Free-fall corers
- Hand corers
- Push tubes

SEDIMENT SAMPLING EQUIPMENT
Grabs

- Ekman
- Ponar
- Augers

CONTAINERS RECOMMENDED FOR SURFACE WATER

• Volatiles	Two 40-ml vials with Teflon®-lined septum caps Preservative: 4 drops concentrated HCL Cool to 4°C
• Semi-volatiles	One 1-gallon or two 1/2-gallon amber glass with Teflon® liner Preservative: Cool to 4°C
• Pesticides/ PCBs	One 1-gallon or two 1/2-gallon amber glass with Teflon® liner Preservative: Cool to 4°C

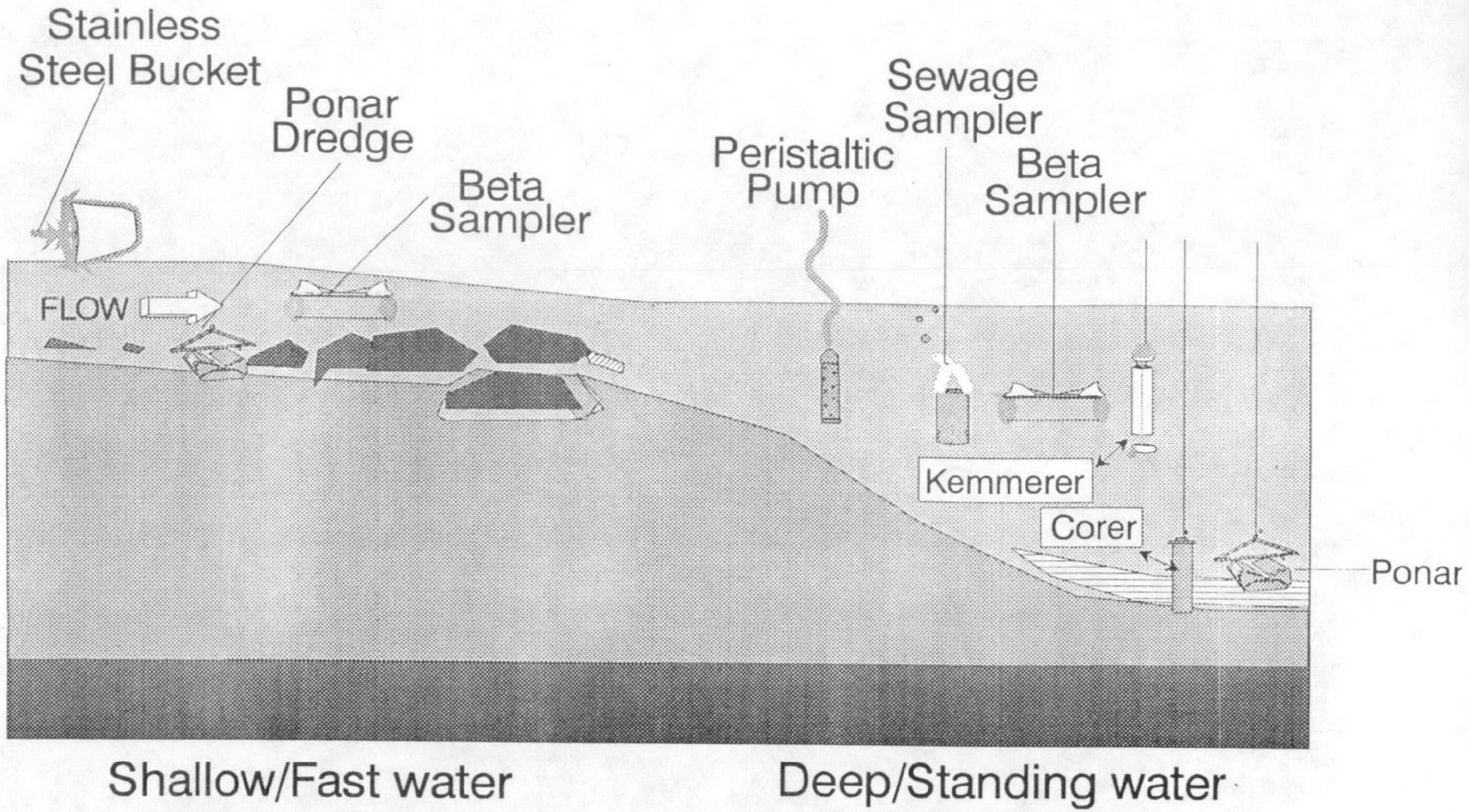
CONTAINERS RECOMMENDED FOR SURFACE WATER (cont.)

• Metals	One 1-L polyethylene with polyethylene-lined closure Preservative: Nitric acid to pH < 2 Cool to 4°C
• Cyanide	One 1-L polyethylene or one 1/2-gallon polyethylene with polyethylene or polyethylene-lined closure Preservative: NaOH to pH > 12 Cool to 4°C

CONTAINERS RECOMMENDED FOR SEDIMENT SAMPLES

• Volatiles	4-oz. wide-mouth glass jar
• Semivolatiles	8-oz. wide-mouth glass jar
• Pesticides/PCBs	8-oz. wide-mouth glass jar
• Metals	8-oz. wide-mouth glass jar
• Cyanide	8-oz. wide-mouth glass jar or 16-oz. (500-ml) polyethylene jar
• Preservatives:	Cool to 4°C

SURFACE WATER/SEDIMENT SAMPLING



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U.S EPA. 1991. Region IV Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual. U.S. Environmental Protection Agency, Athens, GA.

U.S Geological Survey 1989. Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples. Techniques of Water-Resources Investigations of the U.S.G.S. Book 5, Chapter A4 U.S Geological Survey, Reston, VA.

Section 9

GROUNDWATER SAMPLING

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Describe the media to be sampled.

2. List the reasons for sampling the groundwater on the site using existing or new monitoring wells.

3. Determine which groundwater sampling strategy should be used in a particular situation.

4. List and describe the appropriate procedures for taking groundwater samples.

5. Determine the appropriate sample container and preservative for a groundwater sample for a given analysis.

6. Operate the available groundwater sampling equipment in a manner appropriate with the analysis requested.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

GROUNDWATER SAMPLING

GROUNDWATER

Subsurface water that occurs

below the water table

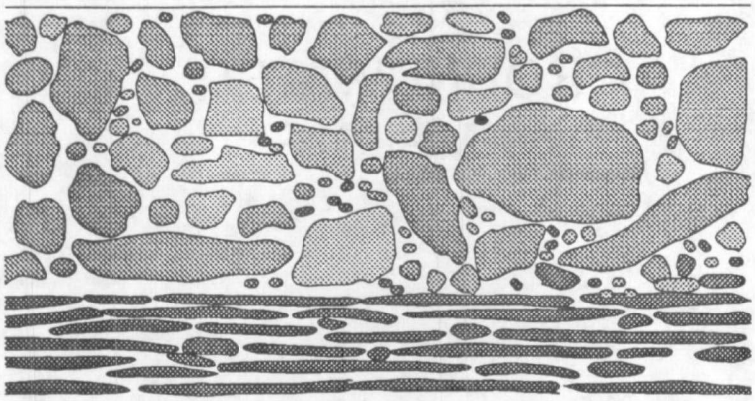
in fully saturated unconsolidated

and/or consolidated aquifers

BASIC PROPERTIES OF AQUIFERS

- Porosity
- Permeability

POROSITY: OPENINGS
PERMEABILITY: CONNECTIONS



BASIC GROUNDWATER PARAMETERS

- pH
- Temperature
- Conductivity
- Redox potential
- Turbidity

GROUNDWATER COLLECTION

- Monitoring wells
- Piezometers
- Groundwater production wells
- Sumps
- Direct push or open boreholes

MONITORING WELL

- Specifically constructed
- Represents particular aquifer or particular zone within aquifer
- Allows collection of defensible groundwater sample

PURPOSE OF SAMPLING GROUNDWATER

- Determine groundwater quality
- Indicate contaminant release
- Identify contaminant
- Indicate contaminant migration

GROUNDWATER SAMPLING STRATEGY

Determine optimum sampling location:

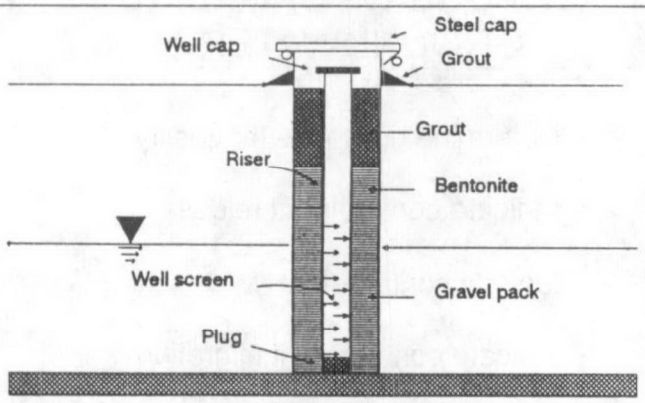
- Use existing wells
- Place new wells

MONITORING WELL DESIGN

Must be properly constructed to sample target contaminant(s). Consider the following:

- Well depth
- Screen depth
- Screen length

MONITORING WELL



COLLECTION OF GROUNDWATER SAMPLES

SAMPLING PROCEDURE

- Record water level, water parameters, and depth of well
- Calculate water volume in well
- Purge well
- Determine collection order
- Determine collection equipment
- Place in containers with preservatives

WATER LEVEL MEASUREMENT EQUIPMENT

- Steel tape with chalk
- Electric sounders
- Interface probe

WELL WATER VOLUME CALCULATION

Water column (in feet) x (Well radius)^2 (in inches) x 0.163 (conversion)

= Water volume (in gallons)

WELL PURGING

A Compendium of Superfund Field Operations Methods, 1987

- Common procedure: Three to five well volumes
- Reliable method: Stability of water parameters (temperature, pH, conductivity) over three well volumes

SAMPLE COLLECTION ORDER

1. Volatile organics
2. Extractable organics
   Base/neutral acid extractables (BNAs)
   Pesticides/PCBs
3. Total metals
4. Dissolved metals (if applicable)
5. Cyanide

SAMPLE COLLECTION EQUIPMENT

- Submersible pump (Fultz or Grunfos)
- Bladder pump
- Bailers
- Inertial pump (Waterra)
- Direct push

SAMPLE CONTAINER AND PRESERVATIVE

• Volatiles	Two 40-ml vials with Teflon®-lined septum caps Preservative: 4 drops concentrated HCL Cool to 4°C Holding time: 14 days
• Semi-volatiles, Pesticides, and PCBs	One 1-gallon or two 1/2-gallon amber glass with Teflon® liner Preservative: Cool to 4°C Holding time: 7 days extraction 40 days analysis

SAMPLE CONTAINER AND PRESERVATIVE (cont.)

• Metals	One 1-L polyethylene with polyethylene-lined closure Preservative: Nitric acid to pH < 2 Cool to 4°C Holding time: 6 mo. (mercury 28 days)
• Cyanide	One 1-L polyethylene or one 1/2-gallon polyethylene with polyethylene or polyethylene-lined closure Preservative: NaOH to pH > 12 Cool to 4°C Holding time: 14 days

FIELD FILTERING

- Follow standard operating procedures (SOPs)
- Used for dissolved inorganics
- Not used for:
  - TOX (total organic halogens)
  - TOC (total organic carbon)
  - Organic analysis

REFERENCES

U.S. EPA. 1986. Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring Technical Enforcement Guidance Document. EPA/600/2-85/104. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1992. RCRA Ground-Water Monitoring: Draft Technical Guidance. EPA/540-R-93-001. U.S. Environmental Protection Agency, Washington, DC.

FIELD EXERCISE

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Sample groundwater, soil, sediment, surface water, and containerized waste using the proper tools and techniques.

2. List the appropriate sampling equipment according to media and the advantages and disadvantages of each.

3. Properly label all types of sample containers.

4. Correctly complete the chain of custody for each collected sample.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

FIELD EXERCISE DESCRIPTION

STATION ONE: SOIL SAMPLING

The following equipment is available:

Bucket augers
Hand trowels
Stainless steel pans
Sieves

Each team will collect one grab sample for semivolatile analysis and one grab sample for volatile analysis Each team will collect samples in accordance with ERT's FSOP #2012, Soil Sampling.

STATION TWO: FIELD DECONTAMINATION

The following equipment is available.

Isopropyl alcohol
Buckets
Spray and squirt bottles
Catch basins
Brushes
Detergent and water
Aluminum foil

Each team will field decontaminate at least two different pieces of sampling equipment from the soil and/or groundwater sampling station. Each team will collect a field blank for volatiles in accordance with ERT's FSOP #2006, Decontamination.

STATION THREE: SURFACE WATER AND SEDIMENT SAMPLING

The following equipment is available·

LaMotte sampler
Bacon bomb
Kemmerer sampler
Gravity corer
Ekman dredge
Ponar dredge
Peristaltic pump
Hand auger
Beta sampler

Each team will collect a grab sample of surface water for cyanide analysis and a sediment sample for metals analysis. Each team will collect samples in accordance with ERT's FSOP #2013, Water Sampling, and FSOP # 2016, Sediment Sampling

STATION FOUR: GROUNDWATER SAMPLING

The following equipment is available:

Water-level indicator	Bailers
Bladder pump	Peristaltic pump
pH meter	Waterra pump

Each team will collect two 40-mL vials for volatile analysis from Monitoring Wells 1 and 3 and take water level and pH measurements from the appropriate well. Each team will use the water-level indicator in accordance with ERT's FSOP # 2115, Water-Level Measurements, and samples will be collected in accordance with ERT's FSOP #2007, Groundwater Sampling.

STATION FIVE: CONTAINERIZED WASTE SAMPLING

The following equipment is available:

COLIWASA	Drum thief
Bacon bomb	Bung wrenches
Hand trowel	Dip stick

Each team will collect representative samples from the drums for pesticides/PCB analysis and BNAs. Each team will collect samples in accordance with ERT's FSOP #2009, Drum Sampling.

PROJECT NO X III X | PROJECT LEADER | REMARKS

PROJECT NAME/LOCATION SFHM OUI

SAMPLE TYPES

1 SURFACE WATER
2 GROUND WATER
3 POTABLE WATER
4 WASTEWATER
5 LEACHATE
6 SOIL/SEDIMENT
7 SLUDGE
8 WASTE
9 AIR
10 FISH
11 OTHER _____

SAMPLERS (SIGN)

ANALYSES

STATION NO	SAMPLE TYPE	19___ DATE	TIME	COMP	GRAB	STATION LOCATION/DESCRIPTION	TOTAL CONTAINERS	VOA	BNAs	METALS	PEST/PCBs	CYANIDE	NUTRIENTS	BOD SOLIDS	REMARKS	LAB USE ONLY

RELINQUISHED BY (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY (PRINT) / (SIGN)	RELINQUISHED BY (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY (PRINT) / (SIGN)
RELINQUISHED BY (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY (PRINT) / (SIGN)	RELINQUISHED BY (PRINT) / (SIGN)	DATE/TIME	RECEIVED BY (PRINT) / (SIGN)

INDIVIDUAL DRUM LOG SHEET

Job #_____ Date_____ Page_____ of_____

Client_____

Drum #_____ Sample #_____

Drum Size: ☐ 85 Gallon ☐ 55 Gallon ☐ 42 Gallon ☐ 30 Gallon
☐ 15 Gallon ☐ 5 Gallon ☐ Other_____

Type of Drum: ☐ Fiber ☐ Poly ☐ Steel ☐ Open Top ☐ Tight Head ☐ Other_____

Description of Sample: HNU Reading_____

LAYER 1 (TOP)

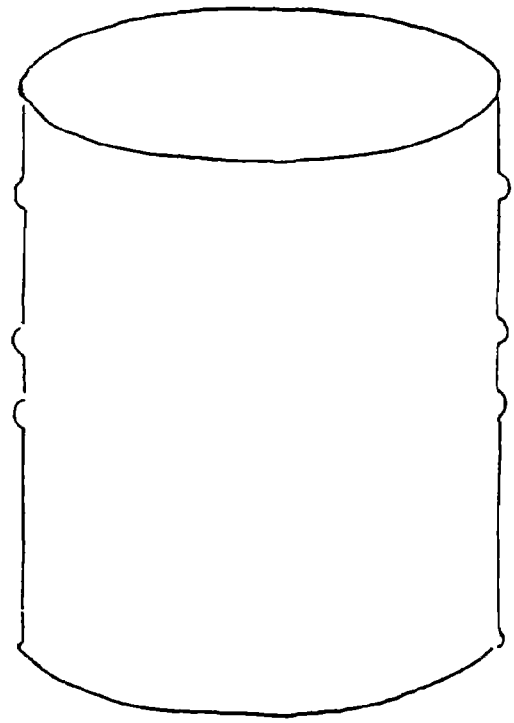
Color_____ Amount (in)_____
☐ Liquid ☐ Solid ☐ Sludge

LAYER 2 (MIDDLE)

Color_____ Amount (in)_____
☐ Liquid ☐ Solid ☐ Sludge

LAYER 3 (BOTTOM)

Color_____ Amount (in)_____
☐ Liquid ☐ Solid ☐ Sludge



Amount in Drum: ☐ Empty (< 1" residuals) ☐ 1/4 ☐ 1/2 ☐ 3/4 ☐ Full

Description of Drum (Drum Label, Markings and Conditions): Overpack Needed? ☐ Yes ☐ No

Compatibility Group:_____ Composite Number_____

Time_____ Sampled by_____ Witness_____

PROBLEM SESSION: SAMPLE PLAN DEVELOPMENT EXERCISE

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. List the elements of a phased sampling plan.

2. Perform the initial elements of a sampling event from background data analysis through field data point selection, collection, and analysis.

NOTE: Students may use all references and material provided in the course, unless otherwise specified, to perform the objectives. Students are expected to perform each objective without error.

Sample Plan Development Exercise
American Creosote Works, Inc., Winnfield, Louisiana

PROJECT OBJECTIVE

Your environmental consulting firm, _____, has been contracted by the U.S. Environmental Protection Agency (EPA) to develop a sampling plan for the American Creosote Works, Inc (ACWI) facility. The site may be evaluated using background data (Phase I), field screening techniques, and some limited sampling of water and sediment (Phase II). Finally, your firm is to outline in a class presentation its recommendations of further sampling points, including monitoring wells.

PROJECT SCOPE

Phase I: Background Data Search

Objective: Determine initial areas of interest for the screening phase and begin to "build" a site conceptual model

You will do a thorough background search using the information provided and the cost of obtaining this information will be subtracted from your total budget for Phases I and II. This information will assist you in establishing the objectives for the remaining phases of the project. Phase I will include a site walkover and a review of available topographic maps, aerial photographs, and general geologic information.

Phase II: Selection and Implementation of Field Screening Techniques

Objective: Determine general areas of contamination, contaminant movement, and media of concern

After choosing the field screening technique, level of analytical support, and location of sampling points, visit the instructors at the "data table" and purchase your field data. Your Phase II budget is $27,000. You may not exceed your budget. Phase II should be broken down into discrete sampling events as if the sampling were proceeding on a day-by-day basis. In other words, get a few boring logs and some soil gas data, review the results, and then decide where to sample next. **Do not wait until the end of Phase II to get the majority of the data. Doing so defeats the immediate feedback aspect of field screening.**

The available field screening data consist of·

- Soil gas data collected from four 0 25-acre contiguous blocks.
- Geologic logs for soil borings to 10 ft below the surface.
- Field laboratory analysis of sediment samples collected from surface to 6 in. below surface
- Field laboratory analysis of surface water samples.
- Field laboratory analysis of groundwater samples collected using a direct-drive well point (average groundwater depth is 12 ft below the surface).

Each group should chose the type of sample and sample location. The sample location should be marked on the gridded map provided To obtain data, present the map at the data table and the data will either be provided on the map or as a separate analytic sheet In some cases, computer work stations will be available to obtain data The data can be obtained by following the menu on the computer screen. Analytical worksheets will be provided to record analytical information found on the computer screen All the data points except the soil gas 0.25-acre soil gas blocks need an identification number, such as SB-1 or SED-5, so that the data from that location can correspond to the data sheet.

Phase III: Development of a Sampling and Analysis Plan

Objective: Determine specific chemicals and their concentrations in each media, delineate areas and volumes of contamination for each media, and track movement of the contaminants in each media

Evaluate your preliminary data from Phases I and II and develop a sampling and analysis plan for the next step in the ACWI site investigation The primary focus of this phase is to use the findings from the background and screening phases to characterize the site. The specific sampling objectives by media will be provided. Select the sample locations, media, analytical support level, procedures, etc. Record the costs and present the final estimate with the sample locations in Phase IV.

Phase IV: Results and Conclusions

Each group will present their sampling and analysis plan (as well as any conclusions and recommendations) to the class. Choose a spokesperson to present your firm's efforts. By preparing this presentation, you will have to organize your findings, develop a reasonable conceptual model, and make your recommendations understandable to someone outside your group. Though a rough budget should be presented, this is not an exercise in finding the low bidder. The presentation should concentrate on the proposed sampling locations; the screening phase should be covered only in presenting the conceptual model **Do not present your Phase II field screening locations.**

BUDGET WORKSHEET

Phase I: Background Data Search

Phase II: Selection and Implementation of Field Screening Techniques

These are the costs to be used for the field screening activities. Data should be collected in a phased fashion. Obtain some boring and soil gas data and analyze these data in relation to your firm's conceptual model Then, gather more data to expand an area of interest or perhaps find a new area of contamination.

Mobilization fee (one-time charge)	$3000.00	$3000.00
Ambient air monitoring for entire site using OVA-128, GC mode, tentative identification (one-time charge)	$1000.00	$1000.00
Shallow soil boring, stratigraphic identification	$500.00 ea.	_____
Soil gas survey in four 0 25-acre blocks	$500.00/acre	_____
Water analysis of drive points (Volatiles [VOAs] and base/neutral acid extractables [BNAs] only)	$500.00/point	_____
Surface water analysis VOAs and BNAs only	$500.00/sample	_____
Sediment sample analysis VOAs and BNAs only	$500.00/sample	_____

This price schedule does not take into account any surcharge for higher levels of protection than Level D **IMPORTANT:** You must review the air monitoring survey before any other work is performed on the site. This will allow you to make a determination of the level of protection appropriate for the site However, no surcharge for higher levels of protection will be added at this time The optimum use of field screening techniques is to get some data and then make informed decisions on where to proceed to obtain more data.

TOTAL BUDGET FOR PHASE II = $27,000.00

BUDGET WORKSHEET

Phase III: Development of a Sampling and Analysis Plan

Phase IV: Results and Conclusions

Your recommendations will include some of the following analytical support. The prices provided must be used to approximate the cost of your recommendations (these lab prices include taking the sample in the field). Calculate the amount spent on each phase, particularly the cost of your Phase III sampling effort. This number will be part of the Phase IV presentation.

Data interpretation, report preparation	$30,000.00	$30,000.00
VOAs	$450.00	_____
BNAs	$800 00	_____
Pesticides/PCBs	$500.00	_____
Total inorganics	$700.00	_____
Benzene, toluene, ethyl-benzene, and xylenes (BTEX)	$150.00	_____
Special analyses (ask instructor for price)		_____
Exploratory borings	$100.00/ft	_____
Monitoring wells Drilling costs **plus** $1000.00		_____
Heavy equipment		_____
Geophysical surveys		_____

Drilling and sampling will be $100.00/ft. To construct a monitoring well in the boring, add $1000.00 for materials and installation. Again, no surcharge will be assessed for increased levels of protection (above Level D). However, you must determine what level of protection is appropriate. Be sure to include the appropriate number of quality assurance and quality control samples and their cost. Figure an additional 10% surcharge to complete the chain-of-custody paperwork and properly package the samples for shipment.

The budget for phase III is not set, your firm will determine the necessary activities and calculate the cost. Any activities not listed above that are deemed appropriate or equipment not listed may be included. If a price is needed ask an instructor and a reasonable estimate will be provided. Use your imagination and experience and the class resources to determine the necessary activities and include them in the final sampling plan.

TOTAL BUDGET FOR PHASE III

PHASE I: BACKGROUND DATA

Louisiana Department of Environmental Quality Files

The Louisiana Department of Environmental Quality (LDEQ) had reports of potential waste management problems at the ACWI site in Winnfield. LDEQ issued a Compliance Order 2 years previous. Last year, LDEQ found the site abandoned and the case was referred to EPA. EPA is the now the lead agency on the environmental assessment and, as such, all pertinent file information has been transferred to EPA.

U.S. Army Corps of Engineers' Files

The U.S. Army Corps of Engineers' files show no record of an application by American Creosote Works, Inc. (ACWI) to fill, build upon, or otherwise alter a wetland. No further information is available regarding ACWI.

Louisiana Geological Survey

Winnfield, Louisiana, is within the Mississippian-age section of the Gulf Coastal Plain. Deposits in this region consist mainly of braided stream channel deposits (sand, silts, and clays with associated interspersed gravel).

The ACWI facility is located on the Cockfield Formation. This formation was deposited during the Tertiary Period (65 to 10 million years before present). It consists primarily of interbedded clays, silts, and sands with significant lignite (a brownish-black coal that is intermediate in coalification between peat and a subbituminous coal) deposits.

Soil Conservation Survey Data

The Soil Conservation Service (SCS) survey for the area is incomplete at this time. Preliminary data indicate that the soil type is composed of fine-grained, organic-rich material characteristic of flood plain or marsh deposits. The available report is in the brown folder along with a set of aerial photographs.

Information from the Chamber of Commerce

The ACWI site has been operating under various names and owners in this location since 1901. It has been the site of wood-preserving operations since approximately 1910, when it was bought by the Louisiana Creosoting Company. The site has operated as a wood-preserving facility by various entities over the years. The present owners bought the site in 1980. The major product lines in recent years have been telephone poles and railroad ties.

State of Louisiana Water Supply Board Files

The State of Louisiana Water Supply Board files indicate that there are no known residential supply wells in the vicinity of the ACWI site The wells for the City of Winnfield are screened in the Sparta Formation at a depth of about 600 ft below ground surface. The nearest municipal well to the site is the Red Hill Well located about 4000 ft east-southeast of the site. The other wells are located farther than a mile from the site to the north.

Information from the Tax Assessor's Office

ACWI is located in the town of Winnfield, Louisiana, Winn Parish, on a small access road. It is near several major truck routes and railroad lines. All taxes are currently paid.

The property consists of 34.21 acres, two large and three small buildings, as well as fifteen above ground vertical storage tanks and five pressure treatment vessels.

Climatological Data

The climate in Winnfield, Louisiana, is subtropical. The average temperature (from 1951 to 1980) ranges from 47°F in January to 81° in July and August The average net annual rainfall is 50 in. The heaviest rainfall is in April and May and the lightest is in October. Tropical storms and hurricanes occasionally pass through the area. Flood-producing rains may occur during any month of the year.

Historical precipitation data:

2 yr 30 min	1.7 in.
10 yr 30 min	2.4 in.
100 yr 30 min	3.5 in.
2 yr 1 hr	2.2 in.
10 yr 1 hr	3 in.
100 yr 1 hr	4 in .
2 yr 6 hr	3.5 in.
10 yr 6 hr	5.5 in.
100 yr 6 hr	8 in.
2 yr 24 hr	4.5 in.
10 yr 24 hr	8.5 in.
100 yr 24 hr	11 in.

Mean annual lake evaporation is 48 in.

Interview with Local Residents

The local fire department was contacted to determine whether any fire-related problems had been attributed to the facility. Fire department records did not indicate that any fires had occurred at the facility. Mr. Mercer, the fire chief, did recall that the fire department had been asked to provide help at the publicly owned treatment works (POTW) to remove siltation within one of the construction areas. Sediments from Creosote Branch had backwashed into one of the concrete basins under construction and needed to be removed. During removal, members of the construction crew experienced blistered skin and breathing difficulties. Creosote was reportedly smelled. Mr. Mercer did not know whether anyone had received medical attention for injuries specific to the removal efforts.

Hydrologic Information

The groundwater table in the vicinity of the site is shallow, as indicated by the numerous marshy areas surrounding the site. At the site, groundwater was encountered within 10 ft of the ground surface. Using a limited number of data points in the area, the near-surface aquifer flow direction and velocity were estimated using the triangulation method and Darcy's Law. The direction of groundwater flow is generally to the north in the area of the site. Groundwater seepage velocity is approximately 0.9 feet per day.

The local residents are all on city water, which is obtained from four wells. Each of the wells is screened in the Sparta Sand Formation. Water analysis shows no contaminants in the water supply at this time

The ACWI site is located in Winn Parish, in the town of Winnfield, Louisiana, and is a part of the flood plain of the Mississippi River. The region is heavily forested, primarily with tall, standing white pines and some cedar. It is located within easy access to several truck routes and railroad lines. The property is relatively flat, with a total relief of 19 ft Drainage is to the north and east into Creosote Branch and is enhanced by the presence of two major drainage ditches (**Figure 1**).

Access to the site is limited, largely due to the surrounding wetlands and heavily forested areas. In August 1989, a perimeter reconnaissance of the site was performed. At the time of the reconnaissance, several storage tanks were present at the facility There was a large (approximately 100 ft by 300 ft) tar stain on the ground surface in the eastern portion of the site. In addition to the stained area, three areas of disturbed soil were reported by former workers in the north, central, and southern portions of the site, however, the reconnaissance team was unable to visually locate the three areas. It is suspected that these areas were covered with clean soil to conceal old tar pits. Five buildings were present on the site One was used for offices and administration, one was used as a laboratory, and the others were used for industrial processing Five large pressure vessels (PV) were present in the processing buildings. Some soil staining was observed around the pressure vessels.

Wetland habitats in the area include emergent palustrine wetland near the tar area containing rushes, reeds, and dead maple trunks. Creosote Branch becomes a freshwater wetland 1 km downstream of the site, and remains a wetland for the next 15 miles. The forested areas are concentrated on the eastern portion of the site and extend from the Creosote Branch south along the eastern edge of the tar area and around the pond. Vegetation in the forested area is characteristic of the loblolly-slash pine forest common in the southeastern United States. A large portion of the site is open or disturbed by prior industrial activity. When these areas are vegetated, they are dominated by grasses and herbs

Ambient air monitoring of the site indicated elevated levels of volatile organic compounds, with the highest levels in the vicinity of the surface tar area.

A memorandum from a chemical engineer whose specialty is process design was found in some onsite files It stated that compounds that might be expected at a wood preservative plant include, but are not limited to, naphthalene, 2-methylnaphthalene, 1-methylnaphthalene, 2,6-dimethylnaphthalene, pentachlorophenol, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and several different volatile organic compounds. Other records found onsite gave some information about the magnitude of the operation. For a 7-month period ending July 31, 1966, more than 750,000 gallons of petroleum distillate, 40,000 gallons of creosote, and 54,000 pounds of pentachlorophenol were used to treat approximately 7.5 million board-feet of wood. After 1981, however, the site was purchased after the previous site owner declared bankruptcy. The new owner ran the operation on a much smaller scale than the 1960s operation.

Figure 1. ACWI Site Map.

United States
Environmental Protection
Agency

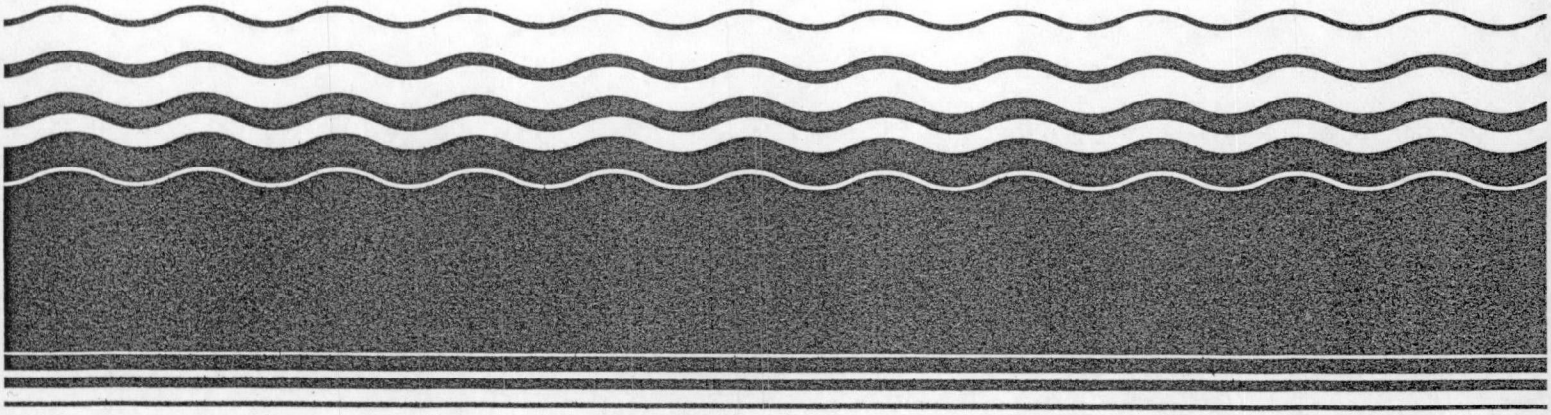
Office of Emergency and
Remedial Response
Washington, DC 20460

Publication 9360.4-10
PB92-963408
November 1991

EPA

Removal Program Representative Sampling Guidance

Volume 1 - Soil



United States
Environmental Protection
Agency

Office of Emergency and
Remedial Response
Washington, DC 20460

Superfund

EPA

Compendium of ERT Groundwater Sampling

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide general field sampling guidelines that will assist REAC personnel in choosing sampling strategies, location, and frequency for proper assessment of site characteristics This SOP is applicable to all field activities that involve sampling

These are standard (i e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S EPA endorsement or recommendation for use

2.0 METHOD SUMMARY

Sampling is the selection of a representative portion of a larger population, universe, or body Through examination of a sample, the characteristics of the larger body from which the sample was drawn can be inferred In this manner, sampling can be a valuable tool for determining the presence, type, and extent of contamination by hazardous substances in the environment

The primary objective of all sampling activities is to characterize a hazardous waste site accurately so that its impact on human health and the environment can be properly evaluated It is only through sampling and analysis that site hazards can be measured and the job of cleanup and restoration can be accomplished effectively with minimal risk The sampling itself must be conducted so that every sample collected retains its original physical form and chemical composition In this way, sample integrity is insured, quality assurance standards are maintained, and the sample can accurately represent the larger body of material under investigation

The extent to which valid inferences can be drawn from a sample depends on the degree to which the sampling effort conforms to the project's objectives For example, as few as one sample may produce adequate, technically valid data to address the project's objectives Meeting the project's objectives requires thorough planning of sampling activities, and implementation of the most appropriate sampling and analytical procedures These issues will be discussed in this procedure

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount of sample to be collected, and the proper sample container type (i e , glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest Sample preservation, containers, handling, and storage for air and waste samples are discussed in the specific SOPs for air and waste sampling techniques

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The nature of the object or materials being sampled may be a potential problem to the sampler If a material is homogeneous, it will generally have a uniform composition throughout In this case, any sample increment can be considered representative of the material On the other hand, heterogeneous samples present problems to the sampler because of changes in the material over distance, both laterally and vertically

Samples of hazardous materials may pose a safety threat to both field and laboratory personnel Proper health and safety precautions should be implemented when handling this type of sample

Environmental conditions, weather conditions, or non-target chemicals may cause problems and/or interferences when performing sampling activities or when sampling for a specific parameter Refer to the specific SOPs for sampling techniques

5.0 EQUIPMENT/APPARATUS

The equipment/apparatus required to collect samples must be determined on a site specific basis Due to the wide variety of sampling equipment available, refer to the specific SOPs for sampling techniques which include lists of the equipment/apparatus required for sampling

6.0 REAGENTS

Reagents may be utilized for preservation of samples and for decontamination of sampling equipment The preservatives required are specified by the analysis to be performed Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination

7.0 PROCEDURE

7.1 Types of Samples

In relation to the media to be sampled, two basic types of samples can be considered the environmental sample and the hazardous sample

Environmental samples are those collected from streams, ponds, lakes, wells, and are off-site samples that are not expected to be contaminated with hazardous materials They usually do not require the special handling procedures typically used for concentrated wastes However, in certain instances, environmental samples can contain elevated concentrations of pollutants and in such cases would have to be handled as hazardous samples

Hazardous or concentrated samples are those collected from drums, tanks, lagoons, pits, waste piles, fresh spills, or areas previously identified as contaminated, and require special handling procedures because of their potential toxicity or hazard These samples can be further subdivided based on their degree of hazard, however, care should be taken when handling and shipping any wastes believed to be concentrated regardless of the degree

The importance of making the distinction between environmental and hazardous samples is two-fold

(1) Personnel safety requirements Any sample thought to contain enough hazardous materials to pose a safety threat should be designated as hazardous and handled in a manner which ensures the safety of both field and laboratory personnel

(2) Transportation requirements Hazardous samples must be packaged, labeled, and shipped according to the International Air Transport Association (IATA) Dangerous Goods Regulations or Department of Transportation (DOT) regulations and U S EPA guidelines

7.2 Sample Collection Techniques

In general, two basic types of sample collection techniques are recognized, both of which can be used for either environmental or hazardous samples

Grab Samples

A grab sample is defined as a discrete aliquot representative of a specific location at a given point in time The sample is collected all at once at one particular point in the sample medium 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

Composite Samples

Composites are nondiscrete samples composed of more than one specific aliquot 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 problems by diluting isolated concentrations of some hazardous compounds below detection limits

Compositing is often used for environmental samples and may be used for hazardous samples under certain conditions For example, compositing of hazardous waste is often performed after compatibility tests have

been completed to determine an average value over a number of different locations (group of drums) This procedure generates data that can be useful by providing an average concentration within a number of units, can serve to keep analytical costs down, and can provide information useful to transporters and waste disposal operations

For sampling situations involving hazardous wastes, grab sampling techniques are generally preferred because grab sampling minimizes the amount of time sampling personnel must be in contact with the wastes, reduces risks associated with compositing unknowns, and eliminates chemical changes that might occur due to compositing

7.3 Types of Sampling Strategies

The number of samples that should be collected and analyzed depends on the objective of the investigation There are three basic sampling strategies random, systematic, and judgmental sampling

Random sampling involves collection of samples in a nonsystematic fashion from the entire site or a specific portion of a site Systematic sampling involves collection of samples based on a grid or a pattern which has been previously established When judgmental sampling is performed, samples are collected only from the portion(s) of the site most likely to be contaminated Often, a combination of these strategies is the best approach depending on the type of the suspected/known contamination, the uniformity and size of the site, the level/type of information desired, etc

7.4 QA Work Plans (QAWP)

A QAWP is required when it becomes evident that a field investigation is necessary It should be initiated in conjunction with, or immediately following, notification of the field investigation This plan should be clear and concise and should detail the following basic components, with regard to sampling activities

- Objective and purpose of the investigation
- Basis upon which data will be evaluated
- Information known about the site including location, type and size of the facility, and length of operations/abandonment
- Type and volume of contaminated material, contaminants of concern (including concentration), and basis of the information/data
- Technical approach including media/matrix to be sampled, sampling equipment to be used, sample equipment decontamination (if necessary), sampling design and rationale, and SOPs or description of the procedure to be implemented
- Project management and reporting, schedule, project organization and responsibilities, manpower and cost projections, and required deliverables
- QA objectives and protocols including tables summarizing field sampling and QA/QC analysis and objectives

Note that this list of QAWP components is not all-inclusive and that additional elements may be added or altered depending on the specific requirements of the field investigation It should also be recognized that although a detailed QAWP is quite important, it may be impractical in some instances Emergency responses and accidental spills are prime examples of such instances where time might prohibit the development of site-specific QAWPs prior to field activities In such cases, investigators would have to rely on general guidelines and personal judgment, and the sampling or response plans might simply be a strategy based on preliminary information and finalized on site In any event, a plan of action should be developed, no matter how concise or informal, to aid investigators in maintaining a logical and consistent order to the implementation of their task

7.5 Legal Implications

The data derived from sampling activities are often introduced as critical evidence during litigation of a hazardous waste site cleanup Legal issues in which sampling data are important may include cleanup cost recovery, identification of pollution sources and responsible parties, and technical validation of remedial design methodologies Because of the potential for involvement in legal actions, strict adherence to technical and administrative SOPs is essential during both the development and implementation of sampling activities

Technically valid sampling begins with thorough planning and continues through the sample collection and analytical procedures Administrative requirements involve thorough, accurate

documentation of all sampling activities Documentation requirements include maintenance of a chain of custody, as well as accurate records of field activities and analytical instructions Failure to observe these procedures fully and consistently may result in data that are questionable, invalid and non-defensible in court, and the consequent loss of enforcement proceedings

8.0 CALCULATIONS

Refer to the specific SOPs for any calculations which are associated with sampling techniques

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

Refer to the specific SOPs for the type and frequency of QA/QC samples to be analyzed, the acceptance criteria for the QA/QC samples, and any other QA/QC activities which are associated with sampling techniques

10.0 DATA VALIDATION

Refer to the specific SOPs for data validation activities that are associated with sampling techniques

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S EPA, OSHA, and corporate health and safety procedures

SAMPLING EQUIPMENT DECONTAMINATION

SOP#: 200t
DATE 08/11/94
REV. #. 0.0

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide a description of the methods used for preventing, minimizing, or limiting cross-contamination of samples due to inappropriate or inadequate equipment decontamination and to provide general guidelines for developing decontamination procedures for sampling equipment to be used during hazardous waste operations as per 29 Code of Federal Regulations (CFR) 1910 120 This SOP does not address personnel decontamination

These are standard (i e typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitation, or limitations imposed by the procedure In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S Environmental Protection Agency (U S EPA) endorsement or recommendation for use

2.0 METHOD SUMMARY

Removing or neutralizing contaminants from equipment minimizes the likelihood of sample cross contamination, reduces or eliminates transfer of contaminants to clean areas, and prevents the mixing of incompatible substances

Gross contamination can be removed by physical decontamination procedures These abrasive and non-abrasive methods include the use of brushes, air and wet blasting, and high and low pressure water cleaning

The first step, a soap and water wash, removes all visible particulate matter and residual oils and grease This may be preceded by a steam or high pressure water wash to facilitate residuals removal The second step involves a tap water rinse and a distilled/deionized water rinse to remove the detergent An acid rinse provides a low pH media for trace metals removal and is included in the decontamination process if metal samples are to be collected It is followed by another distilled/deionized water rinse If sample analysis does not include metals, the acid rinse step can be omitted Next, a high purity solvent rinse is performed for trace organics removal if organics are a concern at the site Typical solvents used for removal of organic contaminants include acetone, hexane, or water Acetone is typically chosen because it is an excellent solvent, miscible in water, and not a target analyte on the Priority Pollutant List If acetone is known to be a contaminant of concern at a given site or if Target Compound List analysis (which includes acetone) is to be performed, another solvent may be substituted The solvent must be allowed to evaporate completely and then a final distilled/deionized water rinse is performed This rinse removes any residual traces of the solvent

The decontamination procedure described above may be summarized as follows

1 Physical removal
2 Non-phosphate detergent wash
3 Tap water rinse
4 Distilled/deionized water rinse
5 10% nitric acid rinse
6 Distilled/deionized water rinse
7 Solvent rinse (pesticide grade)
8 Air dry
9 Distilled/deionized water rinse

If a particular contaminant fraction is not present at the site, the nine (9) step decontamination procedure specified above may be modified for site specificity For example, the nitric acid rinse may be eliminated if metals are not of concern at a site Similarly, the solvent rinse may be eliminated if organics are not of

concern at a site Modifications to the standard procedure should be documented in the site specific work plan or subsequent report

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount of sample to be collected and the proper sample container type (i e , glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest

More specifically, sample collection and analysis of decontamination waste may be required before beginning proper disposal of decontamination liquids and solids generated at a site This should be determined prior to initiation of site activities

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free (specifically for the contaminants of concern)
- The use of an untreated potable water supply is not an acceptable substitute for tap water Tap water may be used from any municipal or industrial water treatment system
- If acids or solvents are utilized in decontamination they raise health and safety, and waste disposal concerns
- Damage can be incurred by acid and solvent washing of complex and sophisticated sampling equipment

5.0 EQUIPMENT/APPARATUS

Decontamination equipment, materials, and supplies are generally selected based on availability Other considerations include the ease of decontaminating or disposing of the equipment Most equipment and supplies can be easily procured For example, soft-bristle scrub brushes or long-handled bottle brushes can be used to remove contaminants Large galvanized wash tubs, stock tanks, or buckets can hold wash and rinse solutions Children's wading pools can also be used Large plastic garbage cans or other similar containers lined with plastic bags can help segregate contaminated equipment Contaminated liquid can be stored temporarily in metal or plastic cans or drums

The following standard materials and equipment are recommended for decontamination activities

5.1 Decontamination Solutions

- Non-phosphate detergent
- Selected solvents (acetone, hexane, nitric acid, etc)
- Tap water
- Distilled or deionized water

5.2 Decontamination Tools/Supplies

- Long and short handled brushes
- Bottle brushes
- Drop cloth/plastic sheeting
- Paper towels
- Plastic or galvanized tubs or buckets
- Pressurized sprayers (H_2O)
- Solvent sprayers
- Aluminum foil

5.3 Health and Safety Equipment

Appropriate personal protective equipment (i e , safety glasses or splash shield, appropriate gloves, aprons or coveralls, respirator, emergency eye wash)

5.4 Waste Disposal

- Trash bags
- Trash containers
- 55-gallon drums
- Metal/plastic buckets/containers for storage and disposal of decontamination solutions

6.0 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions Table 1 (Appendix A) lists solvent rinses which may be required for elimination of particular chemicals In

general, the following solvents are typically utilized for decontamination purposes

- 10% nitric acid is typically used for inorganic compounds such as metals An acid rinse may not be required if inorganics are not a contaminant of concern
- Acetone (pesticide grade)[1]
- Hexane (pesticide grade)[1]
- Methanol[1]

[1] - Only if sample is to be analyzed for organics

7.0 PROCEDURES

As part of the health and safety plan, a decontamination plan should be developed and reviewed The decontamination line should be set up before any personnel or equipment enter the areas of potential exposure The equipment decontamination plan should include

- The number, location, and layout of decontamination stations
- Decontamination equipment needed
- Appropriate decontamination methods
- Methods for disposal of contaminated clothing, equipment, and solutions
- Procedures can be established to minimize the potential for contamination This may include (1) work practices that minimize contact with potential contaminants, (2) using remote sampling techniques, (3) covering monitoring and sampling equipment with plastic, aluminum foil, or other protective material, (4) watering down dusty areas, (5) avoiding laying down equipment in areas of obvious contamination, and (6) use of disposable sampling equipment

7.1 Decontamination Methods

All samples and equipment leaving the contaminated area of a site must be decontaminated to remove any contamination that may have adhered to equipment Various decontamination methods will remove contaminants by (1) flushing or other physical action, or (2) chemical complexing to inactivate contaminants by neutralization, chemical reaction, disinfection, or sterilization

Physical decontamination techniques can be grouped into two categories abrasive methods and non-abrasive methods, as follows

7 1 1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant The mechanical abrasive cleaning methods are most commonly used at hazardous waste sites The following abrasive methods are available

Mechanical

Mechanical methods of decontamination include using metal or nylon brushes The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushed, degree of brush contact, degree of contamination, nature of the surface being cleaned, and degree of contaminant adherence to the surface

Air Blasting

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities The distance between nozzle and surface cleaned, air pressure, time of application, and angle at which the abrasive strikes the surface will dictate cleaning efficiency Disadvantages of this method are the inability to control the amount of material removed and the large amount of waste generated

Wet Blasting

Wet blast cleaning involves use of a suspended fine abrasive The abrasive/water mixture is delivered by compressed air to the contaminated area By using a very fine abrasive, the amount of materials removed can be carefully controlled

7 1 2 Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off a surface with pressure In general, the equipment surface is not removed using non-abrasive methods

Low-Pressure Water

This method consists of a container which is filled with water The user pumps air out of the container to create a vacuum A slender nozzle and hose allow the user to spray in hard-to-reach places

High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and a high-pressure hose Operating pressure usually ranges from 340 to 680 atmospheres (atm) and flow rates usually range from 20 to 140 liters per minute

Ultra-High-Pressure Water

This system produces a water jet that is pressured from 1,000 to 4,000 atmospheres This ultra-high-pressure spray can remove tightly-adhered surface films The water velocity ranges from 500 meters/second (m/s) (1,000 atm) to 900 m/s (4,000 atm) Additives can be used to enhance the cleaning action

Rinsing

Contaminants are removed by rinsing through dilution, physical attraction, and solubilization

Damp Cloth Removal

In some instances, due to sensitive, non-waterproof equipment or due to the unlikelihood of equipment being contaminated, it is not necessary to conduct an extensive decontamination procedure For example, air sampling pumps hooked on a fence, placed on a drum, or wrapped in plastic bags are not likely to become heavily contaminated A damp cloth should be used to wipe off contaminants which may have adhered to equipment through airborne contaminants or from surfaces upon which the equipment was set

Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents Unfortunately, standard sterilization methods are impractical for large equipment This method of decontamination is typically performed off-site

7.2 Field Sampling Equipment Decontamination Procedures

The decontamination line is setup so that the first station is used to clean the most contaminated item It progresses to the last station where the least contaminated item is cleaned The spread of contaminants is further reduced by separating each decontamination station by a minimum of three (3) feet Ideally, the contamination should decrease as the equipment progresses from one station to another farther along in the line

A site is typically divided up into the following boundaries Hot Zone or Exclusion Zone (EZ), the Contamination Reduction Zone (CRZ), and the Support or Safe Zone (SZ) The decontamination line should be setup in the Contamination Reduction Corridor (CRC) which is in the CRZ Figure 1 (Appendix B) shows a typical contaminant reduction zone layout The CRC controls access into and out of the exclusion zone and confines decontamination activities to a limited area The CRC boundaries should be conspicuously marked The far end is the hotline, the boundary between the exclusion zone and the contamination reduction zone The size of the decontamination corridor depends on the number of stations in the decontamination process, overall dimensions of the work zones, and amount of space available at the site Whenever possible, it should be a straight line

Anyone in the CRC should be wearing the level of protection designated for the decontamination crew Another corridor may be required for the entry and exit of heavy equipment Sampling and monitoring equipment and sampling supplies are all maintained outside of the CRC Personnel don their equipment away from the CRC and enter the exclusion zone through a separate access control point at the hotline One person (or more) dedicated to decontaminating equipment is recommended

7.2 1 Decontamination Setup

Starting with the most contaminated station, the decontamination setup should be as follows

Station 1 Segregate Equipment Drop

Place plastic sheeting on the ground (Figure 2, Appendix B) Size will depend on amount of

equipment to be decontaminated Provide containers lined with plastic if equipment is to be segregated Segregation may be required if sensitive equipment or mildly contaminated equipment is used at the same time as equipment which is likely to be heavily contaminated

Station 2 Physical Removal With A High-Pressure Washer (Optional)

As indicated in 7 1 2, a high-pressure wash may be required for compounds which are difficult to remove by washing with brushes The elevated temperature of the water from the high-pressure washers is excellent at removing greasy/oily compounds High pressure washers require water and electricity

A decontamination pad may be required for the high-pressure wash area An example of a wash pad may consist of an approximately 1 1/2 foot-deep basin lined with plastic sheeting and sloped to a sump at one corner A layer of sand can be placed over the plastic and the basin is filled with gravel or shell The sump is also lined with visqueen and a barrel is placed in the hole to prevent collapse A sump pump is used to remove the water from the sump for transfer into a drum

Typically heavy machinery is decontaminated at the end of the day unless site sampling requires that the machinery be decontaminated frequently A separate decontamination pad may be required for heavy equipment

Station 3 Physical Removal With Brushes And A Wash Basin

Prior to setting up Station 3, place plastic sheeting on the ground to cover areas under Station 3 through Station 10
Fill a wash basin, a large bucket, or child's swimming pool with non-phosphate detergent and tap water Several bottle and bristle brushes to physically remove contamination should be dedicated to this station Approximately 10 - 50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination

Station 4 Water Basin

Fill a wash basin, a large bucket, or child's swimming pool with tap water Several bottle and bristle brushes should be dedicated to this station Approximately 10-50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination

Station 5 Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water Provide a 5-gallon bucket or basin to contain the water during the rinsing process Approximately 10-20 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination

Station 6 Nitric Acid Sprayers

Fill a spray bottle with 10% nitric acid An acid rinse may not be required if inorganics are not a contaminant of concern The amount of acid will depend on the amount of equipment to be decontaminated Provide a 5-gallon bucket or basin to collect acid during the rinsing process

Station 7 Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water Provide a 5-gallon bucket or basin to collect water during the rinsate process

Station 8 Organic Solvent Sprayers

Fill a spray bottle with an organic solvent After each solvent rinse, the equipment should be rinsed with distilled/deionized water and air dried Amount of solvent will depend on the amount of equipment to decontaminate Provide a 5-gallon bucket or basin to collect the solvent during the rinsing process

Solvent rinses may not be required unless organics are a contaminant of concern, and may be eliminated from the station sequence

Station 9 Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water Provide a 5-gallon bucket or basin to collect water during the rinsate process

Station 10 Clean Equipment Drop

Lay a clean piece of plastic sheeting over the bottom

plastic layer This will allow easy removal of the plastic in the event that it becomes dirty Provide aluminum foil, plastic, or other protective material to wrap clean equipment

7.2 2 Decontamination Procedures

Station 1 Segregate Equipment Drop

Deposit equipment used on-site (i e , tools, sampling devices and containers, monitoring instruments radios, clipboards, etc) on the plastic drop cloth/sheet or in different containers with plastic liners Each will be contaminated to a different degree Segregation at the drop reduces the probability of cross contamination Loose leaf sampling data sheets or maps can be placed in plastic zip lock bags if contamination is evident

Station 2 Physical Removal With A High-Pressure Washer (Optional)

Use high pressure wash on grossly contaminated equipment Do not use high- pressure wash on sensitive or non-waterproof equipment

Station 3 Physical Removal With Brushes And A Wash Basin

Scrub equipment with soap and water using bottle and bristle brushes Only sensitive equipment (i e , radios, air monitoring and sampling equipment) which is waterproof should be washed Equipment which is not waterproof should have plastic bags removed and wiped down with a damp cloth Acids and organic rinses may also ruin sensitive equipment Consult the manufacturers for recommended decontamination solutions

Station 4 Equipment Rinse

Wash soap off of equipment with water by immersing the equipment in the water while brushing Repeat as many times as necessary

Station 5 Low-Pressure Rinse

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer

Station 6 Nitric Acid Sprayers (required only if metals are a contaminant of concern)

Using a spray bottle rinse sampling equipment with nitric acid Begin spraying (inside and outside) at one end of the equipment allowing the acid to drip to the other end into a 5-gallon bucket A rinsate blank may be required at this station Refer to Section 9

Station 7 Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer

Station 8 Organic Solvent Sprayers

Rinse sampling equipment with a solvent Begin spraying (inside and outside) at one end of the equipment allowing the solvent to drip to the other end into a 5-gallon bucket Allow the solvent to evaporate from the equipment before going to the next station A QC rinsate sample may be required at this station

Station 9 Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure washer

Station 10 Clean Equipment Drop

Lay clean equipment on plastic sheeting Once air dried, wrap sampling equipment with aluminum foil, plastic, or other protective material

7 2 3 Post Decontamination Procedures

1 Collect high-pressure pad and heavy equipment decontamination area liquid and waste and store in appropriate drum or container A sump pump can aid in the collection process Refer to the Department of Transportation (DOT) requirements for appropriate containers based on the contaminant of concern

2 Collect high-pressure pad and heavy equipment decontamination area solid waste and store in appropriate drum or container Refer to the DOT requirements for appropriate containers based on the contaminant of concern

3 Empty soap and water liquid wastes from basins and buckets and store in appropriate

drum or container Refer to the DOT requirements for appropriate containers based on the contaminant of concern

4 Empty acid rinse waste and place in appropriate container or neutralize with a base and place in appropriate drum pH paper or an equivalent pH test is required for neutralization Consult DOT requirements for appropriate drum for acid rinse waste

5 Empty solvent rinse sprayer and solvent waste into an appropriate container Consult DOT requirements for appropriate drum for solvent rinse waste

6 Using low-pressure sprayers, rinse basins, and brushes Place liquid generated from this process into the wash water rinse container

7 Empty low-pressure sprayer water onto the ground

8 Place all solid waste materials generated from the decontamination area (i e , gloves and plastic sheeting, etc) in an approved DOT drum Refer to the DOT requirements for appropriate containers based on the contaminant of concern

9 Write appropriate labels for waste and make arrangements for disposal Consult DOT regulations for the appropriate label for each drum generated from the decontamination process

8.0 CALCULATIONS

This section is not applicable to this SOP

9.0 QUALITYASSURANCE/ QUALITY CONTROL

A rinsate blank is one specific type of quality control sample associated with the field decontamination process This sample will provide information on the effectiveness of the decontamination process employed in the field

Rinsate blanks are samples obtained by running analyte free water over decontaminated sampling equipment to test for residual contamination The blank water is collected in sample containers for handling, shipment, and analysis These samples are treated identical to samples collected that day A rinsate blank is used to assess cross contamination brought about by improper decontamination procedures Where dedicated sampling equipment is not utilized, collect one rinsate blank per day per type of sampling device samples to meet QA2 and QA3 objectives

If sampling equipment requires the use of plastic tubing it should be disposed of as contaminated and replaced with clean tubing before additional sampling occurs

10.0 DATA VALIDATION

Results of quality control samples will be evaluated for contamination This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow OSHA, U.S EPA, corporate, and other applicable health and safety procedures

Decontamination can pose hazards under certain circumstances Hazardous substances may be incompatible with decontamination materials For example, the decontamination solution may react with contaminants to produce heat, explosion, or toxic products Also, vapors from decontamination solutions may pose a direct health hazard to workers by inhalation, contact, fire, or explosion

The decontamination solutions must be determined to be acceptable before use Decontamination materials may degrade protective clothing or equipment, some solvents can permeate protective clothing If decontamination materials do pose a health hazard, measures should be taken to protect personnel or substitutions should be made to eliminate the hazard The choice of respiratory protection based on contaminants of concern from the site may not be appropriate for solvents used in the decontamination process

Safety considerations should be addressed when using abrasive and non-abrasive decontamination

equipment Maximum air pressure produced by abrasive equipment could cause physical injury Displaced material requires control mechanisms

Material generated from decontamination activities requires proper handling, storage, and disposal Personal Protective Equipment may be required for these activities

Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard (i e , acetone, alcohol, and trisodiumphosphate)

In some jurisdictions, phosphate containing detergents (i e , TSP) are banned

12.0 REFERENCES

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, February, 1988

A Compendium of Superfund Field Operations Methods, EPA 540/p-87/001

Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, USEPA Region IV, April 1, 1986

Guidelines for the Selection of Chemical Protective Clothing, Volume 1, Third Edition, American Conference of Governmental Industrial Hygienists, Inc , February, 1987

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, October, 1985

APPENDIX A

Table

Table 1 Soluble Contaminants and Recommended Solvent Rins

TABLE I Soluble Contaminants and Recommended Solvent Rinse		
SOLVENT[1]	EXAMPLES OF SOLVENTS	SOLUBLE CONTAMINANTS
Water	Deionized water Tap water	Low-chain hydrocarbons Inorganic compounds Salts Some organic acids and other polar compounds
Dilute Acids	Nitric acid Acetic acid Boric acid	Basic (caustic) compounds (e g., amines and hydrazines)
Dilute Bases	Sodium bicarbonate (e g , soap detergent)	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents [2]	Alcohols Ethers Ketones Aromatics Straight chain alkalines (e.g., hexane) Common petroleum products (e.g , fuel, oil, kerosene)	Nonpolar compounds (e g , some organic compounds)
Organic Solvent[2]	Hexane	PCBs

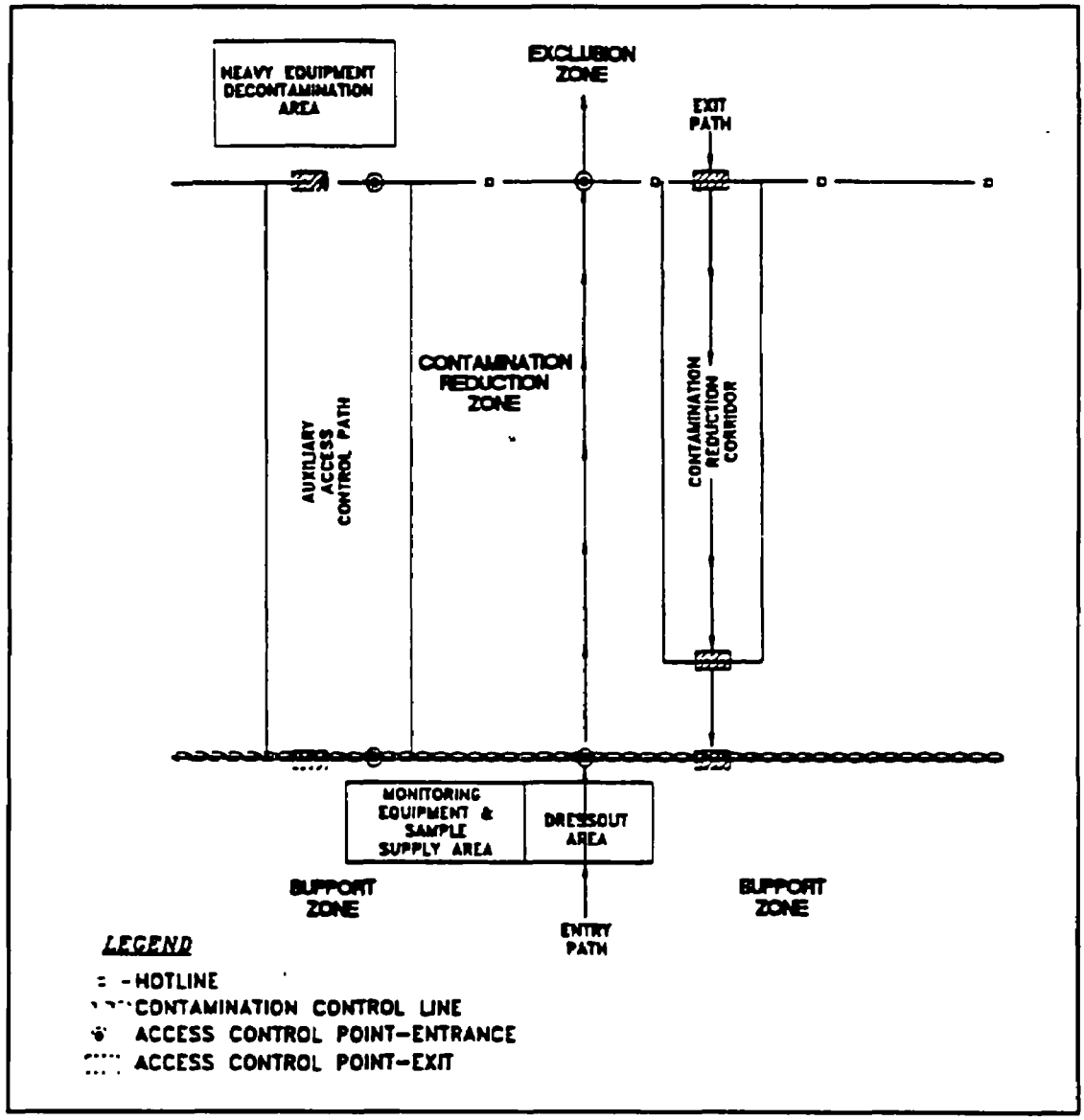
[1] - Material safety data sheets are required for all decontamination solvents or solutions as require by the Hazard Communication Standard

[2] - WARNING: Some organic solvents can permeate and/or degrade the protective clothing

APPENDIX B

Figures

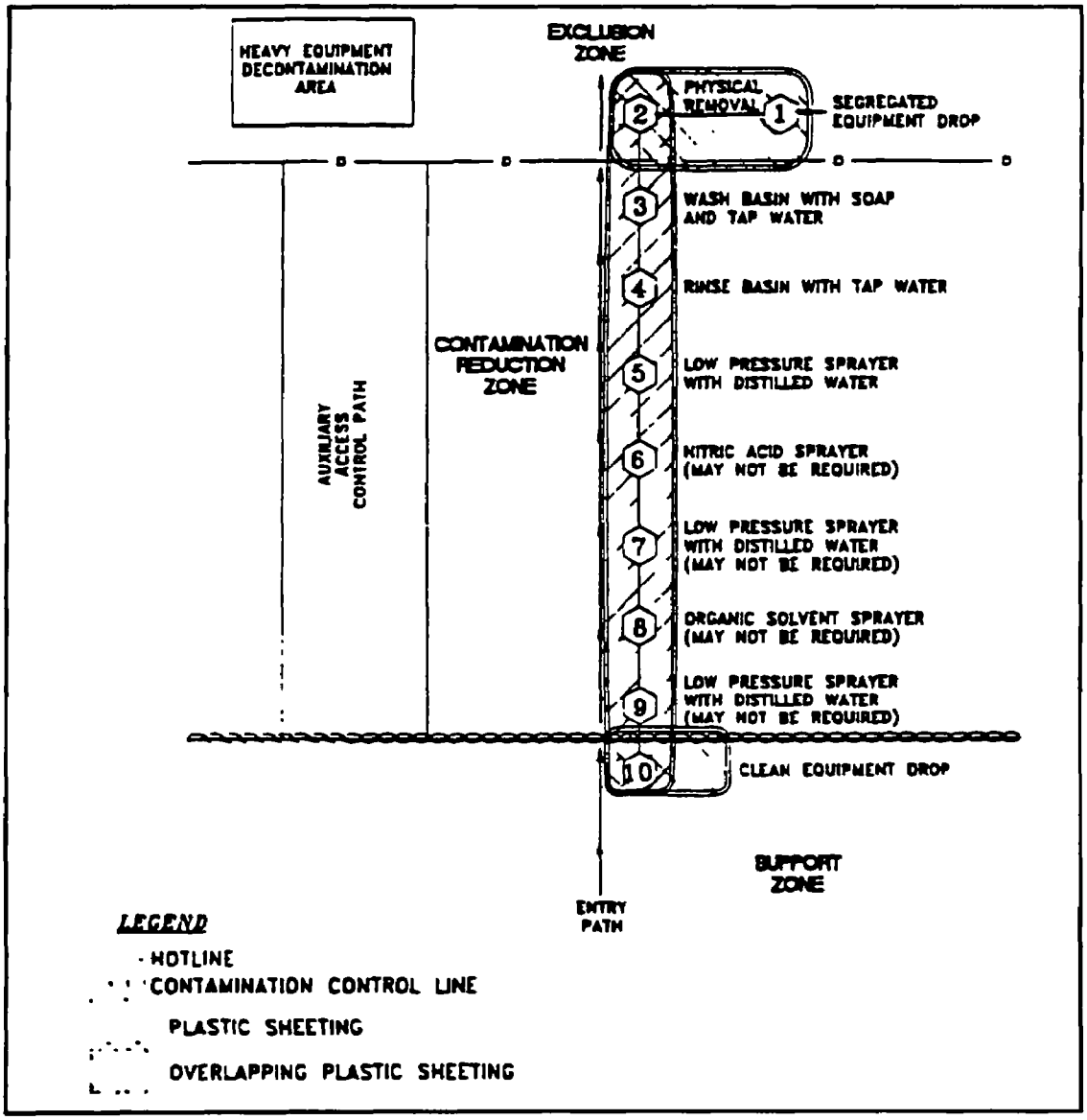
Figure 1 Contamination Reduction Zone Layout



APPENDIX B (Cont'd.)

Figures

Figure 2 Decontamination Layout



WATER LEVEL MEASUREMENT

SOP# 204.
DATE: 10/03/94
REV #. 0.0

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to set guidelines for the determination of the depth to water and floating chemical product (i e , gasoline, kerosene) in an open borehole, cased borehole, monitoring well or piezometer

Generally, water level measurements taken in boreholes, piezometers, or monitoring wells are used to construct water table or potentiometric surface maps and to determine flow direction as well as many other aquifer characteristics Therefore, all water level measurements at a given site should be collected within a 24-hour period with a great deal of accuracy Certain situations may necessitate that all water level measurements be taken within a shorter time interval These situations may include

1 The magnitude of the observed changes between wells appears too large

2 Atmospheric pressure changes

3 Aquifers which are tidally influenced

4 Aquifers affected by river stage, impoundments, and/or unlined ditches

5 Aquifers stressed by intermittent pumping of production wells

6 Aquifers being actively recharged due to precipitation event

7 Occurrence of pumping

These are standard (i e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S EPA endorsement or recommendation for use

2.0 METHOD SUMMARY

A survey mark should be placed on the casing for use as a reference point for measurement Generally, the reference point is made at the top of casing or "stickup," but often the lip of the riser pipe is not flat Another measuring reference should be located on the grout apron The measuring point should be documented in the site logbook and on the groundwater level data form (Appendix A) Every attempt should be made to notify future field personnel of such reference point in order to ensure comparable data and measurements

Prior to measurement, water levels in piezometers and monitoring wells should be allowed to stabilize for a minimum of 24 hours after well construction and development In low yield situations, recovery may take longer All measurements should be made to an accuracy of 0 01 feet

In general, working with decontaminated equipment, proceed from least to most contaminated wells Where many wells are to be sampled (i e., greater than ten), measurements may be taken in a systematic manner to insure efficiency and accuracy Open the well and monitor headspace with the appropriate monitoring instrument to determine the presence of volatile organic compounds Lower water level measurement device into well until water surface or bottom of casing at least twice is encountered

Measure distance from water surface to reference point on well casing at least twice and record in site logbook and/or groundwater level data form Remove all downhole equipment, decontaminate as necessary, and replace casing cap Note that if floating hydrocarbon product is present, a special dual liquid water level indicator is required

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this standard operating procedure (SOP)

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

1 The chalk used on steel tape may contaminate the well

2 Cascading water may obscure the water mark or cause it to be inaccurate

3 Many types of electric sounders use metal indicators at five-foot intervals around a conducting wire These intervals should be checked with a surveyor's tape (preferably with units divided in hundredths of a foot) to insure accuracy

4 If there is oil present on the water, it can insulate the contacts of the probe on an electric sounder or give false readings due to thickness of the oil It is recommended to determine the thickness and density of the oil layer in order to determine the correct water level A special liquid water level indicator is required

5 Turbulence in the well and/or cascading water can make water level determination difficult with either an electric sounder or steel tape

6 An airline measures drawdown during pumping It is only accurate to 0 5 foot unless it is calibrated for various drawdowns

5.0 EQUIPMENT/APPARATUS

There are a number of devices which can be used to measure water levels The device must be capable of attaining an accuracy of 0 01 feet, and calibrated on a regular basis

Field equipment includes

- C Air monitoring equipment
- C Well depth measurement device
- C Electronic water level indicator
- C Metal tape measure
- C Airline
- C Chalk
- C Ruler
- C Logbook
- C Paper towels
- C Groundwater water level data forms
- C pH meter (optional)
- C Specific conductivity meter (optional)
- C Thermometer (optional)

6.0 REAGENTS

No chemical reagents are used in this procedure, however, decontamination solutions may be necessary If decontamination of equipment is required, refer to the SOP for Sampling Equipment Decontamination, and the site specific work plan

7.0 PROCEDURES

7.1 Preparation

1 Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed

2 Obtain necessary sampling and monitoring equipment

3 Decontaminate or pre-clean equipment, and ensure that it is in working order

4 Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate

5 Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan

6 Identify and mark all sampling locations

7.2 Procedures

Procedures for determining water levels are as follows

1 Make sure water level measuring equipment is in good operating condition

2 If possible and when applicable, start at those wells that are least contaminated and proceed to those wells that are most contaminated

3 Clean all equipment entering well by the following decontamination procedure

- C Triple rinse equipment with deionized water
- C Wash equipment with an Alconox solution which is followed by a deionized water rinse
- C Rinse with an approved solvent (e g , methanol, isopropyl alcohol, acetone) as per the work plan, if organic contamination is suspected
- C Place equipment on clean surface such as a teflon or polyethylene sheet

4 Remove locking well cap, note well ID, time of day, elevation (top of casing) and date in site logbook or an appropriate groundwater level data form

5 Remove well casing cap

6 If required by site-specific condition, monitor headspace of well with a photoionization detector (PID) or flame ionization detector (FID) to determine presence of volatile organic compounds, and record in site logbook

7 Lower electric water level measuring device or equivalent (i e , permanently installed transducers or airline) into the well until water surface is encountered

8 Measure the distance from the water surface to the reference measuring point on the well casing or protective barrier post and record in the site logbook In addition, note that the water level measurement was from the top of the steel casing, the top of the PVC riser pipe, the ground surface, or some other position on the well head

9 The groundwater level data forms (Form 1, Appendix A) should be completed as follows

- C Site Name Site name
- C Logger Name Person taking field notes
- C Date Date when the water levels are being measured
- C Location Monitor well number and physical location
- C Time Time (military time) at which the water level measurement was recorded
- C Depth to Water Water level measurement in feet, tenths, or hundredths of feet, depending on the equipment used Two measurements are required to insure accuracy
- C Comments Any information the field personnel feels to be applicable may be included here
- C Measuring Point Marked measuring point on PVC riser pipe, protective steel casing or concrete pad surrounding well casing from which all water level measurements for individual wells should be measured This provides consistency in future water level measurements

10 Measure total depth of well (at least twice to confirm measurement) and record in site logbook or on groundwater level data form

11 Remove all downhole equipment, replace well casing cap and locking steel caps

12 Rinse all downhole equipment and store for transport to next well Decontaminate all equipment as outlined in Step 3 above

13 Note any physical changes, such as erosion or cracks in protective concrete pad or variation in total depth of well, in field logbook and on groundwater level data form

8.0 CALCULATIONS

To determine groundwater elevation above mean sea level, use the following equation

$$E_W = E - D$$

where

E_W = Elevation of water above mean sea level (ft) or local datum

E = Elevation above sea level or local datum at point of measurement (ft)

D = Depth to water (ft)

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply

1 All data must be documented on standard chain of custody forms, field data sheets, groundwater level data forms, or within personal/site logbooks

2 All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented

3 Each well should be tested at least twice in order to compare results

10.0 DATA VALIDATION

This section is not applicable to this SOP

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U S EPA, OSHA, or corporate health and safety practices

12.0 REFERENCES

U S Environmental Protection Agency, 1986 RCRA Groundwater Monitoring Technical Enforcement Guidance Document, pp 207

U S Environmental Protection Agency, 1987, A Compendium of Superfund Field Operations Methods EPA/540/p-87/001 Office of Emergency and Remedial Response Washington, D C 20460

APPENDIX A

Groundwater Level Data Form

FORM 1 Groundwater Level Data Form

PAGE _ OF _

SITE NAME _____ LOGGER NAME _____

LOG DATE _____ W A # _____

Well I.D	TIME	Well Elevation (T O C)	Depth to Bottom of Well (ft)	Depth to Water (ft)	COMMENTS (pH, temperature, specific conductance)

MEASUREMENT REFERENCE POINT FROM __ TOP OF GROUND OR __ TOP OF CASING

Weather Conditions

Other significant observations

WELL DEVELOPMENT

SOP# 204
DATE 10/03/94
REV #. 0.0

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide an overview of monitor well development practices The purpose of monitor well development is to ensure removal of fines from the vicinity of the well screen This allows free flow of water from the formation into the well and also reduces the turbidity of the water during sampling events The most common well development methods are surging, jetting, overpumping and bailing

Surging involves raising and lowering a surge block or surge plunger inside the well The resulting surging motion forces water into the formation and loosens sediment to be pulled from the formation into the well Occasionally, sediments must be removed from the well with a sand bailer to prevent sand locking of the surge block This method may cause the sand pack around the screen to be displaced to a degree that damages its value as a filtering medium For example, channels or voids may form near the screen if the filter pack sloughs away during surging (Keely and Boateng, 1987)

Jetting involves lowering a small diameter pipe into the well a few feet above the well screen, and injecting water or air through the pipe under pressure so that sediments at the bottom are geysered out of the top of the well It is important not to jet air or water directly across the screen This may cause fines in the well to be driven into the entrance of the screen openings, thereby causing blockages

Overpumping involves pumping at a rate rapid enough to draw the water level in the well as low as possible, and allowing it to recharge This process is repeated until sediment-free water is produced

Bailing includes using a simple check-valve bailer to remove water from the well The bailing method, like other methods, should be repeated until sediment free water is produced Bailing may be the method of choice in a shallow well or well that recharges slowly

These are standard (i e , typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S EPA endorsement or recommendation for use

2.0 METHOD SUMMARY

Development of a well should occur as soon as it is practical after installation, but not sooner than 48 hours after grouting is completed, if a rigorous well development method is being used If a less rigorous method, such as bailing, is used for development, it may be initiated shortly after installation The main concern is that the method being used for development does not interfere with allowing the grout to set

Open the monitoring well, take initial measurements (i e , head space air monitor readings, water level, well depth, pH, temperature, and specific conductivity) and record results in the site logbook Develop the well by the appropriate method (i e , overpumping, jetting, or surging) to accommodate site conditions and project requirements Continue until the developed water is clear and free of sediments Containerize all discharge water from known or suspected contaminated areas Record final measurements in logbook Decontaminate equipment as appropriate prior to use in the next well

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this (SOP)

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The following interferences or problems may occur during well development

1 Overpumping is not as vigorous as surging and jetting, and is probably the most desirable method for monitor well development

2 The possibility of disturbing the filter pack increases with surging and jetting well development methods

3 The introduction of external water or air by jetting may alter the hydrochemistry of the aquifer

5.0 EQUIPMENT/APPARATUS

The type of equipment used for well development is dependent on the diameter of the well and the development method For example, the diameter of most submersible pumps is too large to fit in a two-inch inner diameter (I D) well and an inertia pump or other development method should be used

In general, the well should be developed with the drilling equipment shortly after it is drilled Most drilling rigs have air compressors or pumps that may be used for the development process

6.0 REAGENTS

No chemical reagents are used in this procedure, however, decontamination solutions may be necessary If decontamination of equipment is required at a well, refer to the SOP for Sampling Equipment Decontamination and the site specific work plan

7.0 PROCEDURES

7.1 Preparation

1 Coordinate site access and obtain keys to the locks

2 Obtain information on each well to be developed (i e , drilling, method, well diameter, depth, screened interval, anticipated contaminations, etc)

3 Obtain a water level meter, a depth sounder, air monitoring equipment, materials for decontamination, pH and specific conductivity meters, a thermometer, stopwatch, and development equipment/apparatus

4 Assemble containers for temporary storage of water produced during well development Containers must be structurally sound, compatible with anticipated contaminants, and easy to manage in the field The use of truck-mounted tanks may be necessary in some cases, alternately, a portable water treatment unit (i e , activated carbon) may be used to decontaminate the purge water

7.2 Operation

Development should be performed as soon as it is practical after the well is installed, but no sooner than 48 hours after grouting is completed Dispersing agents, acids, or disinfectants should not be used to enhance development of the well

1 Assemble necessary equipment on a plastic sheet around the well

2 Record pertinent information in field logbook (personnel, time, location ID, etc)

3 Open monitor well, take air monitoring reading at the top of casing and breathing zone as appropriate

4 Measure depth to water and the total depth of the monitoring well

5 Develop the well until the water is clear and free of sediments Note the initial color, clarity, and odor of the water

6 Measure the initial pH, temperature, and specific conductivity of the water and record in logbook

7 All water produced by development in contaminated or suspected contaminated areas must be containerized or treated Each

container must be clearly labeled with the location ID Determination of the appropriate disposal method will be based on the first round of analytical results from each well

8 No water shall be added to the well to assist development without prior approval by appropriate personnel If a well cannot be cleaned of mud to produce formation water because the aquifer yields insufficient water, small amounts of potable water may be injected to clean up this poorly yielding well This may be done by dumping in buckets of water When most of the mud is out, continue development with formation water only It is essential that at least five times the amount of water injected must be produced back from the well in order to assure that all injected water is removed from the formation

9 Note the final color, clarity and odor of the water

10 Measure the final pH, temperature and specific conductance of the water and record in the site logbook

11 Record the following data in the site logbook

- C Well designation (location ID)
- C Date(s) of well installation
- C Date(s) and time of well development
- C Static water level before and after development
- C Quantity of water removed and time of removal
- C Type and size/capacity of pump and/or bailer used
- C Description of well development techniques used

7.3 Post-Operation

1 Decontaminate all equipment

2 Store containers of water produced during development in a safe and secure area

3 After the first round of analytical results have been received, determine and implement the appropriate water disposal method

8.0 CALCULATIONS

There are no calculations necessary to implement this procedure However, if it is necessary to calculate the volume of water in the well, utilize the following equation

$$Well\ volume = \pi r^2 h\ (cf) \quad [Equation\ 1]$$

where

π	=	pi
r	=	radius of monitoring well (feet)
h	=	height of the water column (feet) [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point]
cf	=	conversion factor (gal/ft^3) = 7 48 gal/ft^3 [In this equation, 7 48 gal/ft^3 is the necessary conversion factor]

Monitor well diameters are typically 2", 3", 4", or 6" Knowing the diameter of the monitor well, there are a number of standard conversion factors which can be used to simplify the equation above

The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows

$$V\ (gal/ft) = \pi r^2\ (cf) \quad [Equation\ 2]$$

where

π	=	pi
r	=	radius of monitoring well (feet)
cf	=	conversion factor (7 48 gal/ft^3)

For example, a two inch diameter well, the volume per linear foot can be calculated as follows

vol/linear ft	=	πr^2 (cf) [Equation 2]
	=	3 14 (1/12 ft)^2 7 48 gal/ft^3
	=	0 1632 gal/ft

Remember that if you have a two inch diameter, well you must convert this to the radius in feet to be able to use the equation

The conversion factors for the common size monitor wells are as follows

Well diameter	2"	3"	4"	6"
Volume (gal/ft)	0 1632	0 3672	0 6528	1 4688

If you utilize the conversation factors above, Equation 1 should be modified as follows

Well volume ' ***(h)(cf)*** ***[Equation 3]***

where

h = height of water column (feet)
cf = the conversion factor calculated from Equation 2

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures However, the following general QA procedures apply

1 All data must be documented in personal/site logbooks

2 All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented

10.0 DATA VALIDATION

This section is not applicable to this SOP

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U S EPA, OSHA, and corporate health and safety practices

12.0 REFERENCES

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CONTROLLED PUMPING TEST

SOP#: 2045
DATE: 10/04/94
REV #: 0.0

1.0 SCOPE AND APPLICATION

The most reliable and commonly used method of determining aquifer characteristics is by controlled aquifer pumping tests Groundwater flow varies in space and time and depends on the hydraulic properties of the rocks and the boundary conditions imposed on the groundwater system Pumping tests provide results that are more representative of aquifer characteristics than those predicted by slug or bailer tests Pumping tests require a greater degree of activity and expense, however, and are not always justified for all levels of investigation As an example, slug tests may be acceptable at the reconnaissance level whereas pumping tests are usually performed as part of a feasibility study in support of designs for aquifer remediation

Aquifer characteristics which may be obtained from pumping tests include hydraulic conductivity (K), transmissivity (T), specific yield (Sy) for unconfined aquifers, and storage coefficient (S) for confined aquifers These parameters can be determined by graphical solutions and computerized programs The purpose of this standard operating procedure (SOP) is to outline the protocol for conducting controlled pumping test

These are standard (i e , typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S EPA endorsement or recommendation for use

2.0 METHOD SUMMARY

It is desirable to monitor pre-test water levels at the test site for about one week prior to performance of the pump test This information allows for the determination of the barometric efficiency of the aquifer, as well as noting changes in head, due to recharging or pumping in the area adjacent to the well Prior to initiating the long term pump test, a step test is conducted to estimate the greatest flow rate that may be sustained by the pump well

After the pumping well has recovered from the step test, the long term pumping test begins At the beginning of the test, the discharge rate is set as quickly and accurately as possible The water levels in the pumping well and observation wells are recorded accordingly with a set schedule Data is entered on the Pump/Recovery Test Data Sheet (Appendix A) The duration of the test is determinated by project needs and aquifer properties, but rarely goes beyond three days or until water levels become constant

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Interferences and potential problems include atmospheric conditions, impact of local potable wells, and compression of the aquifer due to trains, heavy traffic, etc

5.0 EQUIPMENT/APPARATUS

The following equipment is required to perform a pump test

- Tape measure (subdivided into tenths of feet)
- Submersible pump

- C Water pressure transducer
- C Electric water level indicator
- C Weighted tapes
- C Steel tape (subdivided into tenths of feet)
- C Generator
- C Electronic data-logger (if transducer method is used)
- C Watch or stopwatch with second hand
- C Semi-log graph paper (if required)
- C Water proof ink pen and logbook
- C Thermometer
- C Appropriate references and calculator
- C A barometer or recording barograph (for tests conducted in confined aquifers)
- C Heat shrinks
- C Electrical tape
- C Flashlights and lanterns
- C pH meter
- C Conductivity meter
- C Discharge pipe
- C Flow meter

6.0 REAGENTS

No chemical reagents are used for this procedure, however, decontamination solutions may be necessary If decontamination of equipment is required, refer to the SOP for Sampling Equipment Decontamination and the site specific work plan

7.0 PROCEDURES

7.1 Preparation

1 Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed

2 Obtain necessary sampling and monitoring equipment

3 Decontaminate or preclean equipment, and ensure that it is in working order

4 Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate

5 Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan

6 Identify and mark all sampling locations

7.2 Field Preparation

1 Review the site work plan and become familiar with information on the wells to be tested

2 Check and ensure the proper operation of all field equipment Ensure that the electronic data-logger is fully charged, if appropriate Test the electronic data-logger using a container of water Always bring additional transducers in case of malfunctions

3 Assemble a sufficient number of field data forms to complete the field assignment

4 The pumping well should be properly developed prior to testing, following the guidelines outlined in the Well Development SOP

5 An orifice, weir, flow meter, container or other type of water measuring device to accurately measure and monitor the discharge from the pumping well shall be provided

6 Sufficient pipe to transport the discharge from the pumping well to an area beyond the expected cone of depression is needed Conducting a pumping test in contaminated groundwater may require treatment, special handling, or a discharge permit before the water can be discharged

7 The discharge pipe must have a gate valve to control the pumping rate

8 Determine if there is an outlet near the well head for water quality determination and sampling

7.3 Pre-Test Monitoring

It is desirable to monitor pretest water levels at the test site for about one week prior to performance of the test This can be accomplished by using a continuous-recording device such as a Stevens Recorder This information allows the determination of the barometric efficiency of the aquifer when

barometric records are available It also helps determine if the aquifer is experiencing an increase or decrease in head with time due to recharge or pumping in the nearby area, or diurnal effects of evapotranspiration Changes in barometric pressure are recorded during the test (preferably with an on-site barograph) in order to correct water levels for any possible fluctuations which may occur due to changing atmospheric conditions Pretest water level trends are projected for the duration of the test These trends and/or barometric changes are used to "correct" water levels during the test so they are representative of the hydraulic response of the aquifer due to pumping of the test well

7.4 Step Test

Prior to initiating a long term pumping test, a step test shall be conducted The purpose of a step test is to estimate the greatest flow rate that may be sustained during a long term test The test shall be performed by progressively increasing the flow rate on one hour intervals The generated drawdown versus time data is plotted on semilogarithmic graph paper, and the discharge rate is determined from this graph

7.5 Pump Test

7 5 1 Time Intervals

After the pumping well has fully recovered from the step test, the long term pumping test may start At the beginning of the test, the discharge rate should be set as quickly and accurately as possible The water levels in the pumping well and observation wells will be recorded according to the following schedule

TABLE 1. Time Intervals for Measuring Drawdown in the Pumped Well

Elapsed Time Since Start or Stop of Test (Minutes)	Interval Between Measurements (Minutes)
0-10	5-1
10-15	1
15-60	5
60-300	30
300-1440	60
1440-termination	480

TABLE 2 Time Intervals for Measuring Drawdown in an Observation Well

Elapsed Time Since Start or Stop of Test (Minutes)	Interval Between Measurements (Minutes)
0-60	2
60-120	5
120-240	10
240-360	30
360-1440	60
1440-termination	480

7.5 2 Water Level Measurements

Water levels will be measured as specified in the Well Level Measurement SOP During the early part of the test, sufficient personnel should be available to have at least one person at each observation well and at the pumping well After the first two hours, two people are usually sufficient to continue the test It is not necessary that readings at the wells be taken simultaneously It is very important that depth to water readings be measured accurately and readings recorded at the exact time measured Alternately, individual pressure transducers and electronic data-loggers may be used to reduce the number of field personnel hours required to complete the pumping test A typical aquifer pump test form is shown in Appendix A

During a pumping test, the following data must be recorded accurately on the aquifer test data form

1 Site ID - A number assigned to identify a specific site

2 Location - The location of the well in which water level measurements are being taken

3 Distance from Pumped Well - Distance the observation well is from the pumping well in feet

4 Logger - The company conducting the pumping test

5 Test Start Date - The date when the pumping test began

6 Test Start Time - Start time, using a 24-hour clock

7 Static Water Level (Test Start) - Depth to water, in feet and tenths of feet, in the observation well at the beginning of the pumping test

8 Test End Date - The date when the pumping test was completed

9 Test End Time - End time, using a 24-hour clock

10 Static Water Level (Test End) - Depth to water, in feet and tenths of feet, in the observation well at the end of the pumping test

11 Average Pumping Rate - Summation of all entries recorded in the Pumping Rate (gal/min) column divided by the total number of Pumping Rate (gal/min) readings

12 Measurement Methods - Type of instrument used to measure depth-to-water (this may include steel tape, electric sounding probes, Stevens recorders, or pressure transducers)

13 Comments - Appropriate observations or information which has not been recorded elsewhere, including notes on sampling

14 Elapsed Time (min) - Time of measurement record continuously from time 0 00 (start of test) recorded in minutes

15 Depth to Water (ft) - Depth to water, in feet and tenths of feet, in the observation well at the time of the water level measurement

16 Pumping Rate (gal/min) - Flow rate of pump measured from an orifice, weir, flow meter, container or other type of water measuring device

7 5 3 Test Duration

The duration of the test is determined by the needs of the project and properties of the aquifer One simple test for determining adequacy of data is when the log-time versus drawdown for the most distant observation well begins to plot as a straight line on the semi-log graph paper There are several exceptions to this simple rule of thumb, therefore, it should be considered a minimum criteria Different hydrogeologic conditions can produce straight line trends on log-time versus drawdown plots In general, longer tests produce more definitive results A duration of one to three days is desirable, followed by a similar period of monitoring the recovery of the water level Unconfined aquifers and partially penetrating wells may have shorter test durations Knowledge of the local hydrogeology, combined with a clear understanding of the overall project objectives is necessary in interpreting just how long the test should be conducted There is no need to continue the test if the water level becomes constant with time This normally indicates that a hydrogeologic source has been intercepted and that additional useful information will not be collected by continued pumping

7.6 Post Operation

The following activities shall be performed after completion of water level recovery measurements

1 Decontaminate and/or dispose of equipment as per the Sampling Equipment Decontamination SOP

2 When using an electronic data-logger, use the following procedures

- C Stop logging sequence
- C Print data, or save memory and disconnect battery at the end of the day's activities

3 Replace testing equipment in storage containers

4 Check sampling equipment and supplies Repair or replace all broken or damaged equipment

5 Review field forms for completeness

6 Interpret pumping/recovery test field results

8.0 CALCULATIONS

There are several accepted methods for determining

aquifer properties such as transmissivity, storativity, and conductivity However, the method to use is dependent on the characteristics of the aquifer being tested (confined, unconfined, leaky confining layer etc) When reviewing pump test data the following texts may be used to determine the method most appropriate to your case

- Applied Hydrogeology (Fetter, 1980)
- Groundwater and Wells (Driscoll, 1986)
- Groundwater (Freeze & Cherry, 1979)

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

All gauges, transducers, flow meters, and other equipment used in conducting pumping tests shall be calibrated before use at the site Copies of the documentation of instrumentation calibration should be obtained and filed with the test data records The calibration records will consist of laboratory measurements and, if necessary, any on-site zero adjustment and/or calibration will be performed Where possible, all flow and measurement meters will be checked on-site using a container of measured volume and stopwatch, the accuracy of the meters must be verified before testing proceeds

10.0 DATA VALIDATION

This section is not applicable to this SOP

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, following U S EPA, OSHA, and corporate health and safety practices

12.0 REFERENCES

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APPENDIX A

Pump/Recovery Test Data Sheet

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PUMP/RECOVERY TEST DATA SHEET

SITE ID DISTANCE FROM PUMPED WELL (FT)

LOCATION LOGGER

TEST START	TEST END
DATE	DATE
TIME	TIME
STATIC WATER LEVEL (FT) __	STATIC WATER LEVEL (FT) __

AVERAGE PUMPING RATE (GAL/MIN)

MEASUREMENT METHODS

COMMENTS

ELAPSED TIME (MIN)	PUMP TEST DEPTH TO WATER (FT)	PUMPING RATE (GAL/MIN)	RECOVERY TEST ELAPSED TIME (MIN)	DEPTH TO WATER (FT)
0 00			0 00	

APPENDIX A (Cont'd)

Pump/Recovery Test Data Sheet

PAGE __ OF __

PUMP/RECOVERY TEST DATA

SITE

LOCATION ID DATE

ELAPSED TIME (MIN)	PUMP TEST DEPTH TO WATER (FT)	PUMPING RATE (GAL/MIN)	RECOVERY TEST ELAPSED TIME (MIN)	DEPTH TO WATER (FT)
0 00			0 00	

SLUG TESTS

SOP#: 204(
DATE 10/03/94
REV. #: 0 0

1.0 SCOPE AND APPLICABILITY

This procedure is applicable to determine the horizontal hydraulic conductivity of distinct geologic horizons under in-situ conditions The hydraulic conductivity (K) is an important parameter for modeling the flow of groundwater in an aquifer

These are standard (i e typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limimtations imposed by the procedure In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S Environmental Protection Agency (U S EPA) endorsement or recommendation for use

2.0 METHOD SUMMARY

A slug test involves the instantaneous injection or withdrawal of a volume or slug of water or solid cylinder of known volume This is accomplished by displacing a known volume of water from a well and measuring the artificial fluctuation of the groundwater level

The primary advantages of using slug tests to estimate hydraulic conductivities are numerous First, estimates can be made in-situ, thereby avoiding errors incurred in laboratory testing of disturbed soil samples Second, tests can be performed quickly at relatively low costs because pumping and observation wells are not required And lastly, the hydraulic conductivity of small discrete portions of an aquifer can be estimated (e g , sand layers in a clay)

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this standard operating procedure (SOP)

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Limitations of slug testing include 1) only the hydraulic conductivity of the area immediately surrounding the well is estimated which may not be representative of the average hydraulic conductivity of the area, and 2) the storage coefficient, S, usually cannot be determined by this method

5.0 EQUIPMENT/APPARATUS

The following equipment is needed to perform slug tests All equipment which comes in contact with the well should be decontaminated and tested prior to commencing field activities

- C Tape measure (subdivided into tenths of feet)
- C Water pressure transducer
- C Electric water level indicator
- C Weighted tapes
- C Steel tape (subdivided into tenths of feet)
- C Electronic data-logger (if transducer method is used)
- C Stainless steel slug of a known volume
- C Watch or stopwatch with second hand
- C Semi-log graph paper (if required)
- C Water proof ink pen and logbook
- C Thermometer
- C Appropriate references and calculator
- C Electrical tape
- C 21X micrologger
- C Compact portable computer or equivalent with Grapher installed on the hard disk

6.0 REAGENTS

No chemical reagents are used in this procedure, however, decontamination solvents may be necessary If decontamination of the slug or equipment is required, refer to the Sampling Equipment Decontamination SOP and the site specific work plan

7.0 PROCEDURES

7.1 Field Procedures

The following general procedures may be used to collect and report slug test data These procedures may be modified to reflect site specific conditions

1 When the slug test is performed using an electronic data-logger and pressure transducer, all data will be stored internally or on computer diskettes or tape The information will be transferred directly to the main computer and analyzed A computer printout of the data shall be maintained in the files as documentation

If the slug test data is collected and recorded manually, the slug test data form (Figure 1, Appendix A) will be used to record observations The slug test data form shall be completed as follows

- C Site ID - Identification number assigned to the site
- C Location ID - Identification of location being tested
- C Date - The date when the test data was collected in this order year, month, day (e g , 900131 for January 31, 1990)
- C Slug volume (ft^3) - Manufacturers specification for the known volume or displacement of the slug device
- C Logger - identifies the company or person responsible for performing the field measurements
- C Test method - The slug device is either injected or lowered into the well or withdrawn or pulled-out from the monitor well Check the method that is applicable to the test situation being run
- C Comments Appropriate observations or information for which no other blanks are provided
- C Elapsed time (min) - Cumulative time readings from beginning of test to end of test, in minutes
- C Depth to water (ft) - Depth to water recorded in tenths of feet

2 Decontaminate the transducer and cable

3 Make initial water level measurements on monitor wells in an upgradient to downgradient sequence, if possible

4 Before beginning the slug test, information will be recorded and entered into the electronic data-logger The type of information may vary depending on the model used When using different models, consult the operator's manual for the proper data entry sequence to be used

5 Test wells from least contaminated to most contaminated, if possible

6 Determine the static water level in the well by measuring the depth to water periodically for several minutes and taking the average of the readings

7 Cover sharp edges of the well casing with duct tape to protect the transducer cables

8 Install the transducer and cable in the well to a depth below the target drawdown estimated for the test but at least two feet from the bottom of the well Be sure the depth of submergence is within the design range stamped on the transducer Temporarily tape the transducer cable to the well to keep the transducer at a constant depth

9 Connect the transducer cable to the electronic data-logger

10 Enter the initial water level and transducer design range into the recording device according to manufacturers instructions (the transducer design range will be stamped on the side of the transducer) Record the initial water level on the recording device

11 "Instantaneously" introduce or remove a

known volume or slug of water to the well Another method is to introduce a solid cylinder of known volume to displace and raise the water level, allow the water level to restabilize and remove the cylinder It is important to remove or add the volumes as quickly as possible because the analysis assumes an "instantaneous" change in volume is created in the well

12 At the moment of volume addition or removal assigned time zero, measure and record the depth to water and the time at each reading Depths should be measured to the nearest 0 01 foot The number of depth-time measurements necessary to complete the test are variable It is critical to make as many measurements as possible in the early part of the test The number and intervals between measurements will be determined from earlier previous aquifer tests or evaluations

13 Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a semi-log plot of time versus depth

14 Retrieve slug (if applicable)

Note The time required for a slug test to be completed is a function of the volume of the slug, the hydraulic conductivity of the formation and the type of well completion The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions The length of the test may range from less than a minute to several hours

If the well is to be used as a monitoring well, precautions should be taken that the wells are not contaminated by material introduced into the well If water is added to the monitoring well, it should be from an uncontaminated source and transported in a clean container Bailers or measuring devices should be cleaned prior to the test If tests are performed on more than one monitor well, care must be taken to avoid cross contamination of the wells

Slug tests shall be conducted on relatively undisturbed wells If a test is conducted on a well that has recently been pumped for water sampling purposes, the measured water level must be within 0 1 foot of the water level prior to sampling At least one week should elapse between the drilling of a well and the performance of a slug test

7.2 Post Operation Procedures

When using an electronic data-logger use the following procedure

1 Stop logging sequence

2 Print data

3 Send data to computer by telephone

4 Save memory and disconnect battery at the end of the day's activities

5 Review field forms for completeness

8.0 CALCULATIONS

The simplest interpretation of piezometer recovery is that of Hvorslev (1951) The analysis assumes a homogenous, isotropic medium in which soil and water are incompressible Hvorslev's expression for hydraulic conductivity (K) is

$$K = \frac{r^2 \ln (L/R)}{2 L T_0} \quad \text{for } L/R > 8$$

where

K	=	hydraulic conductivity [ft/sec]
r	=	casing radius [ft]
L	=	length of open screen (or borehole) [ft]
R	=	filter pack (borehole) radius [ft]
T_0	=	Basic Time Lag [sec], value of t on semi-logarithmic plot of H-h/H-H_0 vs t, where H-h/H-H_0 = 0 37
H	=	initial water level prior to removal of slug
H_0	=	water level at t = 0
h	=	recorded water level at t > 0

(Hvorslev, 1951, Freeze and Cherry, 1979)

The Bower and Rice method is also commonly used for K calculations However, it is much more time consuming than the Hvorslev method Refer to Freeze and Cherry or Applied Hydrogeology (Fetter) for a discussion of these methods

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply

1 All data must be documented on standard Chain of Custody records, field data sheets, or within personal/site logbooks

2 All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented

The following specific quality assurance activity will apply

1 Each well should be tested at least twice in order to compare results

10.0 DATA VALIDATION

This section is not applicable to this SOP

11.0 HEALTH AND SAFETY

When working with potential hazardouse materials, follow U S EPA, OSHA and corporate health and safety procedures

12.0 REFERENCES

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APPENDIX A

Slug Test Data Form

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FIGURE 1 Slug Test Data Form

DATE _____

SITE ID _____ SLUG VOLUME (ft^3) _____

LOCATION ID _____ LOGGER _____

TEST METHOD _ SLUG INJECTION _ SLUG WITHDRAWAL

COMMENTS _____

_____

_____

Time Beginning of Test #1 _____ Time Beginning of Test #2 _____

Time End of Test #1 _____ Time End of Test #2 _____

ELAPSED TIME (MIN)	DEPTH TO WATER (FT)	ELAPSED TIME (MIN)	DEPTH TO WATER (FT)

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide an overview of the methods used for groundwater monitor wells Monitor well installation create permanent access for collection of samples to assess groundwater quality and the hydrogeologic properties of the aquifer in which contaminants may exist Such wells should not alter the medium which is being monitored

The most commonly used drilling methods are the hollow-stem auger, cable tool, and hydraulic rotary Rotary drilling can utilize mud rotary or air rotary methods

These are standard (i e, typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedures themselves In all instances, the ultimate procedures employed should be documented and described in the final report as well as in logbooks

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U S EPA) endorsement or recommendation for use

2.0 METHOD SUMMARY

There is no ideal monitor well installation method for all conditions therefore, hydrogeologic conditions at the site as well as project objectives must be considered before deciding which drilling method is appropriate

2.1 Hollow-Stem Augering

Outside diameters of hollow-stem augers generally range from 6 1/4 inches to 22 inches with corresponding inner diameters ranging from 2 1/4 inches to 13 inches Auger lengths are usually 5 feet which allows easy handling However, lengths of 10 or 20 feet may be used for deeper holes drilled with machines capable of handling the extended lengths Formation samples can be taken in a number of ways, depending on the accuracy required Cuttings may suffice for shallow depths but become less representative with depth, particularly below the water table The most accurate samples are obtained with various coring devices, such as split spoons or shelby tubes which can be used inside the augers Continuous cores can also be taken with a thin-walled tube which is inserted into the lowest auger and locked in place The tube is retracted with a wire line and hoist after the hole has been advanced the length of the auger A bottom plug in the cutting head or bit prevents cuttings from entering the augers until the first core sample is taken and the plug is knocked out

In unconsolidated material, the augers serve as a temporary casing and gravel-packed wells can be constructed inside the augers and then the augers withdrawn Well development is usually less difficult than with wells drilled by the mud rotary method because a bentonite drilling fluid is not normally used

2.2 Cable Tool Drilling

Cable tool drilling is a percussion method in which a bit, attached to a drilling string, is lifted and dropped The drilling string, consists (bottom to top) of the bit, drill stem, drilling jars, socket, and wire cable A walking beam on the drilling rig provides the lifting and dropping motion to the wire cable and hence to the drilling string The repeated action breaks or loosens the formation material which mixes with formation water or water added to the hole by the operator to form a slurry The slurry facilitates removal of the cuttings which are periodically removed from the hole with a bailer In unconsolidated formations, steel casing must be driven or pushed into the ground as the drilling progresses in order to prevent hole collapse A hardened steel drive shoe on the bottom end of the

casing prevents damage during driving A well may then be constructed inside the steel casing and the casing pulled back In consolidated formations, the casing may be driven through the weathered zone, and seated in solid rock The hole below the casing may remain open or may be fitted with a smaller diameter inner casing and screen, depending on the sampling requirements Depending on formation material, extensive well development may often not be necessary

2.3 Rotary Drilling

2 3 1 Mud Rotary Method

In the mud rotary method the drill bit is rotated rapidly to cut the formation material and advance the borehole The drill bit is attached to hollow drilling rods which transfer power from the rig to the bit In conventional rotary drilling, cuttings are removed by pumping drilling fluid (water, or water mixed with bentonite or other additives) down through the drill rods and bit, and up the annulus between the borehole and the drill rods The drilling fluid flows into a mud pit where the cuttings settle out and then is pumped back down the drill rods The drilling fluid also cools the bit and prevents the borehole from collapsing in unconsolidated formations

Sampling may be done from the cuttings but samples are generally mixed and the amount of fine material may not be accurately represented Coring may be done through the drill rods and bit if a coring bit (with a center opening big enough to allow passage of the coring tube) is used When drilling unconsolidated formations, a temporary surface or shallow casing may have to be installed in order to prevent cross-contamination, hole collapse, or wall erosion by the drilling fluid Casing (riser pipe), screen, and gravel pack are usually installed in the open hole or through the surface casing Once the well is constructed, extensive well development may be necessary in order to remove drilling fluid from the formation

2.3 2 Air Rotary Method

The air rotary method uses air as the drilling fluid Air is forced down the drill rods by an air compressor, escapes out of the bit and returns to the surface in the annular space between the hole wall and the drill string Cuttings are moved out of the hole by the ascending air and collect around the rig Cuttings are mixed and may not always be representative of the depth currently being drilled In the conventional air rotary method, the drill string operates in a manner similar to that described for the mud rotary system In a "hammer" or "down-the-hole" air rotary method, the bit is pneumatically driven rapidly against the rock in short strokes while the drilling string slowly rotates The use of air rotary methods are generally limited to consolidated and semi-consolidated formations Casing is often used in semi-consolidated formations and through the weathered portion of consolidated formations to prevent hole collapse In environmental work, the air supply must be filtered to prevent introduction of contamination into the borehole

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Often, a primary objective of the drilling program is to obtain representative lithologic or environmental samples The most common techniques for retrieving samples are

In unconsolidated formations

- Split spoon sampling, carried out continuously or at discrete intervals during drilling, as summarized in ASTM Method D-1586-84, Split Barrel Sampling
- Shelby tube sampling when an undisturbed sample is required from clayey or silty soils, especially for geotechnical evaluation or chemical analysis
- Cutting collection when a general lithologic description and approximate depths are sufficient

In consolidated formations

- Rock coring at continuous or discrete intervals
- Cutting collection when a general lithologic description and approximate depths are sufficient

When collecting environmental samples, the amount of sample to be collected and the proper sample container type (i e , glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest Sample preservation, containers, handling

and storage for air and waste samples are discussed in the specific SOPs for the technique selected

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Advantages and disadvantages of the various drilling methods are summarized below

4.1 Auger Drilling

The advantages of auger drilling are

- Relatively fast and inexpensive
- Because augers act as temporary casing, drilling fluids are not used resulting in reduced well development

The disadvantages of auger drilling are

- Very slow or impossible to use in coarse materials such as cobble or boulders
- Cannot be used in consolidated formations and is generally limited to depths of approximately 100 feet in order to be efficient

4.2 Cable Tool Drilling

The advantages of cable tool drilling are

- Relatively inexpensive with minimum labor requirements
- The water table and water bearing zones are easily identified
- Driven casing stabilizes borehole and minimizes potential for cross-contamination
- Especially successful in drilling caving formations or formations containing boulders
- Accurate formation samples can usually be obtained from cuttings

The disadvantages of cable tool drilling are

- Extremely slow rate of drilling
- Necessity to drive casing may limit depth in large diameter holes

4.3 Rotary Drilling

4.3.1 Mud Rotary Drilling

The advantages of mud rotary drilling are

- Fast, more than 100 feet of borehole advancement per day is common
- Provides an open borehole, necessary for some types of geophysical logging and other tests

The disadvantages of mud rotary drilling are

- Potential for cross-contamination of water-bearing zones
- Drill cuttings may be mixed and not accurately represent lithologies at a given drilling depth
- Drilling mud may alter the groundwater chemistry
- Water levels can only be determined by constructing wells
- Drilling mud may change local permeability of the formation and may not be entirely removed during well development
- Disposal of large volumes of drilling fluid and cuttings may be necessary if they are contaminated

4.3.2 Air Rotary Drilling

The advantages of air rotary drilling are

- Fast, more than 100 feet of borehole advancement a day is possible
- Preliminary estimates of well yields and water levels are often possible
- No drilling fluid to plug the borehole

The disadvantages of air rotary drilling are

- C Generally cannot be used in unconsolidated formations
- C In contaminated zones, the use of high-pressure air may pose a significant hazard to the drill crew because of transport of contaminated material up the hole
- C Introduction of air to the groundwater could reduce concentration of volatile organic compounds

5.0 EQUIPMENT

The following equipment is necessary for the site geologist

- C Metal clipboard box case (container for well logs)
- C Ruler
- C Depth sounder
- C Water level indicator
- C All required health and safety gear
- C Sample collection jars
- C Trowels
- C Description aids (Munsell color chart, grain size charts, etc)
- C Geolis® Logbooks (Appendix A)
- C Field Logbook

Equipment and tools to install the well are normally provided by the drilling contractor

6.0 REAGENTS

Reagents are not required for preservation of soil samples Samples should, however, be cooled to 4° C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample Decontamination of drilling equipment should follow the Sampling Equipment Decontamination SOP and the site-specific work plan

7.0 PROCEDURES

7.1 Preparation

All drilling and well installation programs must be planned and supervised by a professional geologist/hydrogeologist

The planning, selection and implementation of any monitor well installation program should include the following

- C Review of existing data on site geology and hydrogeology including publications, air photos, water quality data, and existing maps These may be obtained from local, state or federal agencies
- C Assesment of the site to determine potential access problems for drill rig, locate water supply sources, establish equipment storage area, and observe outcrops
- C Perform utilities check, note location of underground utilities and of overhead electrical wires
- C Preparation of a Site Safety Plan
- C Select drilling, sampling and well development methods
- C Determination of well construction specifications (i e , casing and screen materials, casing and screen diameter, screen length and screen interval, filter pack and screen slot size)
- C Determination of the need for containing drill cuttings and fluids and their method of disposal
- C Preparation of work plan including all of the above
- C Preparation of and execute the drilling contract

7.2 Field Preparation

Prior to mobilization, the drill rig and all associated equipment should be thoroughly decontaminated by a steam/pressure washer to remove all oil, grease, mud, etc Before drilling each boring, all the "down-the-hole" drill equipment should be steam cleaned and rinsed with potable water to minimize cross-contamination Special attention should be given to the threaded section of the casings, and to the drill rods All drilling equipment should be steam-cleaned at completion of the project to ensure that no contamination is transported to or from the sampling site

7.3 Well Construction

The well casing material should not interact with the groundwater Well casings for environmental projects are usually constructed of polyvinyl chloride (PVC), Teflon™, fiberglass, or stainless steel Details of the construction methods are given in Sections 7 3 1 and 7 3.2

7.3 1 Bedrock Wells

Wells completed in bedrock will be drilled using the air or mud rotary method Crystalline rock wells are usually drilled most efficiently with the air rotary method while consolidated sedimentary formations are drilled using either the air rotary or mud rotary method The compressed air supply will be filtered prior to introduction into the borehole to remove oil or other contaminants Bedrock wells may be completed as an open-hole, providing that borehole cave-in is not a possibility

Bedrock wells will be advanced with air or mud rotary methods until a minimum of 5 feet of competent rock has been drilled Minimum borehole diameter will be 8 inches The drill string will then be pulled from the borehole and 6-inch I D Schedule 80 or 40 PVC casing inserted Portland cement/bentonite grout will be pumped into the hole and up the annular space outside the casing After the grout has set (minimum of 24 hours), the cement will be drilled out and the borehole advanced to the desired depth Figure 1 (Appendix B) shows typical construction details for an open-hole bedrock well

The preferred method of well completion for the bedrock wells will be open-hole However, if the open borehole is subject to cave-in, the well(s) will be completed as screened and cased sand-packed wells For details of completion see Section 7 3 2

7.3 2 Overburden Well Construction

Any of the drilling methods discussed in this SOP can be used to drill or set a well in the overburden The hollow-stem method is the preferred choice for shallow (<100 ft) overburden wells because the well can be constructed inside of the augers Details of the construction are provided below and are shown in Figure 2 (Appendix B)

1 The screen slot size will be determined by the site hydrologist, based upon sand-pack size The length of screen used will be site-dependent Casing sections will be flush-threaded Screw-threaded bottom plugs will be used To prevent introduction of contaminants into the well, no glue-connected fittings will be used Each piece of PVC pipe, screen, and the bottom plug will be steam-cleaned before lowering into the borehole The site hydrogeologist is responsible for the supervision of all steam cleaning procedures

2 The annular space between the well screen and the borehole wall will be filled with a uniform gravel/sand pack to serve as a filter media For wells deeper than approximately 50 feet, or when recommended by the site geologist, the sand pack will be emplaced using a tremie pipe A sand slurry composed of sand and potable water will be pumped through the tremie pipe into the annulus throughout the entire screened interval, and over the top of the screen Allowance must be made for settlement of the sand pack

3 The depth of the top of the sand will be determined using the tremie pipe, thus verifying the thickness of the sand pack Additional sand shall be added to bring the top of the sand pack to approximately 2 to 3 feet above the top of the well screen Under no circumstances should the sand pack extend into any aquifer other than the one to be monitored In most cases, the well design can be modified to allow for a sufficient sand pack without threat of crossflow between producing zones through the sand pack

4 In materials that will not maintain an open hole using hollow-stem augers, the temporary or outer casing will be withdrawn gradually during placement of sand pack/grout For example, after filling two feet with sand pack, the outer casing should be withdrawn 2 feet This step of placing more gravel and withdrawing the outer casing should be repeated until the level of the sand pack is approximately 3 feet above the top of the well screen This ensures that there is no locking of the permanent (inner) casing in the outer casing

5 A bentonite seal of a minimum 2-foot vertical thickness will be placed in the annular space above the sand pack to separate the sand pack from the cement surface seal The bentonite will be placed through a tremie pipe or poured directly into the annular space, depending upon the depth and site conditions The bentonite will be pourable pellets The hydrogeologist will record the start and stop times of the bentonite seal emplacement, the interval of the seal, the amount of bentonite that was used, and problems that arise The type of bentonite and the supplier will also be recorded

A cap placed over the top of the well casing before pouring the bentonite pellets will prevent pellets from entering the well casing

6 If a slurry of bentonite is used as annular seal, it is prepared by mixing powdered or granular bentonite with potable water The slurry must be of sufficiently high specific gravity and viscosity to prevent its displacement by the grout to be emplaced above it As a precaution (regardless of depth) and depending on fluid viscosity, a few handfuls of bentonite pellets may be added to solidify the bentonite slurry surface

7 Cement and/or bentonite grout is placed from the top of the bentonite seal to the ground surface

Only Type I or II cement without accelerator additives may be used An approved source of potable water must be used for mixing grouting materials The following mixes are acceptable

C Neat cement, a maximum of 6 gallons of water per 94 pound bag of cement

C Granular bentonite, 1 5 pounds of bentonite per 1 gallon of water

C Cement-bentonite, 5 pounds of pure bentonite per 94 pound bag of cement with 7-8 gallons of water

C Cement-bentonite, 6 to 8 pounds of pure bentonite per 94 pound bag of cement with 8-10 gallons of water, if water mixed

C Non-expandable cement, mixed at 7 5 gallons of water to one half (1/2) teaspoon of Aluminum Hydroxide, 94 pounds of neat cement (Type I) and 4 pounds of bentonite

C Non-expandable cement, mixed at 7 gallons of water to one half (1/2) teaspoon of Aluminum Hydroxide, 94 pounds of neat cement (Type I and Type II)

8 Grout is pumped through a tremie pipe (normally a 1 25-inch PVC or steel pipe) to the bottom of the annulus until undiluted grout flows from the annulus at the ground surface

9 In materials that will not maintain an open hole, the temporary steel casing should be withdrawn in a manner that prevents the level of grout from dropping below the bottom of the casing

10 Additional grout may be added to compensate for the removal of the temporary casing and the tremie pipe to ensure that the top of the grout is at or above ground surface After the grout has set (about 24 hours), any depression due to settlement is filled with a grout mix similar to that described above

11 The protective casing should now be set Casing may be a 5 foot minimum length of black iron or galvanized pipe extending about 1 5 to 3 feet above the ground surface, and set in concrete or cement grout The protective casing diameter should be 4 inches greater than the well casing A 0 5-inch drain hole may be installed near ground level A flush-mount protective casing may also be used in areas of high traffic or where access to other areas would be limited by a well stick-up

12 A protective steel cap, secured to the protective casing by a padlock, should be installed

13 Steel guard posts should be installed around the protective casing in areas where vehicle traffic may be a problem Posts should have a minimum diameter of 3 inches and be a

minimum of 4 feet high

14 All monitor wells should be labelled and dated with paint or steel tags

7.4 Well Development

Well development is the process by which the aquifer's hydraulic conductivity is restored by removing drilling fluids, and fine-grained formation material from newly installed wells Two methods of well development that are commonly used are surging and bailing, and overpumping A well is considered developed when the pH and conductivity of the groundwater stabilizes and the measured turbidity is <50 nephelometric turbidity units (NTUs)

Surging and bailing will be performed as follows

1 Measure the total depth (TD) of the well and depth to water (DTW)

2 Using an appropriately sized surge block, surge 5-foot sections of well screen, using 10-20 up/down cycles per section Periodically remove the surge block and bail accumulated sediment from the well, as required

3 For open-hole wells, a 6-inch surge block will be used inside the cased portion of the well Sediments will be bailed periodically, as required Overpumping may be used in combination with surging and bailing for development of bedrock wells The method(s) used will be based on field conditions encountered, and will be determined by the site hydrogeologist However, sediment will initially be removed from the wells by bailing in order to minimize the volume of development water generated

The pump used must be rated to achieve the desired yield at a given depth The pump system should include the following

- C A check valve to prevent water from running back into the well when the pump is shut off
- C Flexible discharge hose
- C Safety cable or rope to remove the pump from the well
- C Flow meter monitoring system (measuring bucket or inline flow meter)
- C Generator
- C Amp meter, to measure electrical current (load)

The amp meter is used to monitor pump performance If the pump becomes clogged, the current will increase due to stress on the pump If the water level drops below the intake ports, the current will drop due to decreased resistance on the pump

8.0 CALCULATIONS

To maintain an open borehole during rotary drilling, the drilling fluid must exert a pressure greater than the formation pore pressure Typical pore pressures for unconfined and confined aquifers are 0 433 define (psi/ft) and 0 465 psi/ft, respectively

The relationship for determining the hydrostatic pressure of the drilling fluid is

Hydrostatic Pressure (psi) = Fluid Density (lb/gal) x Height of Fluid Column (ft) x 0 052

The minimum grout volume necessary to grout a well can be calculated using

Grout Vol (ft^3) = Vol of Borehole (ft^3) - Vol of Casing (ft^3) = $L (r_B^2 - r_C^2)$

where

L = length of borehole to be grouted (ft)
r_B = radius of boring (ft)
r_C = radius of casing (ft)

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities that apply to the implementation of these procedures However, the following general QA procedures apply

1 All data must be documented on standard well completion forms, field data sheets or within field/site logbooks Descriptive logs, pump tests, and well completion date are entered on Geolis® forms The Geolis® forms are used to ensure data is collected uniformly by all Site Geologists and provide

input to a standardized computer well file Appendix A contains examples of Geolis® forms used to record descriptions of geologic samples

2 All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan Equipment checkout and calibration activities must occur prior to sampling/operation and must be documented

10.0 DATA VALIDATION

This section is not applicable to this SOP

11.0 HEALTH AND SAFETY

Drilling rigs and equipment present a variety of safety hazards REAC personnel working around drilling rigs should know the position of the emergency "kill" switch Wirelines and ropes should be inspected and frayed or damaged sections discarded Swivels and blocks should turn freely Gages should be operational and controls clearly marked All underground utilities should be clearly marked, and drillers should be aware of any overhead hazards such as power lines Avoid drilling in these areas Ear protection should be worn when working around drilling equipment for extended periods of time, particularly air rotary equipment Failure to follow safety procedure or wear the proper personal protection gear on the part of either the drilling crew or REAC personnel may result in dismissal from the job

When working with potentially hazardous materials, follow U S EPA, OSHA, and corporate health and safety practices

12.0 REFERENCES

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APPENDIX A

Geolis Forms

Form 1 Geolis® Borehole Logging Form

GEOLIS® Borehole Logging Form

COMPANY: _____ LOCATION ID: _____

CLIENT _____ DATE _____

PROJECT _____ LOGGER _____

SITE / AREA _____ SIGNATURE _____

SAMPLING METHOD: SPS - CSS - STB - CTS - CUT - COR - NS

OTHER _____

SAMPLING INTERVAL: _____ TO _____ FT/M BGS

RECOVERY: _____ / _____ FT/M NA

BLOW COUNT: [ ][ ][ ][ ] / [ ] IN/CM NA

RQD: _____ % NA

FLUID ENTRY/ LOSS ZONES _____ FT/M BGS _____ GPM

_____ FT/M BGS _____ GPM

ANALYTICAL SAMPLE ID | INTERVAL (FT/M BGS)

_____ _____ - _____

TYPE / LAB UND - DIS - CMP / MOB - GEO - CHM - _____

/ _____ - _____

TYPE / LAB UND - DIS - CMP / MOB - GEO - CHM - _____

SAMPLING INTERVAL No _____

LITHOLOGIC INTERVAL No. _____

LITHOLOGIC INTERVAL: _____ TO _____ FT/M BGS

LITHOLOGY ARCHIVED? YES - NO

NO RECOVERY

MATERIAL NATURAL - FILL - UNCERTAIN

OBSERVED STN - SHN - CDR - PRD - NA - OTHER _____

INSTRUMENT 1 TYPE _____ READING _____

INSTRUMENT 2 TYPE _____ READING _____

OVERBURDEN

SECONDARY TYPE NA - BED - CLB - MIX — SECONDARY

COLOR MUN - GBA _____

COLORATION UNI - STN - MOT - VAR

BOULDERS _____ % MAX DIAM _____ IN

COBBLES _____ % MAX DIAM _____ IN

TEXTURE C - M - F

GRAVEL	_ _ _	_____ %	_____ %
SAND	_ _ _	_____ %	_____ %
SILT		_____ %	_____ %
CLAY		_____ %	_____ %
ORGANIC		_____ %	_____ %

ROUNDNESS
GRAVEL FAC - STR - ANG - SUB - RND - NA
SAND ANG - SUB - RND - NA

SORTING WEL - MOD - POR - NA

PLASTICITY NON - LOW - MOD - HIGH - NA

MOISTURE DRY - MST - WET - SAT - NA

CEMENTATION NON - SLT - MOD - WEL - NA

GRAIN TYPE QTZ - FRG - FOS - BIO - NA _____

MATRIX MSM - CSM - CAL - OXD - ARG - SIL - NA

STRENGTH
COHESIVE VSF - SFT - FRM - STF - VST - HRD
NONCOHESIVE VDN - DEN - FIR - LSE - NA

UPPER CONTACT SHP - GRD - DIF - SME - NA

BEDDING THICK _____ IN/CM No. _____

TYPE XBD - RPL - HOR - INC - NA
MAS - LNS - LAM - GRU - GRD

GRAPHIC LOG

BEDROCK

SECONDARY TYPE NA - BED - VEN - MIX — SECONDARY

COLOR MUN - GBA _____

ROCK TYPE OTHER _____
SED SHL - SLT - SST - CGL - LST - DOL - COL
MET SLA - PHY - SHS - GNS - MRN - QZT - MBL
IGN GRN - RHY - BSL - GBR - TUF - SRC

TEXTURE C - M - F NA

GRAVEL	_ _ _	_____ %	_____ %
SAND	_ _ _	_____ %	_____ %
SILT		_____ %	_____ %
CLAY/LIME MUD		_____ %	_____ %

GRAIN TYPE: QTZ - FRG - FOS - BIO - NA

MATRIX CAL - MIC - OXD - ARG - SIL - ORG - NA

STRENGTH EWK - VWK - WEK - MOD STR - VST - EST

UPPER CONTACT SHP - GRD - DIF - SAM - NA

SECONDARY POROSITY VUG - FRC - BED - NA - OTHER
HGH - MOD - LOW

WEATHERING FRS - SLT - MOD - HGH - CPL - NA

NATURAL FRACTURE SETS

INTERVAL (FT/M BGS)	#/FT-M	DIP	DIR	FILL/SHAPE/ROUGH/SURFACE
-				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
-				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
-				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
-				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH

STRAT UNIT

NOTE LINE

NEXT INTERVAL: SAMP/LITH No _____ / _____ DEPTH INTERVAL _____ TO _____ NOT SAMPLED NO RECOVERY

COMMENTS (1) _____

(2) _____

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GEOLIS Version 1.4 JAN 1995 G030195

APPENDIX A (Cont'd)

Geolis Forms

Form 2 Geolis® Well Construction Form

GEOLIS Well Construction Form Sheet ___ of ___

COMPANY _____ LOCATION ID _____
PROJECT _____ DATE _____
PROPERTY _____ LOGGER _____
SITE/AREA _____ / _____ SIGNATURE _____

START DATE _____ SURVEYED ELEVATIONS (MSL) DEPTH TO WATER DATE / TIME
COMPLETION DATE _____ GROUND LEVEL _____ FT/M _____ FT/M(TOC) _____
WELL STATUS PMP - ABN - COL - NOR MEASURING POINT (TOP OF CASING) _____ FT/M _____ FT/M(TOC) _____
STATUS DATE _____ _____ FT/M(TOC) _____

WELL DIAGRAM - NOT TO SCALE | DEPTH - (FT, BGS) | WELL CODE

0 GRS

WELL TYPE SCREEN - MULTIPLE SCREEN - OPEN HOLE - NESTED - PROBE
CASING SINGLE - DOUBLE - TRIPLE COMPLETION FLUSH - PROT - VAULT - CAP - NA
TOTAL NO OF SCREENS/WELLS _____ SCREEN/WELL NO _____
WELL USE DOM - PUB - IRR - FIR - MON - HYD - EXT - DEW - RCH - VEW - INJ - OTH _____

WELL DESIGN CONSTRUCTION

CASING #1 (INNERMOST) DIAMETER _____ IN/CM INTERVAL _____ TO _____ FT/M BGS
TYPE PVC - STN - LCS - GAL - ____ SCHEDULE 5 - 10 - 20 - 40 - 80 - ____
CASING JOINTS FLT - SLIT - EUT - SOL - WLD - SCW - CAM - OTH _____
CASING #2 DIAMETER _____ IN/CM INTERVAL _____ TO _____ FT/M BGS
TYPE PVC - STN - LCS - GAL - ____ SCHEDULE 5 - 10 - 20 - 40 - 80 - ____
CASING #3 (OUTERMOST) DIAMETER _____ IN/CM INTERVAL _____ TO _____ FT/M BGS
TYPE PVC - STN - LCS - GAL - ____ SCHEDULE 5 - 10 - 20 - 40 - 80 - ____
STICK UP INNER CASING _____ FT/M OUTER CASING _____ FT/M
GROUT TYPE CMT - C/G - BEN - HSB - OTH _____
INTERVAL _____ TO _____ FT/M BGS
PLACEMENT TRM - PRS - GRV CENTRALIZERS NON - 1 - 2 - 3 - OTH ____
SEAL TYPE 1 _____ INTERVAL _____ TO _____ FT/M BGS
TYPE 2 _____ INTERVAL _____ TO _____ FT/M BGS
SAND PACK TYPE _____ INTERVAL _____ TO _____ FT/M BGS
SCREEN OR DEVICE DIAMETER _____ IN/MM INTERVAL _____ TO _____ FT/M BGS
TYPE PVC - STN - LCS - TEF - OER - HDP - OTH _____
SLOTS CON - SLH - SLV - SRG - CUT - OTH _____
SLOT SIZE 5 - 10 - 20 - 30 - 40 - _____ SLOT

STRAT UNIT MONITORED _____
ESTIMATED WELL YIELD _____ GPM/LPM DRAWDOWN _____ FT/M BMP
WATER SAMPLING SYSTEM NON - PMP - PKR - MLS TYPE _____
SEAL INTERVAL _____ TO _____ FT/M BGS INTAKE DEPTH _____ FT/M BGS
NOTES _____

OPEN HOLE DIAMETER 1 _____ IN/CM INTERVAL _____ TO _____ FT/M BGS
DIAMETER 2 _____ IN/CM INTERVAL _____ TO _____ FT/M BGS

SILT TRAP/SUMP YES - NO INTERVAL _____ TO _____ FT/M BGS
INSIDE WELL T D _____ FT/M BGS COLLAPSE/BACKFILL COL - SFL - STH - NON
COLLAPSE INTERVAL _____ TO _____ FT/M BGS
BACKFILL INTERVAL _____ TO _____ FT/M BGS TYPE _____

WELL CONSTRUCTION CODES
GRS = GROUND SURFACE TOC = TOP OF SCREEN
BPC = BOTTOM OF PROTECTIVE CASING TST = TOP OF SILT TRAP
TSE = TOP OF BENTONITE SEAL WTB = TOTAL DEPTH INSIDE WELL
TBR = TOP OF BEDROCK STB = SCHEDULE TOTAL DEPTH
BOC = BOTTOM OF OUTER CASING TSC = TOP OF CASING (INNER)
TSP = TOP OF SAND PACK BGS = BELOW GROUND SURFACE

COMMENTS _____

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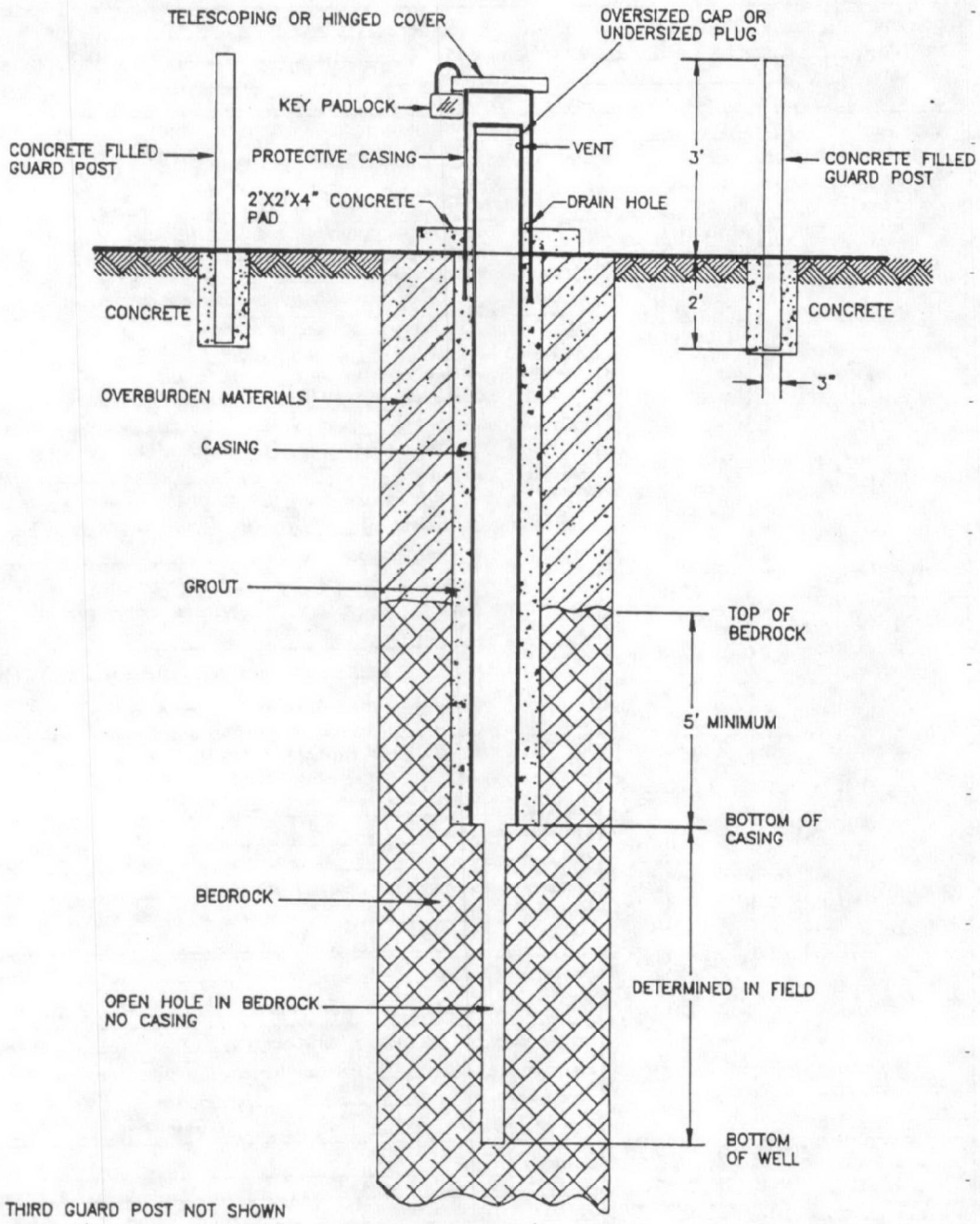
APPENDIX B

Figures

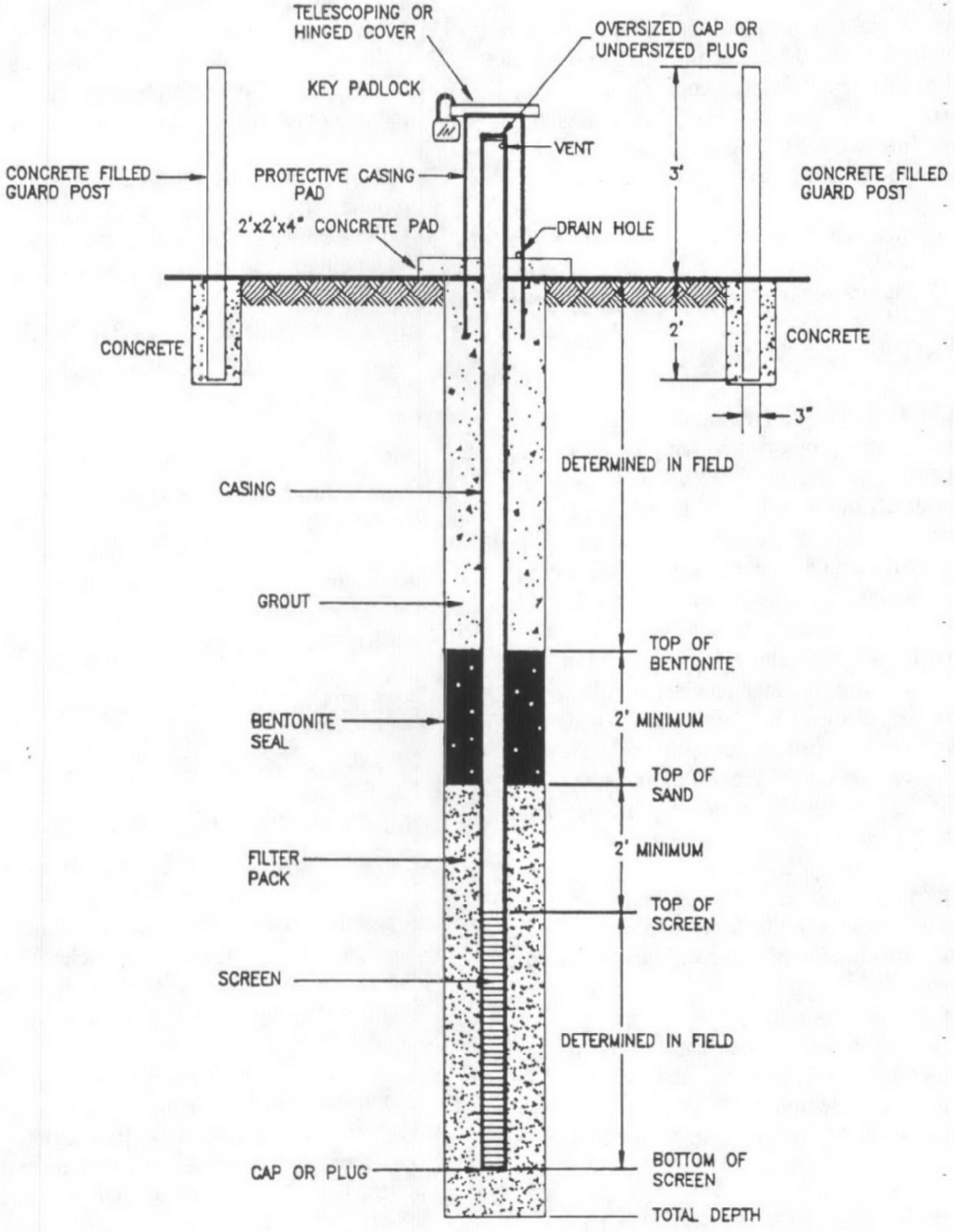
FIGURE 1. Typical Bedrock Well Construction



APPENDIX B (Cont'd)

Figures

FIGURE 2. Typical Overburden Well Construction



MODEL 5400 GEOPROBE™ OPERATION

SOP#: 2050
DATE: 03/27/96
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to describe the collection of representative soil, soil-gas, and groundwater samples using a Model 5400 Geoprobe™ sampling device Any deviations from these procedures should be documented in the site/field logbook and stated in project deliverables

Mention of trade names or commercial products does not constitute U S Environmental Protection Agency (U S EPA) endorsement or recommendation for use

2.0 METHOD SUMMARY

The Geoprobe™ sampling device is used to collect soil, soil-gas and groundwater samples at specific depths below ground surface (BGS) The Geoprobe™ is hydraulically powered and is mounted in a customized four-wheel drive vehicle The base of the sampling device is positioned on the ground over the sampling location and the vehicle is hydraulically raised on the base As the weight of the vehicle is transferred to the probe, the probe is pushed into the ground A built-in hammer mechanism allows the probe to be driven through dense materials Maximum depth penetration under favorable circumstances is about 50 feet Components of the Model 5400 Geoprobe™ are shown in Figures 1 through 6 (Appendix A)

Soil samples are collected with a specially-designed sample tube The sample tube is pushed and/or vibrated to a specified depth (approximately one foot above the intended sample interval) The interior plug of the sample tube is removed by inserting small-diameter threaded rods The sample tube is then driven an additional foot to collect the samples The probe sections and sample tube are then withdrawn and the sample is extruded from the tube into sample jars

Soil gas can be collected in two ways One method involves withdrawing a sample directly from the probe rods, after evacuating a sufficient volume of air from the probe rods The other method involves collecting a sample through tubing attached by an adaptor to the bottom probe section Correctly used, the latter method provides more reliable results

Slotted lengths of probe can be used to collect groundwater samples if the probe rods can be driven to the water table Groundwater samples are collected using either a peristaltic pump or a small bailer

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

Refer to specific ERT SOPs for procedures appropriate to the matrix, parameters and sampling objector

Applicable ERT SOPs include

ERT #2012, Soil Sampling

ERT #2007, Groundwater Well Sampling

ERT #2042, Soil Gas Sampling

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

A preliminary site survey should identify areas to be avoided with the truck All underground utilities should be located and avoided during sampling Begin sampling activities with an adequate fuel supply

Decontamination of sampling tubes, probe rods, adaptors, non-expendable points and other equipment that contacts the soil is necessary to prevent cross-contamination of samples During sampling, the bottom portion and outside of the sampling tubes can be contaminated with soil from other depth intervals

Care must be taken to prevent soil which does not represent the sampled interval form being incorporated into the sample Excess soil should be carefully wiped from the outside surface of the sampling tube and the bottom 3 inches of the sample should be discarded before extruding the sample into a sample jar

The amount of sample to be collected and the proper sample container type (i e , glass, plastic), chemical preservation, and storage requirements are dependent upon the parameter(s) of interest Guidelines for the containment, preservation, handling and storage of soil-gas samples are described in ERT SOP #2042, Soil-Gas Sampling

Obtaining sufficient volume of soil for multiple analyses from o.'. sample location may present a problem The Geoprobe™ soil sampling system recovers a limited volume of soil and it is not possible to reenter the same hole and collect additional soil When multiple analyses are to be performed on soil samples collected with the Geoprobe™, it is important that the relative importance of the analyses be identified Identifying the order of importance will ensure that the limited sample volume will be used for the most crucial analyses

5.0 EQUIPMENT/APPARATUS

Sampling with the Geoprobe™ involves use of the equipment listed below Some of the equipment is used for all sample types, others are specific to soil (S), soil gas (SG), or groundwater (GW) as noted

- C Geoprobe™ sampling device
- C Threaded probe rods (36", 24", and 12" lengths)
- C Drive Caps
- C Pull Caps
- C Rod Extractor
- C Expendable Point Holders
- C Expendable Drive Points
- C Solid Drive Points
- C Extension Rods
- C Extension Rod Couplers
- C Extension Rod Handle
- C Hammer Anvil
- C Hammer Latch
- C Hammer Latch Tool
- C Drill Steels
- C Carbide-Tipped Drill Bit
- C Mill-Slotted Well Point (GW)
- C Threaded Drive Point (GW)
- C Well Mini-Bailer (GW)
- C Tubing Bottom Check Valve (GW)
- C 3/8" O D Low Density Polyethylene Tubing (GW, SG)
- C Gas Sampling Adaptor and Cap (SG)
- C Teflon Tape
- C Neoprene "O" - Rings (SG)
- C Vacuum System (mounted in vehicle) (SG)
- C Piston Tip (S)
- C Piston Rod (S)
- C Piston Stop (S)
- C Sample Tube (11 5" in length) (S)
- C Vinyl Ends Caps (S)
- C Sample Extruder (S)
- C Extruder Pistons (Wooden Dowels) (S)
- C Wire Brush
- C Brush Adapters
- C Cleaning Brush (Bottle)

6.0 REAGENTS

Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination

7.0 PROCEDURES

Portions of the following sections have been condensed from the Model 5400 Geoprobe™ Operations Manual(1) Refer to this manual for more detailed information concerning equipment specifications, general maintenance, tools, throttle control, clutch pump, GSK-58 Hammer, and trouble-shooting A copy of this manual will be maintained with the Geoprobe™ and on file in the Quality Assurance (QA) office

7.1 Preparation

1 Determine extent of the sampling effort, sample matrices to be collected, and types and amounts of equipment and supplies required to complete the sampling effort

2 Obtain and organize necessary sampling and monitoring equipment

3 Decontaminate or pre-clean equipment, and ensure that it is in working order

4 Perform a general site survey prior to site

entry in accordance with the site-specific Health and Safety Plan

5 Use stakes or flagging to identify and mark all sampling locations All sample locations should be cleared for utilities prior to sampling

7.2 Setup of Geoprobe™

1 Back carrier vehicle to probing location

2 Shift the vehicle to park and shut off ignition

3 Set parking brake and place chocks under rear tires

4 Attach exhaust hoses so exhaust blows downwind of the sampling location (this is particularly important during soil gas sampling)

5 Start engine using the remote ignition at the Geoprobe™ operator position

6 Activate hydraulic system by turning on the Electrical Control Switch located on the Geoprobe™ electrical control panel (Figure 1, Appendix A) When positioning the probe, always use the SLOW speed The SLOW speed switch is located on the hydraulic control panel (Figure 2, Appendix A)

Important: Check for clearance on vehicle roof before folding Geoprobe™ out of the carrier vehicle.

7 Laterally extend the Geoprobe™ from the vehicle as far as possible by pulling the EXTEND control lever toward the back of the vehicle while the Geoprobe™ is horizontal

8 Using the FOOT control, lower the Derrick Slide so it is below cylinder (A) before folding the Geoprobe™ out of the carrier vehicle (Figure 3, Appendix A) This will ensure clearance at the roof of the vehicle

9 Use the FOLD, FOOT, and EXTEND controls to place Geoprobe™ to the exact probing location Never begin probing in the fully extended position

10 Using the FOLD control, adjust the long axis of the probe / cylinder so that it is perpendicular (visually) to the ground surface

11 Using the FOOT control, put the weight of the vehicle on the probe unit Do not raise the rear of the vehicle more than six inches

Important: Keep rear vehicle wheels on the ground surface when transferring the weight of the vehicle to the probe unit Otherwise, vehicle may shift when probing begins.

12 When the probe axis is vertical and the weight of the vehicle is on the probe unit, probing is ready to begin

7.3 Drilling Through Surface Pavement or Concrete

1 Position carrier vehicle to drilling location

2 Fold unit out of carrier vehicle

3 Deactivate hydraulics

4 Insert carbide-tipped drill bit into hammer

5 Activate HAMMER ROTATION control by turning knob counter-clockwise (Figure 4, Appendix A) This allows the drill bit to rotate when the HAMMER control is pressed

6 Press down on HAMMER control to activate counterclockwise rotation

7 Both the HAMMER control and the PROBE control must be used when drilling through the surface (Figure 4, Appendix A) Fully depress the HAMMER control, and incrementally lower the bit gradually into the pavement by periodically depressing the PROBE control

8 When the surface has been penetrated, turn the HAMMER Control Valve knob

clockwise to deactivate hammer rotation and remove the drill bit from the HAMMER

Important: Be sure to deactivate the rotary action before driving probe rods.

7.4 Probing

1 Position the carrier vehicle to the desired sampling location and set the vehicle parking brake

2 Deploy Geoprobe™ Sampling Device

3 Make sure the hydraulic system is turned off

4 Lift up latch and insert hammer anvil into hammer - push latch back in (Figure 5, Appendix A)

5 Thread the drive cap onto the male end of the probe rod

6 Thread an expendable point holder onto the other end of the first probe rod

7 Slip an expendable drive point into point holder

8 Position the leading probe rod with expendable drive point in the center of the derrick foot and directly below the hammer anvil

Important: Positioning the first probe rod is critical in order to drive the probe rod vertically. Therefore, both the probe rod and the probe cylinder shaft must be in the vertical position (Figure 6, Appendix A).

9 To begin probing, activate the hydraulics and push the PROBE Control downward When advancing the first probe rod, always use the SLOW speed Many times the probe rods can be advanced using only the weight of the carrier vehicle When this is the case, only the PROBE control is used

Important: When advancing rods, always keep the probe rods parallel to the probe cylinder shaft (Figure 6, Appendix A). This is done by making minor adjustments with the FOLD control Failure to keep probe rods parallel to probe cylinder shaft may result in broken rods and increased difficulty in achieving desired sampling depth.

7.5 Probing - Percussion Hammer

The percussion hammer must be used in situations where the weight of the vehicle is not sufficient to advance the probe rods

1 Make sure the Hammer Rotation Valve is closed

2 Using the PROBE control to advance the rod, press down the HAMMER control to allow percussion to drive the rods (Figure 2, Appendix A)

Important: Always keep static weight on the probe rod or the rod will vibrate and chatter while you are hammering, causing rod threads to fracture and break.

3 Keep the hammer tight to the drive cap so the rod will not vibrate

4 Periodically stop hammering and check if the probe rods can be advanced by pushing only

5 Any time the downward progress of the probe rods is refused, the derrick foot may lift off of the ground surface When this happens, reduce pressure on the PROBE control Do not allow the foot to rise more than six inches off the ground or the vehicle's wheels may lift off the ground surface, causing the vehicle to shift (Figure 6, Appendix A)

6 As the derrick foot is raised off the ground surface, the probe cylinder may not be in a perpendicular position If this happens, use the FOLD control to correct the probe cylinder position

7.6 Probing - Adding Rods

1 Standard probe rods are three feet in length If the desired depth is more than three feet,

another rod must be threaded onto the rod that has been driven into the ground In order to ensure a vacuum-tight seal (soil-gas sampling), two wraps of teflon tape around the thread is recommended

2 Using the PROBE control, raise the probe cylinder as high as possible

Important: Always deactivate hydraulics when adding rods.

3 Deactivate hydraulics

4 Unthread the drive cap from the probe rod that is in the ground

5 Wrap teflon tape around the threads

6 Thread the drive cap onto the male end of the next probe rod to be used

7 After threading the drive cap onto the rod to be added, thread the rod onto the probe rod that has been driven into the ground Make sure threads have been teflon taped Continue probing

8 Continue these steps until the desired sampling depth has been reached

7.7 Probing/Pulling Rods

1 Once the probe rods have been driven to depth, they can also be pulled using the Geoprobe™ Machine

2 Turn off the hydraulics

3 Lift up latch and take the hammer anvil out of the hammer

4 Replace the drive cap from the last probe rod driven with a pull cap

5 Lift up the hammer latch

6 Activate the hydraulics

7 Hold down on the PROBE control, and move the probe cylinder down until the latch can be closed over the pull cap

Important: If the latch will not close over the pull cap, adjust the derrick assembly by using the extend control. This will allow you to center the pull cap directly below the hammer latch.

8 Retract the probe rods by pulling up on the PROBE control

Important: Do not raise the probe cylinder all the way when pulling probe rods or it will be impossible to detach a rod that has been pulled out. However, it is necessary to raise the probe cylinder far enough to allow the next probe section to be pulled.

9 After retracting the first probe rod, lower the probe cylinder only slightly to ease the pressure off of the hammer latch

10 Attach a clamping device to the base of the rods where it meets the ground to prevent rods from falling back into the hole

11 Raise the hammer latch

12 Hold the PROBE control up and raise the probe cylinder as high as possible

13 Unthread the pull cap from the retracted rod

14 Unthread the retracted rod

15 Thread the pull cap onto the next rod that is to be pulled

16 Continue these steps until all the rods are retracted from the hole

17 Decontaminate all portions of the equipment that have been in contact with the soil, soil gas and groundwater

7.8 Soil-Gas Sampling Without Interior Tubing

1 Follow procedures outlined in Sections 7 1 through 7 6

2 Remove hammer anvil from hammer

3 Thread on pull cap to end of probe rod

4 Retract rod approximately six inches Retraction of the rod disengages expendable drive point and allows for soil vapor to enter rod

5 Unthread pull cap and replace it with a gas sampling cap Cap is furnished with barbed hose connector

Important: Shut engine off before taking sample (exhaust fumes can cause faulty sample data).

6 Turn vacuum pump on and allow vacuum to build in tank

7 Open line control valve For each rod used, purge 300 liters of volume Example Three rods used = 900 liters = 900 on gauge

8 After achieving sufficient purge volume, close valve and allow sample line pressure gauge to return to zero This returns sample train to atmospheric pressure

9 The vapor sample can now be taken

1 Pinch hose near gas sampling cap to prevent any outside vapors from entering the rods

2 Insert syringe needle into center of barbed hose connector and withdraw vapor sample

10 To maintain suction at the sampling location, periodically drain the vacuum tank

11 To remove rods, follow procedures outlined in Section 7 7

7.9 Soil-Gas Sampling With Post-Run Tubing (PRT)

1 Follow procedures outlined in Sections 7 1 through 7.6

2 Retract rod approximately six inches Retraction of rod disengages expendable drive point and allows for soil vapor to enter rod

3 Remove pull cap from the end of the probe rod

4 Position the Geoprobe™ to allow room to work

5 Secure PRT Tubing Adapter with "O" - Ring to selected tubing

6 Insert the adapter end of the tubing down the inside diameter of the probe rods

7 Feed the tubing down the hole until it hits bottom on the expendable point holder Cut the tubing approximately two feet from the top probe rod

8 Grasp excess tubing and apply some downward pressure while turning it in a counter-clockwise motion to engage the adapter threads with the expendable point holder

9 Pull up lightly on the tubing to test engagement of threads

10 Connect the outer end of the tubing to silicon tubing and vacuum hose (or other sampling apparatus)

11 Follow the appropriate sampling procedure (ERT SOP #2042, Soil Gas Sampling) to collect a soil-gas sample

12 After collecting a sample, disconnect the tubing from the vacuum hose or sampling system

13 Pull up firmly on the tubing until it releases from the adapter at the bottom of the hole

14 Extract the probe rods from the ground and recover the expendable point holder with the attached adapter

15 Inspect the "O"-ring at the base of the adapter to verify that proper sealing was achieved during sampling The "O"-ring should be compressed

Note: If the "O"-ring is not compressed, vapors from within the probe sections may have been collected rather than vapors from the intended sample interval.

7.10 Soil Sampling

1 Follow procedures outlined in Sections 7 1 through 7 6

2 Assemble soil-sampling tube

1 Thread piston rod into piston tip

2 Insert piston tip into sample tube, seating piston tip into cutting edge of sample tube

3 Thread drive head into threaded end of sample tube

4 Thread piston stop pin into drive head Stop pin should be tightened with wrench so that it exerts pressure against the piston rod

3 Attach assembled sampler onto leading probe rod

4 Drive the sampler with the attached probe rods to the top of the interval to be sampled

5 Move probe unit back from the top of the probe rods to allow work room

6 Remove drive cap and lower extension rods into inside diameter of probe rods using couplers to join rods together

7 Attach extension rod handle to top extension rod

8 Rotate extension rod handle clockwise until the leading extension rod is threaded into the piston stop in downhole

9 Continue to rotate extension rod handle clockwise until reverse-threaded stop-pin has disengaged from the drive head

10 Remove extension rods and attached stop-pin from the probe rods

11 Replace drive cap onto top probe rod

12 Mark the top probe rod with a marker or tape at the appropriate distance above the ground surface (dependent on sample tube length)

13 Drive probe rods and sampler the designated distance Be careful not to overdrive the sampler which could compact the soil sample in the tube, making it difficult to extrude

Important: Documentation of sample location should include both surface and subsurface identifiers. Example: Correct Method - Sample Location S-6, 12.0' - 13.0'. Incorrect Method - Sample Location S-6, 12.0'.

14 Retract probe rods from the hole and recover the sample tube Inspect the sample tube to confirm that a sample was recovered

15 Disassemble sampler Remove all parts

16 Position extruder rack on the foot of the Geoprobe™ derrick

17 Insert sample tube into extruder rack with the cutting end up

18 Insert hammer anvil into hammer

19 Position the extruder piston (wood dowel) and push sample out of the tube using the PROBE control on the Geoprobe™ Collect the sample as it is extruded in an appropriate sample container

Caution: use care when performing this task. Apply downward pressure gradually. Use of excessive force could result in injury to operator or damage to tools. Make sure proper diameter extruder piston is used.

20 To remove rods follow procedures outlined in Section 7 7

7.11 Groundwater Sampling

1 Follow Sections 7 1 thorough 7 6 with the following exception the Mill-Slotted Well Rod with attached threaded drive point should be the first section probed into the ground Multiple sections of mill-slotted well rods can be used to provide a greater vertical section into which groundwater can flow

2 Probe to a depth at which groundwater is expected

3 Remove Drive Cap and insert an electric water-level indicator to determine if water has entered the slotted sections of probe rod Refer to ERT SOP #2043, Water Level Measurement, to determine water level

4 If water is not detected in the probe rods, replace the drive cap and continue probing Stop after each additional probe length and determine if groundwater has entered the slotted rods

5 After the probe rods have been driven into the saturated zone, sufficient time should be allowed for the water level in the probe rods to stabilize

Note: It will be difficult if not impossible to collect a groundwater sample in aquifer material small enough to pass through the slots (<0.02 inch diameter).

6 Groundwater samples may be collected with the 20-mL well Mini-Bailer or a pumping device If samples are being collected for volatile organic analysis (VOA), the 20-mL Well Mini-Bailer should be used If samples are being collected for a variety of analyses, VOA samples should be collected first using the bailer. Remaining samples can be collected by pumping water to the surface Withdrawing water with the pump is more efficient than collecting water with the 20-mL well Mini-Bailer

Important: Documentation of sample location should include both surface and subsurface identifiers. Example: Sample Location GW-6, 17'-21' bgs, water level in probe rods is 17 feet bgs, and the leading section of probe rod is 21 feet bgs. The water sample is from this zone, not from 17 feet bgs or 21 feet bgs.

7 Remove rods following procedures outlined in Section 7 7

8.0 CALCULATIONS

Calculating Vapor Purge Volume for Soil-Gas Sampling without Interior Tubing

Volume of Air to be Purged (Liters) = 300 x Number of Rods in the Ground

Volume in Liters/1000 = Reading on Vacuum Pump Instrument Gauge

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general QA procedures apply

1 All data must be documented on field data sheets or within site logbooks

2 All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented

10.0 DATA VALIDATION

This section is not applicable to this SOP

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U S EPA, OSHA and the REAC site specific Health and Safety Plan The following is a list of health and safety precautions which specifically apply to Geoprobe™ operation

1 Always put vehicle in "park", set emergency the brake, and place chocks under the tires, before engaging remote ignition

2 If vehicle is parked on a loose or soft surface, do not fully raise rear of vehicle with probe foot, as vehicle may fall or move

3 Always extend the probe unit out from the vehicle and deploy the foot to clear vehicle roof line before folding the probe unit out

4 Operators should wear OSHA approved steel-toed shoes and keep feet clear of probe foot

5 Operator should wear ANSI approved hard hats

6 Only one person should operate the probe machine and the assemble or disassemble probe rods and accessories

7 Never place hands on top of a rod while it is under the machine

8 Turn off the hydraulic system while changing rods, inserting the hammer anvil, or attaching accessories

9 Operator must stand on the control side of the probe machine, clear of the probe foot and mast, while operating controls

10 Wear safety glasses at all times during the operation of this machine

11 Never continue to exert downward pressure on the probe rods when the probe foot has risen six inches off the ground

12 Never exert enough downward pressure on a probe rod so as to lift the rear tires of the vehicle off the ground

13 Always remove the hammer anvil or other tool from the machine before folding the machine to the horizontal position

14 The vehicle catalytic converter is hot and may present a fire hazard when operating over dry grass or combustibles

15 Geoprobe™ operators must wear ear protection OSHA approved ear protection for sound levels exceeding 85 dba is recommended

16 Locations of buried or underground utilities and services must be known before starting to drill or probe

17 Shut down the hydraulic system and stop the vehicle engine before attempting to clean or service the equipment

18 Exercise extreme caution when using extruder pistons (wooden dowels) to extrude soil from sample tubes Soil in the sample tube may be compacted to the point that the extruder piston will break or shatter before it will push the sample out

19 A dry chemical fire extinguisher (Type ABC) should be kept with the vehicle at all times

12.0 REFERENCES

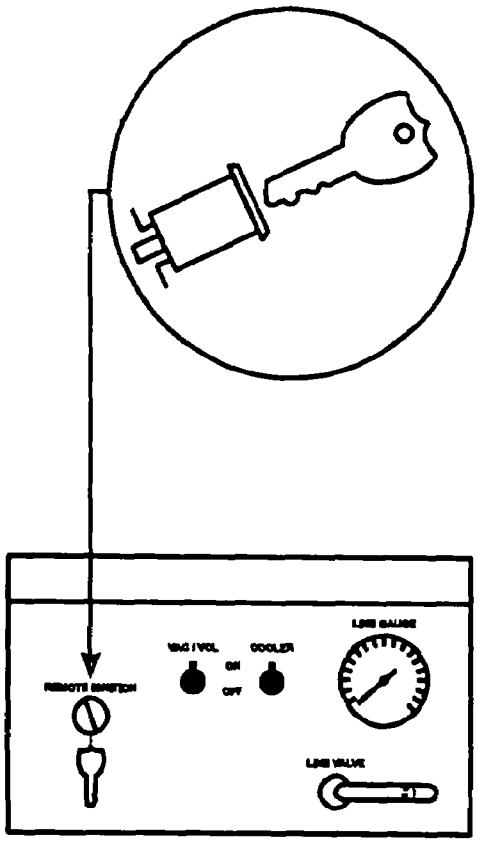
1 Model 5400 Geoprobe™ Operations Manual Geoprobe™ Systems, Salina, Kansas July 27, 1990

2 Geoprobe™ Systems - 1995-96 Tools and Equipment Catalog

APPENDIX A

Figures

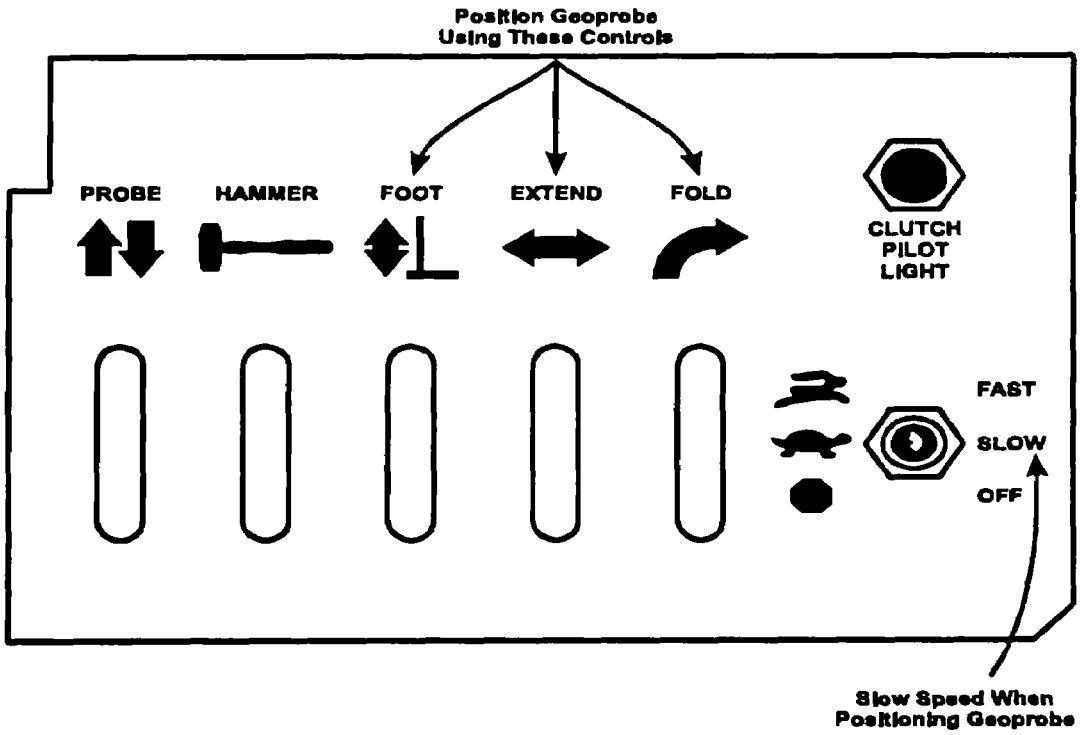
FIGURE 1 Electrical Control Panel



APPENDIX A (Cont'd)

Figures

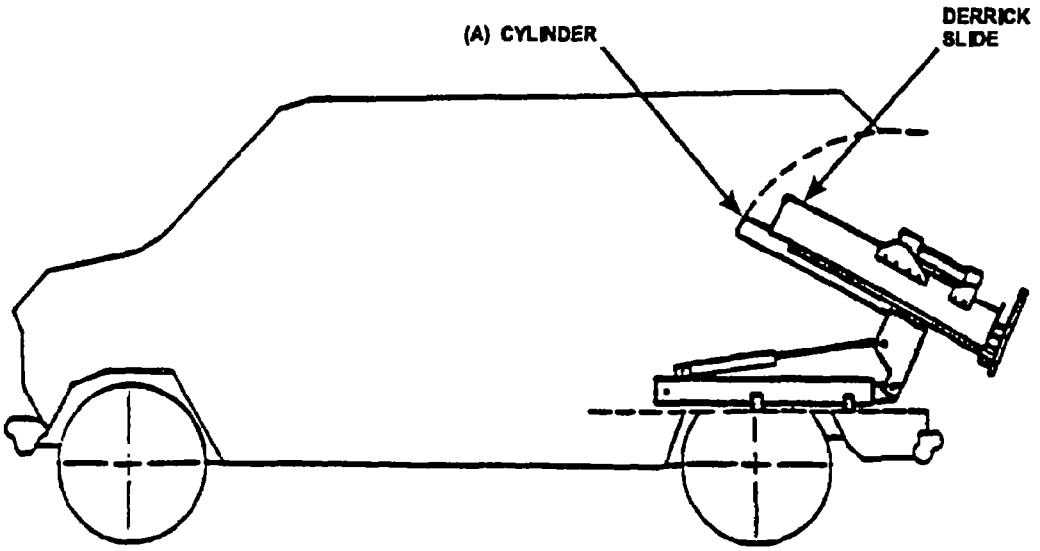
FIGURE 2 Hydraulic Control Panel



APPENDIX A (Cont'd)

Figures

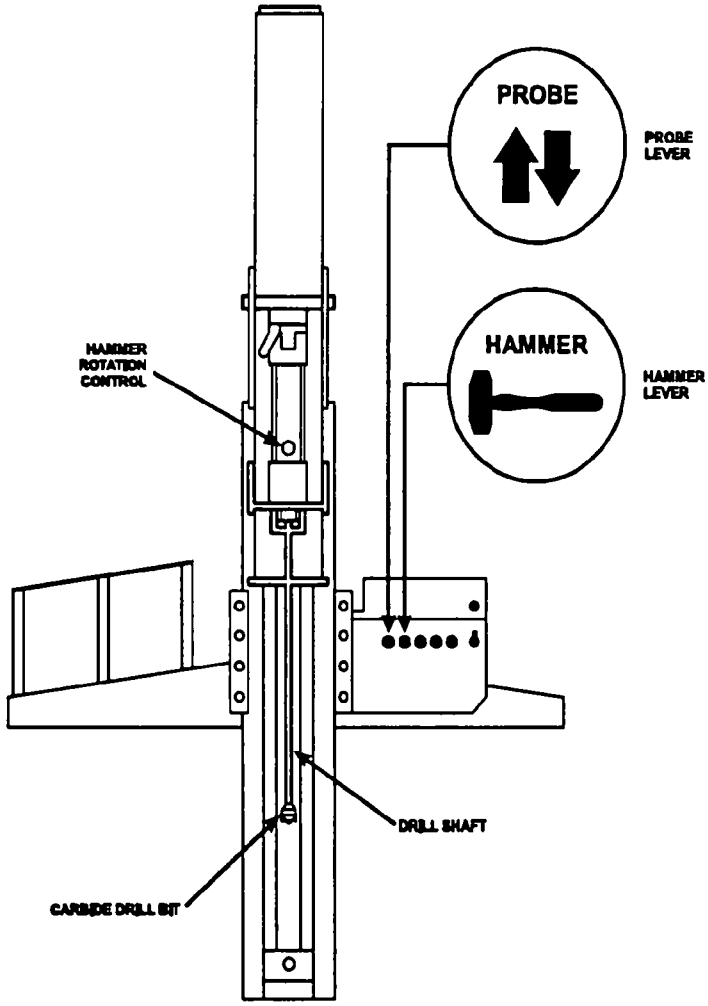
FIGURE 3 Deployment of Geoprobe™ from Sampling Vehicle



APPENDIX A (Cont'd)

Figures

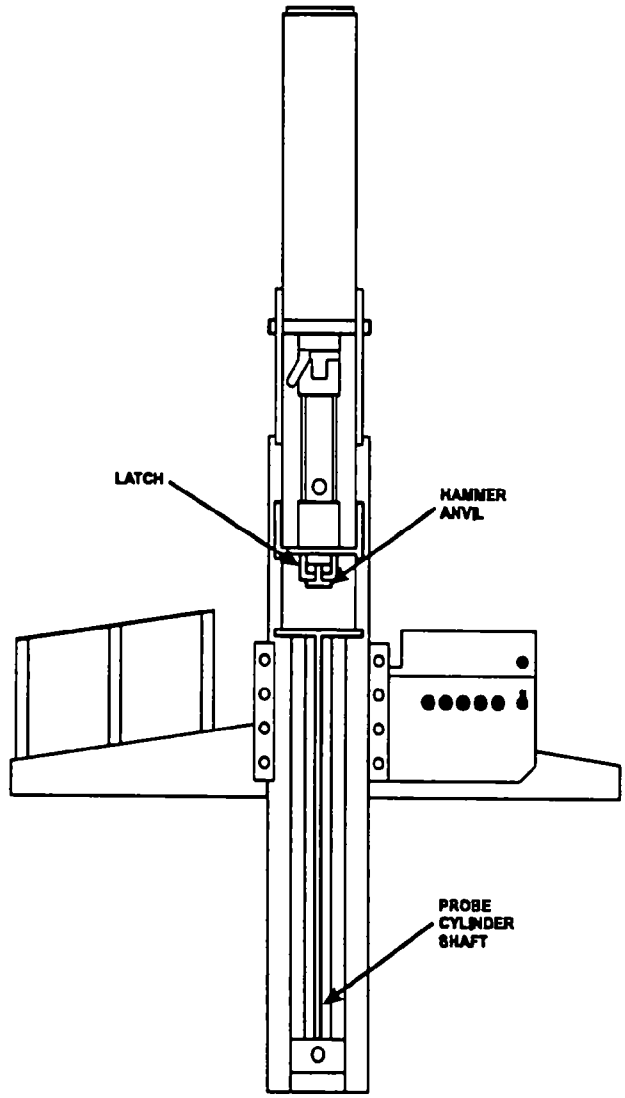
FIGURE 4 Geoprobe™ Setup for Drilling Through Concrete and Pavement



APPENDIX A (Cont'd)

Figures

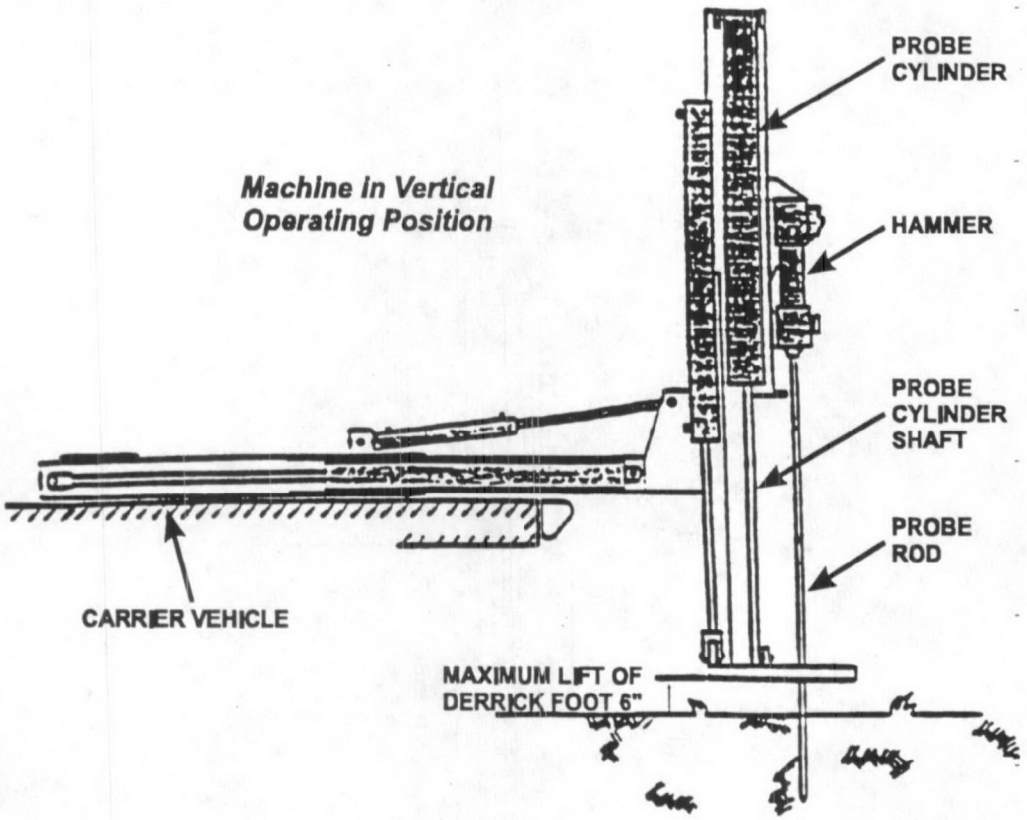
FIGURE 5 Inserting Hammer Anvil



APPENDIX A (Cont'd)

Figures

FIGURE 6. Probe Cylinder Shaft and Probe Rod - Parallel and Vertical



United States
Environmental Protection
Agency

Office of Solid Waste and
Emergency Response
Washington DC 20460

EPA/540/P-91/005
January 1991

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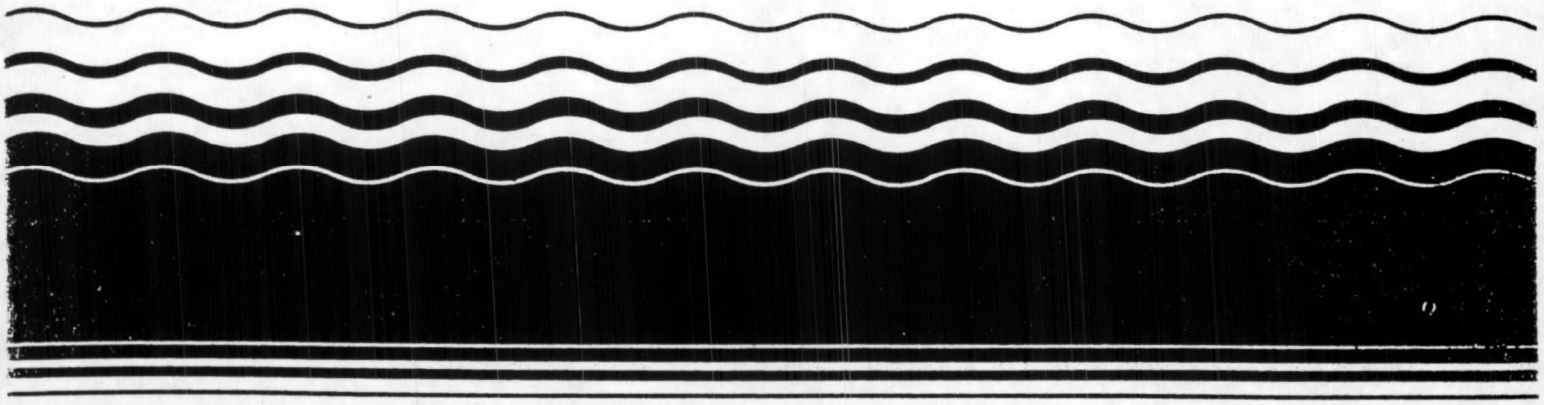
Compendium of ERT Surface Water and Sediment Sampling Procedures



EPA/540/P-91/005
OSWER Directive 9360.4-03
January 1991

COMPENDIUM OF ERT SURFACE WATER AND SEDIMENT SAMPLING PROCEDURES

Sampling Equipment Decontamination

Surface Water Sampling

Sediment Sampling

Interim Final

Environmental Response Team
Emergency Response Division

Office of Emergency and Remedial Response
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Depending on circumstances and needs, it may not be possible or appropriate to follow these procedures exactly in all situations due to site conditions, equipment limitations, and limitations of the standard procedures. Whenever these procedures cannot be followed as written, they may be used as general guidance with any and all modifications fully documented in either QA Plans, Sampling Plans, or final reports of results.

Each Standard Operating Procedure in this compendium contains a discussion on quality assurance/quality control (QA/QC). For more information on QA/QC objectives and requirements, refer to the *Quality Assurance/Quality Control Guidance for Removal Activities*, OSWER directive 9360.4-01, EPA/540/G-90/004.

Questions, comments, and recommendations are welcomed regarding the Compendium of ERT Surface Water and Sediment Sampling Procedures. Send remarks to:

Mr. William A. Coakley
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Acknowledgments

Preparation of this document was directed by William A. Coakley, the Removal Program QA Coordinator of the Environmental Response Team, Emergency Response Division. Additional support was provided under U.S. EPA contract #68-03-3482 and U.S. EPA contract #68-WO-0036.

1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

1.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination

1.2 METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions. Use of a solvent rinse is required when organic contamination is present

1.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP

1.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions.

- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.

- The site work plan must address disposal of the spent decontamination solutions.

- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

  - Stress work practices that minimize contact with hazardous substances.

  - Use remote sampling, handling, and container-opening techniques when appropriate.

  - Cover monitoring and sampling equipment with protective material to minimize contamination.

  - Use disposable outer garments and disposable sampling equipment when appropriate

1.5 EQUIPMENT/APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water

- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/distilled water
- sprayers for solvents
- trash bags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

1.6 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid[1]
- acetone (pesticide grade)[2]
- hexane (pesticide grade)[2]
- methanol

[1] Only if sample is to be analyzed for trace metals.
[2] Only if sample is to be analyzed for organics.

1.7 PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number, location, and layout of decontamination stations
- which decontamination apparatus is needed
- the appropriate decontamination methods
- methods for disposal of contaminated clothing, apparatus, and solutions

1.7.1 Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical: Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- Air Blasting: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.

- Wet Blasting. Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure In general, less of the equipment surface is removed using non-abrasive methods The following non-abrasive methods are available

- High-Pressure Water: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute.

- Ultra-High-Pressure Water: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly-adhered surface film. The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- Disinfection: Disinfectants are a practical means of inactivating infectious agents.

- Sterilization: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.

- Rinsing: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

1.7.2 Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow physical removal procedures specified in section 1.7.1.

2. Wash equipment with a non-phosphate detergent solution.

3. Rinse with tap water.

4. Rinse with distilled/deionized water.

5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.

6. Rinse with distilled/deionized water.

7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.

8. Air dry the equipment completely.

9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

1.8 CALCULATIONS

This section is not applicable to this SOP.

1.9 QUALITY ASSURANCE/ QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory.

Table 1: Recommended Solvent Rinse for Soluble Contaminants

SOLVENT	SOLUBLE CONTAMINANTS
Water	• Low-chain hydrocarbons • Inorganic compounds • Salts • Some organic acids and other polar compounds
Dilute Acids	• Basic (caustic) compounds • Amines • Hydrazines
Dilute Bases -- for example, detergent and soap	• Metals • Acidic compounds • Phenol • Thiols • Some nitro and sulfonic compounds
Organic Solvents[1] - for example, alcohols, ethers, ketones, aromatics, straight-chain alkanes (e.g., hexane), and common petroleum products (e g., fuel, oil, kerosene)	• Nonpolar compounds (e.g., some organic compounds)

[1] - WARNING: Some organic solvents can permeate and/or degrade protective clothing.

A rinsate blank consists of a sample of analyte-free (i.e, deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter, even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

1.10 DATA VALIDATION

This section is not applicable to this SOP.

1.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard

2.0 SURFACE WATER SAMPLING: SOP #2013

2.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative liquid samples, both aqueous and nonaqueous from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface.

2.2 METHOD SUMMARY

Sampling situations vary widely and therefore no universal sampling procedure can be recommended.

However, sampling of both aqueous and non-aqueous liquids from the above mentioned sources is generally accomplished through the use of one of the following samplers or techniques:

- Kemmerer bottle
- bacon bomb sampler
- dip sampler
- direct method

These sampling techniques will allow for the collection of representative samples from the majority of surface waters and impoundments encountered.

2.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Once samples have been collected, follow these procedures:

1. Transfer the sample(s) into suitable labeled sample containers.

2. Preserve the sample if appropriate, or use pre-preserved sample bottles.

3. Cap the container, put it in a Ziploc plastic bag and place it on ice in a cooler.

4 Record all pertinent data in the site logbook and on a field data sheet.

5. Complete the chain of custody form.

6. Attach custody seals to the cooler prior to shipment.

7. Decontaminate all sampling equipment prior to the collection of additional samples.

2.4 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems with surface water sampling. These include cross-contamination of samples and improper sample collection.

- Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to ERT SOP #2006, Sampling Equipment Decontamination.

- Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems.

2.5 EQUIPMENT/APPARATUS

Equipment needed for collection of surface water samples includes·

- Kemmerer bottles
- bacon bomb sampler
- dip sampler
- line and messengers
- sample bottle preservatives
- Ziploc bags
- ice
- cooler(s)
- chain of custody forms, field data sheets

- decontamination equipment
- maps/plot plan
- safety equipment
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and film
- logbook/waterproof pen
- sample bottle labels

2.6 REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

2.7 PROCEDURES

2.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flags, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

2.7.2 Sampling Considerations

Representative Samples

In order to collect a representative sample, the hydrology and morphometrics (e.g., measurements of volume, depth, etc.) of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths.

Water quality data should be collected in impoundments to determine if stratification is present. Measurements of dissolved oxygen, pH, and temperature can indicate if strata exist which would effect analytical results. Measurements should be collected at 1-meter intervals from the substrate to the surface using an appropriate instrument, such as a Hydrolab (or equivalent).

Water quality measurements such as dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential can assist in the interpretation of analytical data and the selection of sampling sites and depths anytime surface water samples are collected.

Generally, the deciding factors in the selection of a sampling device for sampling liquids in streams, rivers, lakes, ponds, lagoons, and surface impoundments are:

- Will the sample be collected from the shore or from a boat on the impoundment?

- What is the desired depth at which the sample is to be collected?

- What is the overall depth and flow direction of river or stream?

Sampler Composition

The appropriate sampling device must be of a proper composition. Samplers constructed of glass, stainless steel, PVC or PFTE (Teflon) should be used based upon the analyses to be performed.

2.7.3 Sample Collection

Kemmerer Bottle

Kemmerer bottle (Figure 1, Appendix A) may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Using a properly decontaminated Kemmerer bottle, set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing the substance to be sampled to pass through this tube.

2. Lower the pre-set sampling device to the predetermined depth. Avoid bottom disturbance.

3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.

4. Retrieve the sampler and discharge the first 10 to 20 mL to clear any potential contamination on the valve. Transfer the sample to the appropriate sample container.

Bacon Bomb Sampler

A bacon bomb sampler (Figure 2, Appendix A) may be used in similar situations to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired 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.

2. Release the trigger line and retrieve the sampler.

3. Transfer the sample to the appropriate sample container by pulling the trigger.

Dip Sampler

A dip sampler (Figure 3, Appendix A) is useful for situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.

2. Extend the device to the sample location and collect the sample.

3. Retrieve the sampler and transfer the sample to the appropriate sample container.

Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the surface. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants are a concern.

Using adequate protective clothing, access the sampling station by appropriate means. For shallow stream stations, collect the sample under the water surface pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

2.8 CALCULATIONS

This section is not applicable to this SOP.

2.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA/QC procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

2.10 DATA VALIDATION

This section is not applicable to this SOP.

2.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling lagoons or surface impoundments containing known or suspected hazardous substances, take adequate precautions. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him or her to lose their balance. The person performing the sampling should be on a lifeline and be wearing adequate protective equipment. When conducting sampling from a boat in an impoundment or flowing waters, follow appropriate boating safety procedures.

3.0 SEDIMENT SAMPLING: SOP #2016

3.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative sediment samples. Analysis of sediment may determine whether concentrations of specific contaminants exceed established threshold action levels, or if the concentrations present a risk to public health, welfare, or the environment.

The methodologies discussed in this procedure are applicable to the sampling of sediment in both flowing and standing water. They are generic in nature and may be modified in whole or part to meet the handling and analytical requirements of the contaminants of concern, as well as the constraints presented by the sampling area However, if modifications occur, they should be documented in the site logbook or report summarizing field activities.

For the purposes of this procedure, sediments are those mineral and organic materials situated beneath an aqueous layer. The aqueous layer may be either static, as in lakes, ponds, or other impoundments or flowing, as in rivers and streams.

3.2 METHOD SUMMARY

Sediment samples may be recovered using a variety of methods and equipment, depending on the depth of the aqueous layer, the portion of the sediment profile required (surface versus subsurface), the type of sample required (disturbed versus undisturbed) and the sediment type.

Sediment is collected from beneath an aqueous layer either directly, using a hand-held device such as a shovel, trowel, or auger, or indirectly using a remotely activated device such as an Ekman or Ponar dredge. Following collection, the sediment is placed into a container constructed of inert material, homogenized, and transferred to the appropriate sample containers The homogenization procedure should not be used if sample analysis includes volatile organics

3.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

- Chemical preservation of solids is generally not recommended. Cooling is usually the best approach, supplemented by the appropriate holding time.

- Wide-mouth glass containers with Teflon-lined caps are utilized for sediment samples. The sample volume is a function of the analytical requirements and will be specified in the work plan.

- Transfer sediment from the sample collection device to an appropriate sample container using a stainless steel or plastic lab spoon or equivalent. If composite samples are collected, place the sediment sample in a stainless steel, plastic or other appropriate composition (e.g.: Teflon) bucket, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then place the sediment sample into labeled containers.

- Samples for volatile organic analysis must be collected directly from the bucket, before mixing the sample, to minimize loss due to volatilization of contaminants.

- All sampling devices should be decontaminated, then wrapped in aluminum foil. The sampler should remain in this wrapping until it is needed. Each sampler should be used for only one sample Dedicated samplers for sediment samples may be impractical due to the large number of sediment samples which may be required and the cost of the sampler. In this case, samplers should be cleaned in the field using the decontamination procedure described in ERT SOP# 2006, Sampling Equipment Decontamination

3.4 INTERFERENCES AND POTENTIAL PROBLEMS

Substrate particle size and organic content are directly related to water velocity and flow characteristics of a body of water. Contaminants are more likely to be concentrated in sediments typified by fine particle size and a high organic content. This type of sediment is most likely to be collected from depositional zones. In contrast, coarse sediments with low organic content do not typically concentrate pollutants and are found in erosional zones. The selection of a sampling location can, therefore, greatly influence the analytical results.

3.5 EQUIPMENT/APPARATUS

Equipment needed for collection of sediment samples includes:

- maps/plot plan
- safety equipment
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and film
- stainless steel, plastic, or other appropriate composition bucket
- 4-oz., 8-oz., and one-quart, wide-mouth jars w/Teflon-lined lids
- Ziploc plastic bags
- logbook
- sample jar labels
- chain of custody forms, field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- spade or shovel
- spatula
- scoop
- trowel
- bucket auger
- thin-walled auger
- extension rods
- T-handle
- sampling trier
- sediment coring device (tubes, points, drive head, drop hammer, "eggshell" check valve devices, acetate cores)
- Ponar dredge
- Ekman dredge
- nylon rope

3.6 REAGENTS

Reagents are not used for preservation of sediment samples. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

3.7 PROCEDURES

3.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flags, or buoys to identify and mark all sampling locations Specific site characteristics, including flow regime, basin morphometry, sediment characteristics, depth of overlying aqueous layer, and extent and nature of contaminant should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions

3.7.2 Sample Collection

Selection of a sampling device is most often contingent upon· (1) the depth of water at the sampling location, and (2) the physical characteristics of the medium to be sampled.

Sampling Surface Sediments with a Trowel or Scoop From Beneath a Shallow Aqueous Layer

Collection of surface sediment from beneath a shallow aqueous layer can be accomplished with

tools such as spades, shovels, and scoops Surface material can be removed to the required depth; then a stainless steel or plastic scoop should be used to collect the sample.

This method can be used to collect consolidated sediments but is limited somewhat by the depth of the aqueous layer. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A stainless steel or plastic scoop or lab spoon will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden trowels.

Follow these procedures to collect sediment samples with a scoop or trowel:

1. Using a precleaned stainless steel scoop or trowel, remove the desired thickness of sediment from the sampling area.

2. Transfer the sample into an appropriate sample or homogenization container.

Sampling Surface Sediments with a Thin-Wall Tube Auger From Beneath a Shallow Aqueous Layer

This system consists of an auger, a series of extension rods, and a "T" handle (see Figure 4, Appendix A). The auger is driven into the sediment and used to extract a core A sample of the core is taken from the appropriate depth.

Use the following procedure to collect sediment samples with a thin-walled auger:

1. Insert the auger into the material to be sampled at a 0° to 45° angle from vertical. This orientation minimizes spillage of the sample from the sampler. Extraction of samples may require tilting of the sampler.

2. Rotate the auger once or twice to cut a core of material.

3. Slowly withdraw the auger, making sure that the slot is facing upward.

4. An acetate core may be inserted into the auger prior to sampling, if characteristics of the sediments or body of water warrant. By using this technique, an intact core can be extracted.

5. Transfer the sample into an appropriate sample or homogenization container.

Sampling Deep Sediments with Augers and Thin-Wall Tube Samplers From Beneath a Shallow Aqueous Layer

This system uses an auger, a series of extension rods, a "T" handle, and a thin-wall tube sampler (Figure 4, Appendix A). The auger bores a hole to a desired sampling depth and then is withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the sediment at the completion depth. The core is then withdrawn and the sample collected. This method can be used to collect consolidated sediments, but is somewhat limited by the depth of the aqueous layer.

Several augers are available which include bucket and posthole augers. Bucket augers are better for direct sample recovery, are fast, and provide a large volume of sample. Posthole augers have limited utility for sample collection as they are designed more for their ability to cut through fibrous, rooted, swampy areas.

Follow these procedures to collect sediment samples with a hand auger:

1. Attach the auger bit to a drill extension rod, then attach the "T" handle to the drill extension rod.

2. Clear the area to be sampled of any surface debris.

3. Begin augering, periodically removing any accumulated sediment from the auger bucket

4. After reaching the desired depth, slowly and carefully remove the auger from boring. (When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.)

5 Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler Install proper cutting tip.

6. Carefully lower tube sampler down borehole Gradually force tube sampler into sediment

Care should be taken to avoid scraping the borehole sides. Also, avoid hammering of the drill rods to facilitate coring, since the vibrations may cause the boring walls to collapse.

7. Remove tube sampler and unscrew drill rods.

8. Remove cutting tip and remove core from device.

9. Discard top of core (approximately 1 inch), as this represents material collected by the tube sampler before penetration of the layer of concern.

10. Transfer sample into an appropriate sample or homogenization container.

Sampling Surface Sediments From Beneath a Deep Aqueous Layer with an Ekman or Ponar Dredge

This technique consists of lowering a sampling device to the sediment by use of a rope, cable, or extended handle. The mechanism is triggered, and the device entraps sediment in spring-loaded jaws, or within lever-operated jaws.

Follow these procedures for collecting sediment with an Ekman dredge (Figure 5, Appendix A):

1. Thread a sturdy nylon or stainless steel cable through the bracket, or secure the extended handle to the bracket with machine bolts.

2. Attach springs to both sides. Arrange the Ekman dredge sampler so that the jaws are in the open position and trip cables are positioned over the release studs

3. Lower the sampler to a point just above the sediment surface.

4. Drop the sampler sharply onto the sediment.

5. Trigger the jaw release mechanism by lowering a messenger down the line, or by depressing the button on the upper end of the extended handle

6. Raise the sampler and slowly decant any free liquid through the top of the sampler. Be careful to retain fine sediments.

7. Open the dredge and transfer the sediment into a stainless steel or plastic bucket. Continue to collect additional sediment until sufficient material has been secured. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample container.

8. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

Follow these procedures for collecting sediment with a Ponar dredge (Figure 6, Appendix A):

1. Attach a sturdy nylon or steel cable to the hook provided on top of the dredge.

2. Arrange the Ponar dredge sampler in the open position, setting the trip bar so the sampler remains open when lifted from the top.

3. Slowly lower the sampler to a point just above the sediment.

4. Drop the sampler sharply into the sediment, then pull sharply up on the line, thus releasing the trip bar and closing the dredge.

5. Raise the sampler to the surface and slowly decant any free liquid through the screens on top of the dredge. Be careful to retain fine sediments.

6. Open the dredge and transfer the sediment to a stainless steel or plastic bucket. Continue to collect additional sediment until sufficient material has been gained. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample container.

7. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

Sampling Subsurface Sediments From Beneath a Deep Aqueous Layer with a Sample Coring Device

Follow these procedures when using a sample coring device (Figure 7, Appendix A) to collect

subsurface sediments. It consists of a coring device, handle, and acetate core utilized in the following procedure:

1. Assemble the coring device by inserting the acetate core into the sampling tube.

2. Insert the "eggshell" check valve mechanisms into the tip of the sampling tube with the convex surface positioned inside the acetate core.

3. Screw the coring point onto the tip of the sampling tube.

4. Screw the handle onto the upper end of the sampling tube and add extension rods as needed.

5. Place the sampler in a perpendicular position on the material to be sampled.

6. This sampler may be used with either a drive hammer for firm consolidated sediments, or a "T" handle for soft sediments. If the "T" handle is used, place downward pressure on the device until the desired depth is reached. Rotate the sampler to shear off the core of the bottom, retrieve the device and proceed to Step 15.

7. If the drive hammer is selected, insert the tapered handle (drive head) of the drive hammer through the drive head.

8. With left hand holding the tube, drive the sampler into the material to the desired depth Do not drive the tube further than the tip of the hammer's guide.

9. Record the length of the tube that penetrated the sample material, and the number of blows required to obtain this depth.

10. Remove the drive hammer and fit the keyhole-like opening on the flat side of the hammer onto the drive head In this position, the hammer serves as a handle for the sampler.

11. Rotate the sampler at least two revolutions to shear off the sample at the bottom.

12. Lower the sampler handle (hammer) until it just clears the two ear-like protrusions on the drive head, and rotate about 90°

13. Withdraw the sampler by pulling the handle (hammer) upwards and dislodging the hammer from the sampler.

14. Unscrew the coring point and remove the "eggshell" check valve.

15. Slide the acetate core out of the sampler tube. The acetate core may be capped at both ends. The sample may be used in this fashion, or the contents transferred to a stainless steel or plastic bucket and mixed thoroughly to obtain a homogeneous sample representative of the entire sampling interval.

16. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

3.8 CALCULATIONS

This section is not applicable to this SOP.

3.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA/QC procedures apply:

1. All data must be documented on field data sheets or within site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

3.10 DATA VALIDATION

This section is not applicable to this SOP.

3.11 HEALTH AND SAFETY

When working with potentially hazardous materials follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling sediment from bodies of water containing known or suspected hazardous substances, adequate precautions must be taken to ensure the sampler's safety. The team member collecting the sample should not get too close to the edge of the water, where bank failure may cause him or her to lose their balance. To prevent this, the person performing the sampling should be on a lifeline, and be wearing adequate protective equipment. If sampling from a vessel is necessary, implement appropriate protective measures.

APPENDIX A

Figures

Figure 1: Kemmerer Bottle

SOP #2013

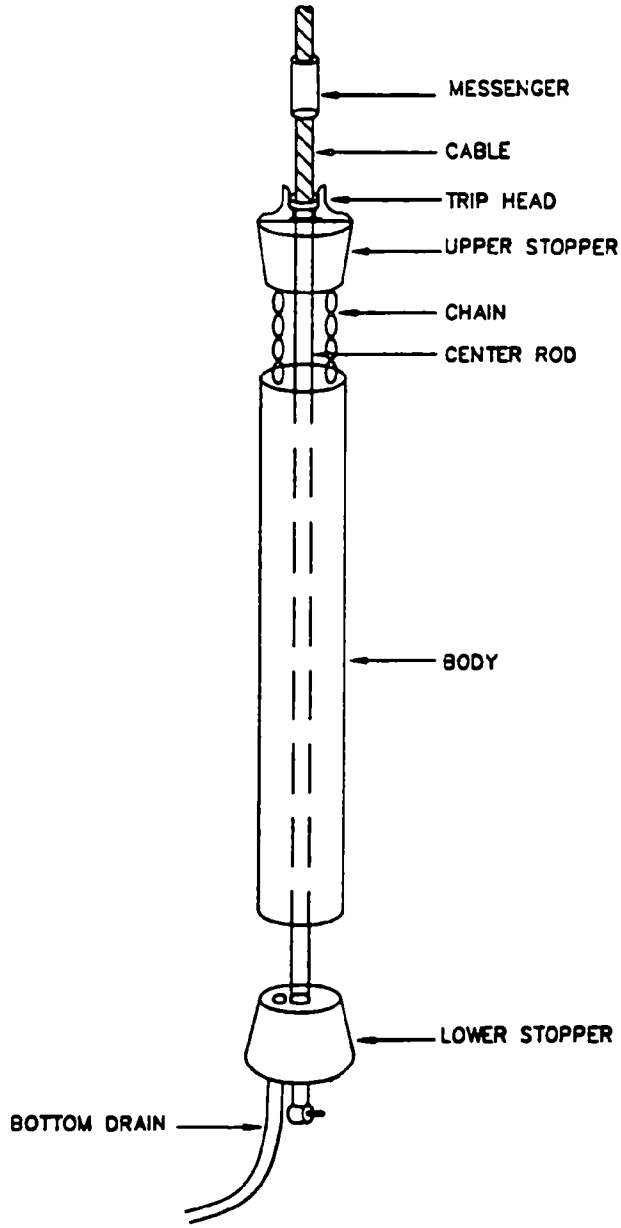


Figure 2: Bacon Bomb Sampler

SOP #2013

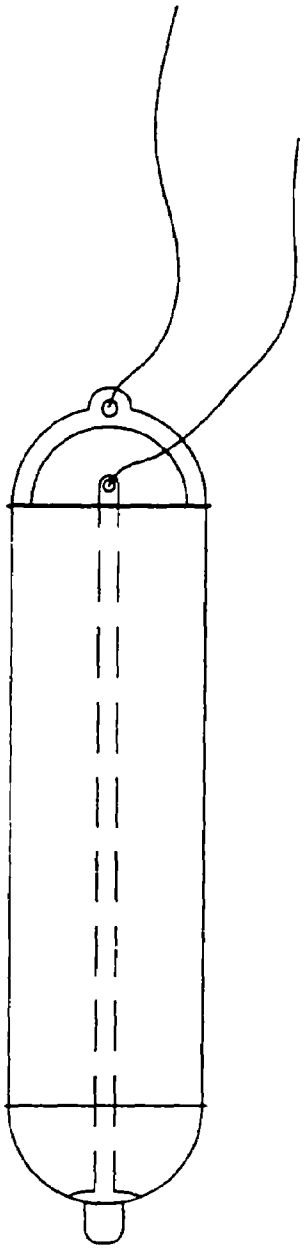


Figure 3: Dip Sampler

SOP #2013

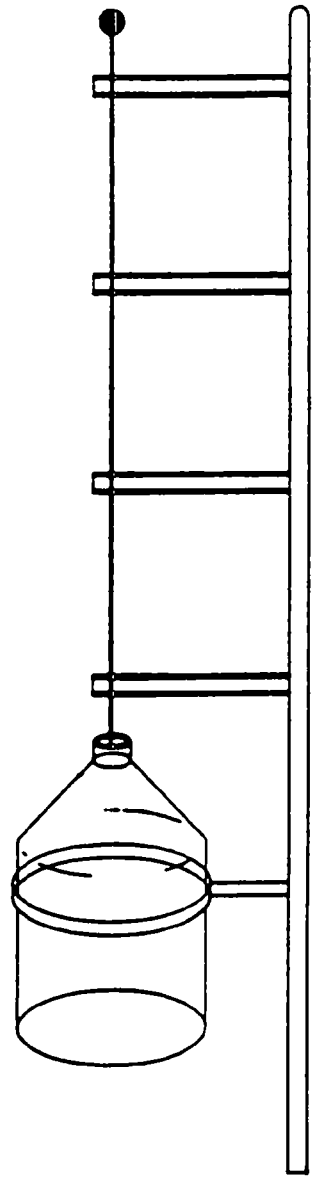


Figure 4: Sampling Auger

SOP #2016

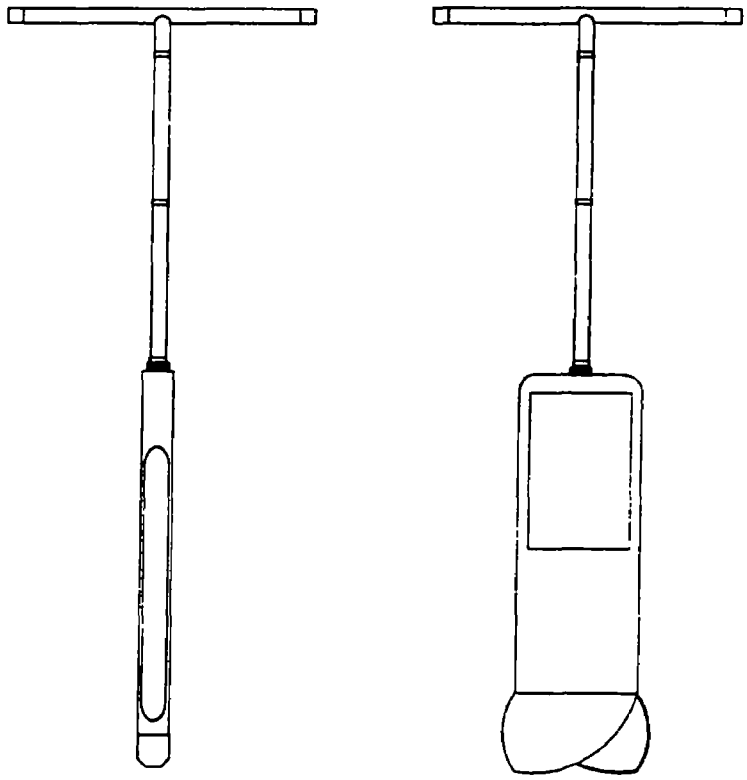


Figure 5: Ekman Dredge

SOP #2016

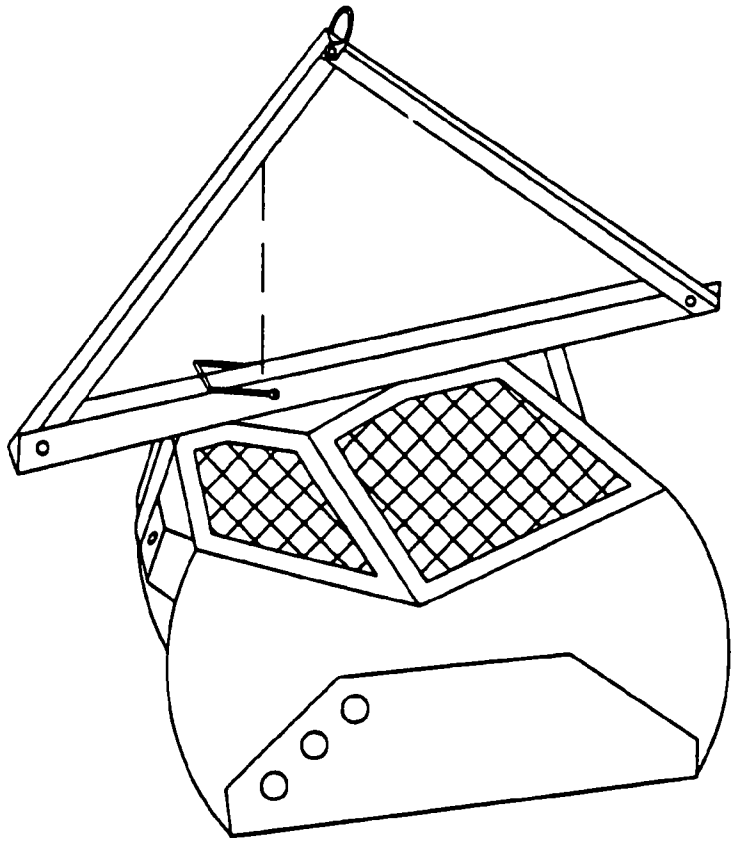


Figure 6: Ponar Dredge

SOP #2016

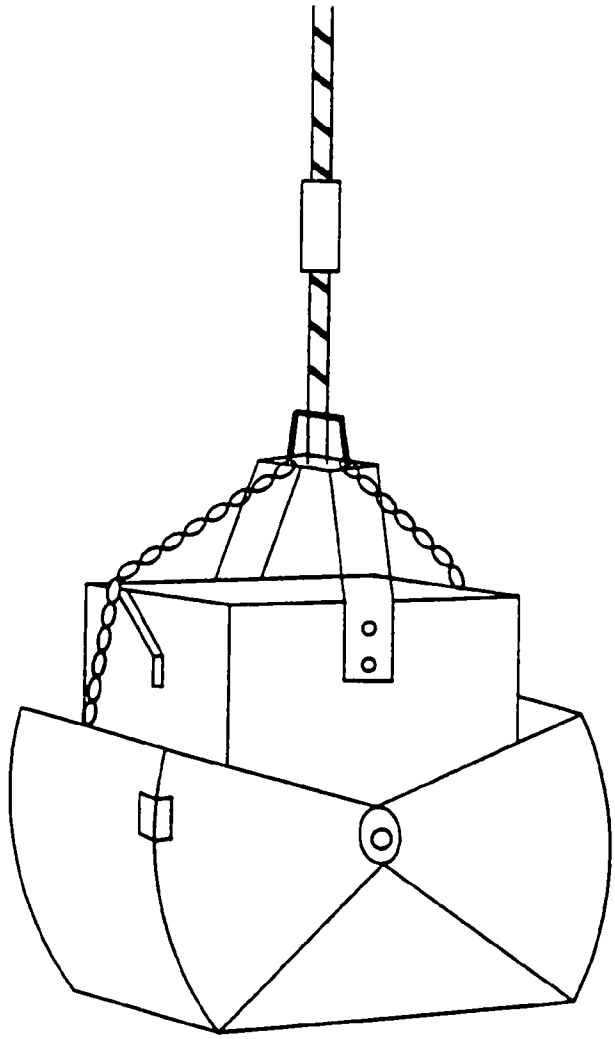
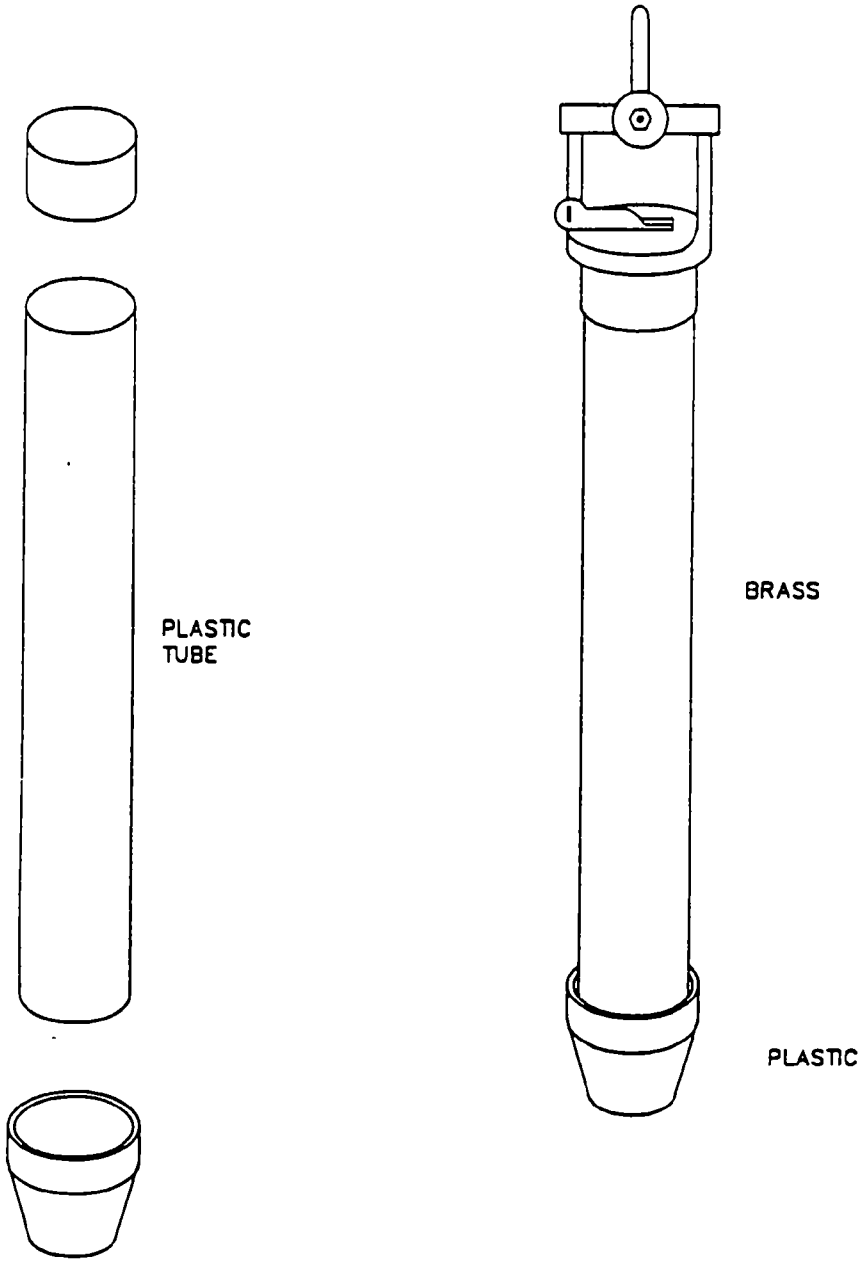


Figure 7: Sample Coring Device

SOP #2016



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*U S Government Printing Office 1991 — 548-187/40580

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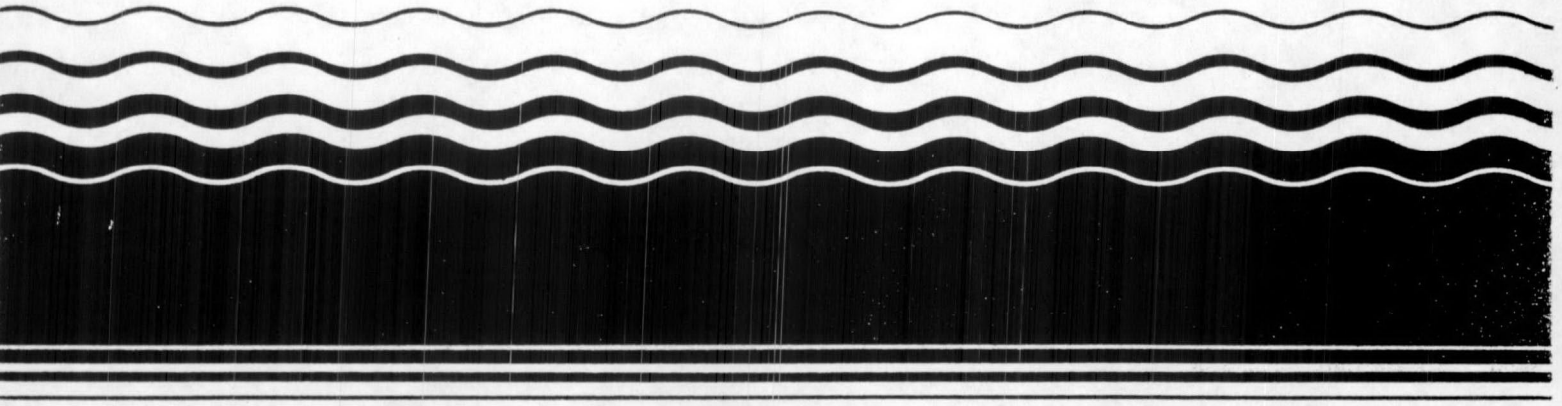
Compendium of ERT Waste Sampling Procedures



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OSWER Directive 9360.4-07
January 1991

COMPENDIUM OF ERT WASTE SAMPLING PROCEDURES

Sampling Equipment Decontamination

Drum Sampling

Tank Sampling

Chip, Wipe, and Sweep Sampling

Waste Pile Sampling

Interim Final

Environmental Response Team
Emergency Response Division

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

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Each Standard Operating Procedure in this compendium contains a discussion on quality assurance/quality control (QA/QC). For more information on QA/QC objectives and requirements, refer to the *Quality Assurance/Quality Control Guidance for Removal Activities,* OSWER directive 9360.4-01, EPA/540/G-90/004.

Questions, comments, and recommendations are welcomed regarding the Compendium of ERT Waste Sampling Procedures. Send remarks to:

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Acknowledgments

Preparation of this document was directed by William A. Coakley, the Removal Program QA Coordinator of the Environmental Response Team, Emergency Response Division. Additional support was provided under U.S. EPA contract #68-03-3482 and U.S. EPA contract #68-WO-0036.

1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

1.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

1.2 METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions Use of a solvent rinse is required when organic contamination is present.

1.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

1.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions.

- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.

- The site work plan must address disposal of the spent decontamination solutions.

- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

  - Stress work practices that minimize contact with hazardous substances.

  - Use remote sampling, handling, and container-opening techniques when appropriate.

  - Cover monitoring and sampling equipment with protective material to minimize contamination.

  - Use disposable outer garments and disposable sampling equipment when appropriate.

1.5 EQUIPMENT/APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water

- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/distilled water
- sprayers for solvents
- trash bags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

1.6 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid[1]
- acetone (pesticide grade)[2]
- hexane (pesticide grade)[2]
- methanol

[1] Only if sample is to be analyzed for trace metals.
[2] Only if sample is to be analyzed for organics.

1.7 PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number, location, and layout of decontamination stations
- which decontamination apparatus is needed
- the appropriate decontamination methods
- methods for disposal of contaminated clothing, apparatus, and solutions

1.7.1 Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical: Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- Air Blasting: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.

- Wet Blasting: Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste.

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods. The following non-abrasive methods are available:

- High-Pressure Water: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute.

- Ultra-High-Pressure Water: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly-adhered surface film. The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- Disinfection: Disinfectants are a practical means of inactivating infectious agents.

- Sterilization: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.

- Rinsing: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

1.7.2 Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow physical removal procedures specified in section 1.7.1.

2. Wash equipment with a non-phosphate detergent solution.

3. Rinse with tap water.

4. Rinse with distilled/deionized water.

5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.

6. Rinse with distilled/deionized water.

7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.

8. Air dry the equipment completely.

9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. An acid rinse step is required if metals are present on-site If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 on page 4 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

1.8 CALCULATIONS

This section is not applicable to this SOP.

1.9 QUALITY ASSURANCE/ QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory.

Table 1: Recommended Solvent Rinse for Soluble Contaminants

SOLVENT	SOLUBLE CONTAMINANTS
Water	• Low-chain hydrocarbons • Inorganic compounds • Salts • Some organic acids and other polar compounds
Dilute Acids	• Basic (caustic) compounds • Amines • Hydrazines
Dilute Bases -- for example, detergent and soap	• Metals • Acidic compounds • Phenol • Thiols • Some nitro and sulfonic compounds
Organic Solvents[1] - for example, alcohols, ethers, ketones, aromatics, straight-chain alkanes (e.g., hexane), and common petroleum products (e.g., fuel, oil, kerosene)	• Nonpolar compounds (e.g., some organic compounds)

[1] - WARNING: Some organic solvents can permeate and/or degrade protective clothing.

A rinsate blank consists of a sample of analyte-free (i e, deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter, even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

1.10 DATA VALIDATION

This section is not applicable to this SOP.

1.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S EPA, OSHA and specific health and safety procedures.

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard

2.0 DRUM SAMPLING: SOP #2009

2.1 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide technical guidance on safe and cost-effective response actions at hazardous waste sites containing drums with unknown contents. Container contents are sampled and characterized for disposal, bulking, recycling, grouping, and/or classification purposes.

2.2 METHOD SUMMARY

Prior to sampling, drums must be inventoried, staged, and opened. An inventory entails recording visual qualities of each drum and any characteristics pertinent to the contents' classification. Staging involves the organization, and sometimes consolidation of drums which have similar wastes or characteristics Opening of closed drums can be performed manually or remotely. Remote drum opening is recommended for worker safety. The most widely used method of sampling a drum involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and requires no decontamination.

2.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples collected from drums are considered waste samples. No preservatives should be added since there is a potential reaction of the sample with the preservative. Samples should, however, be cooled to 4°C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample.

Sample bottles for collection of waste liquids, sludges, or solids are typically wide-mouth amber jars with Teflon-lined screw caps. Actual volume required for analysis should be determined in conjunction with the laboratory performing the analysis.

Follow these waste sample handling procedures:

1 Place sample container in two Ziploc plastic bags.

2. Place each bagged container in a 1-gallon covered can containing absorbent packing material Place the lid on the can.

3. Mark the sample identification number on the outside of the can.

4. Place the marked cans in a cooler, and fill remaining space with absorbent packing material.

5. Fill out chain of custody form for each cooler, place in plastic, and affix to inside lid of cooler.

6. Secure and custody seal the lid of cooler.

7. Arrange for the appropriate transportation mode consistent with the type of hazardous waste involved.

2.4 INTERFERENCES AND POTENTIAL PROBLEMS

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used if the drums are visually overpressurized or if shock-sensitive materials are suspected. A laser thermometer may be used instead.

Drums that have been overpressurized, to the extent that the head is swollen several inches above the level of the chime, should not be moved. A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid, hooking device attached to the tube goes over the chime and holds the tube securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum and the gas vents along the grooves. The venting should be done from behind a wall or barricade. This device can be cheaply and easily designed and constructed where needed Once the pressure has been relieved, the bung can be removed and the drum sampled.

2.5 EQUIPMENT/APPARATUS

The following are standard materials and equipment required for sampling:

- personal protection equipment
- wide-mouth glass jars with Teflon cap liner, approximately 500 mL volume
- uniquely numbered sample identification labels with corresponding data sheets
- 1-gallon covered cans half-filled with absorbent (vermiculite)
- chain of custody forms
- decontamination materials
- glass thief tubes or Composite Liquid Waste Samplers (COLIWASA)
- laser thermometer
- drum opening devices

Drum opening devices include the following:

2.5.1 Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs They are usually constructed of cast iron, brass, or a bronze-beryllium, non-sparking alloy formulated to reduce the likelihood of sparks. The use of a non-sparking bung wrench does not completely eliminate the possibility of a spark being produced. (See Figure 1, Appendix B.)

2.5.2 Drum Deheader

When a bung is not removable with a bung wrench, a drum can be opened manually by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums. Drums with removable heads must be opened by other means. (See Figure 2, Appendix B.)

2.5.3 Hand Pick, Pickaxe, and Hand Spike

These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung The hand picks or pickaxes that are most commonly used are commercially available; whereas the spikes are generally uniquely fabricated 4-foot long poles with a pointed end. (See Figure 3, Appendix B.)

2.5.4 Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personal exposure. (See Figure 4, Appendix B.)

2.5.5 Hydraulic Drum Opener

Another remote method for opening drums is with remotely operated hydraulic devices. One such device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump which pressurizes soil through a length of hydraulic line. (See Figure 5, Appendix B.)

2.5.6 Pneumatic Devices

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high-pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device. (See Figure 6, Appendix B.)

2.6 REAGENTS

Reagents are not typically required for preserving drum samples. However, reagents are used for decontaminating sampling equipment. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

2.7 PROCEDURES

2.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

2.7.2 Drum Inspection

Appropriate procedures for handling drums depend on the contents. Thus, prior to any handling, drums should be visually inspected to gain as much information as possible about their contents. Those in charge of inspections should be on the look-out for:

- drum condition, corrosion, rust, and leaking contents
- symbols, words, or other markings on the drum indicating hazards (i.e., explosive, radioactive, toxic, flammable)
- signs that the drum is under pressure
- shock sensitivity

Monitor around the drums with radiation instruments, organic vapor monitors (OVA) and combustible gas indicators (CGI).

Classify the drums into categories, for instance:

- radioactive
- leaking/deteriorating
- bulging
- drums containing lab packs
- explosive/shock sensitive

All personnel should assume that unmarked drums contain hazardous materials until their contents have been categorized, and that labels on drums may not accurately describe their contents.

If it is presumed that there are buried drums on-site, geophysical investigation techniques such as magnetometry, ground penetrating radar, and metal detection can be employed in an attempt to determine depth and location of the drums. See ERT SOP #2159, General Surface Geophysics.

2.7.3 Drum Staging

Prior to sampling, the drums should be staged to allow easy access. Ideally, the staging area should be located just far enough from the drum opening area to prevent a chain reaction if one drum should explode or catch fire when opened.

While staging, physically separate the drums into the following categories: those containing liquids, those containing solids, lab packs, or gas cylinders, and those which are empty. This is done because the strategy for sampling and handling drums/containers in each of these categories will be different. This may be achieved by:

- Visual inspection of the drum and its labels, codes, etc. Solids and sludges are typically disposed of in open-top drums. Closed-head drums with a bung opening generally contain liquid.

- Visual inspection of the contents of the drum during sampling followed by restaging, if needed.

Once a drum has been excavated and any immediate hazard has been eliminated by overpacking or transferring the drum's contents, affix a numbered tag to the drum and transfer it to a staging area. Color-coded tags, labels, or bands should be used to mark similar waste types. Record a description of each drum, its condition, any unusual markings, and the location where it was buried or stored, on a drum data sheet (Appendix A). This data sheet becomes the principal

recordkeeping tool for tracking the drum onsite.

Where there is good reason to suspect that some drums contain radioactive, explosive, and shock-sensitive materials, these drums should be staged in a separate, isolated area. Placement of explosives and shock-sensitive materials in diked and fenced areas will minimize the hazard and the adverse effects of any premature detonation of explosives.

Where space allows, the drum opening area should be physically separated from the drum removal and drum staging operations. Drums are moved from the staging area to the drum opening area one at a time using forklift trucks equipped with drum grabbers or a barrel grappler. In a large-scale drum handling operation, drums may be conveyed to the drum opening area using a roller conveyor.

2.7.4 Drum Opening

There are three basic techniques available for opening drums at hazardous waste sites:

- Manual opening with non-sparking bung wrenches,
- Drum deheading, and
- Remote drum puncturing or bung removal.

The choice of drum opening techniques and accessories depends on the number of drums to be opened, their waste contents, and physical condition. Remote drum opening equipment should always be considered in order to protect worker safety. Under OSHA 1910.120, manual drum opening with bung wrenches or deheaders should be performed only with structurally sound drums having contents that are known to be (1) not shock sensitive, (2) non-reactive, (3) non-explosive, and (4) non-flammable.

Manual Drum Opening with a Bung Wrench

Manual drum opening with bung wrenches (Figure 1, Appendix B) should not be performed unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. If opening the drum with bung wrenches is deemed reasonably cost-effective and safe, then follow these procedures to minimize the hazard.

1. Fully outfit field personnel with protective gear.
2. Position drum upright with the bung up, or, for drums with bungs on the side, lay the drum on its side with the bung plug up.
3 Wrench the bung with a slow, steady pulling motion across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, attach a "cheater bar" to the handle to improve leverage.

Manual Drum Opening with a Drum Deheader

Drums are opened with a drum deheader (Figure 2, Appendix B) by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will cut off the entire top. If the top chime of a drum has been damaged or badly dented, it may not be possible to cut off the entire top. Since there is always the possibility that a drum may be under pressure, make the initial cut very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to use a remote method to puncture the drum prior to using the deheader.

Self-propelled drum openers which are either electrically or pneumatically driven can be used for quicker and more efficient deheading.

Manual Drum Opening with a Hand Pick, Pickaxe, or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, the drum can be opened for sampling by using a hand pick, pickaxe, or spike (Figure 3, Appendix B). Often the drum lid or head must be hit with a great deal of force in order to penetrate it. The potential for splash or spraying is greater than with other opening methods and, therefore, this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential

Since drums cannot be opened slowly with these tools, spray from drums is common requiring appropriate safety measures. Decontaminate the pick or spike after each drum is opened to avoid cross-contamination and/or adverse chemical reaction from incompatible materials.

Remote Drum Opening with a Backhoe Spike

Remotely operated drum opening tools are the safest available means of drum opening. Remote drum opening is slow, but is much safer compared to manual methods of opening.

Drums should be "staged" or placed in rows with adequate aisle space to allow ease in backhoe maneuvering Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike (Figure 4, Appendix B) should be decontaminated after each drum is opened to prevent cross-contamination. Even though some splash or spray may occur when this method is used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the required level of personal protection gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system.

Remote Drum Opening with Hydraulic Devices

A piercing device with a metal point is attached to the end of a hydraulic line and is pushed into the drum by hydraulic pressure (Figure 5, Appendix B). The piercing device can be attached so that the sampling hole can be made on either the side or the head of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place if desired and serve as a permanent tap or sampling port The piercer is designed to establish a tight seal after penetrating the container.

Remote Drum Opening with Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely (Figure 6, Appendix B)

2.7.5 Drum Sampling

After the drum has been opened, monitor headspace gases using an explosimeter and organic vapor analyzer. In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the vessel.

When sampling a previously sealed vessel, check for the presence of a bottom sludge. This is easily accomplished by measuring the depth to the apparent bottom, then comparing it to the known interior depth.

Glass Thief Sampler

The most widely used implement for sampling is a glass tube commonly referred to as a glass thief (Figure 7, Appendix B). This tool is simple, cost effective, quick, and collects a sample without having to decontaminate. Glass thieves are typically 6mm to 16mm I.D. and 48 inches long.

Procedures for using a glass thief are as follows:

1. Remove cover from sample container.

2. Insert glass tubing almost to the bottom of the drum or until a solid layer is encountered. About one foot of tubing should extend above the drum.

3. Allow the waste in the drum to reach its natural level in the tube.

4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with stopper.

5. Carefully remove the capped tube from the drum and insert the uncapped end in the sample container.

6. Release stopper and allow the glass thief to drain until the container is approximately 2/3 full.

7. Remove tube from the sample container, break it into pieces and place the pieces in the drum.

8. Cap the sample container tightly and place prelabeled sample container in a carrier.

9. Replace the bung or place plastic over the drum.

10. Log all samples in the site logbook and on field data sheets.

11. Package samples and complete necessary paperwork.

12. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

In many instances a drum containing waste material will have a sludge layer on the bottom. Slow insertion of the sample tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

It should be noted that in some instances disposal of the tube by breaking it into the drum may interfere with eventual plans for the removal of its contents. This practice should be cleared with the project officer or other disposal techniques evaluated.

COLIWASA Sampler

Some equipment is designed to collect a sample from the full depth of a drum and maintain it in the transfer tube until delivery to the sample bottle. These designs include primarily the Composite Liquid Waste Sampler (COLIWASA) and modifications thereof. The COLIWASA (Figure 8, Appendix B) is a much cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. One configuration consists of a 152 cm by 4 cm I.D. section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end.

Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. One model of the COLIWASA is shown in Appendix B; however, the design can be modified and/or adapted somewhat to meet the needs of the sampler.

The major drawbacks associated with using a COLIWASA concern decontamination and costs. The sampler is difficult, if not impossible to decontaminate in the field and its high cost in relation to alternative procedures (glass tubes) make it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

Follow these procedures for using the COLIWASA:

1. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

4. Slowly withdraw the sample from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.

5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

6. Cap the sample container tightly and place prelabeled sample container in a carrier.

7. Replace the bung or place plastic over the drum.

8. Log all samples in the site logbook and on field data sheets.

9. Package samples and complete necessary paperwork.

10 Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

2.8 CALCULATIONS

This section is not applicable to this SOP.

2.9 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

- Document all data on standard chain of custody forms, field data sheets, or within site logbooks.

- Operate all instrumentation in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

2.10 DATA VALIDATION

This section is not applicable to this SOP.

2.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures.

The opening of closed containers is one of the most hazardous site activities. Maximum efforts should be made to ensure the safety of the sampling team. Proper protective equipment and a general awareness of the possible dangers will minimize the risk inherent in sampling operations. Employing proper drum-opening techniques and equipment will also safeguard personnel Use remote sampling equipment whenever feasible.

3.0 TANK SAMPLING: SOP #2010

3.1 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide protocols for sampling tanks and other confined spaces from outside the vessel.

3.2 METHOD SUMMARY

The safe collection of a representative sample should be the criterion for selecting sample locations. A representative sample can be collected using techniques or equipment that are designed for obtaining liquids or sludges from various depths. The structure and characteristics of storage tanks present problems with collection of samples from more than one location; therefore, the selection of sampling devices is an important consideration.

Depending on the type of vessel and characteristics of the material to be sampled, one can choose a bailer, glass thief, bacon bomb sampler, sludge judge, COLIWASA, or subsurface grab sampler to collect the sample. For depths of less than 5-feet, a bailer, COLIWASA, or sludge judge can be used. A sludge judge, subsurface grab sampler, bailer, or bacon bomb sampler can be used for depths greater than 5-feet. A sludge judge or bacon bomb can be used to determine if the tank consists of various strata.

All sample locations should be surveyed for air quality prior to sampling. At no time should sampling continue with an LEL reading greater than 25%.

All personnel involved in tank sampling should be advised as to the hazards associated with working in unfavorable conditions.

3.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples collected from tanks are considered waste samples and, as such, addition of preservatives is not required due to the potential reaction of the sample with the preservative. Samples should, however, be cooled to 4°C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample.

Sample bottles for collection of waste liquids, sludges, or solids are typically wide-mouth amber jars with Teflon-lined screw caps. Actual volume required for analysis should be determined in conjunction with the laboratory performing the analysis.

Waste sample handling procedures should be as follows:

1. Place sample container in two Ziploc plastic bags.
2. Place each bagged container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
3. Mark the sample identification number on the outside of the can.
4. Place the marked cans in a cooler, and fill remaining space with absorbent packing material.
5. Fill out a chain of custody form for each cooler, place it in plastic, and affix it to the inside lid of the cooler.
6. Secure and custody seal the lid of cooler.
7. Arrange for the transportation appropriate for the type of hazardous waste involved.

3.4 INTERFERENCES AND POTENTIAL PROBLEMS

Sampling a storage tank requires a great deal of manual dexterity, often requiring the sampler to climb to the top of the tank upon a narrow vertical or spiral stairway or ladder while wearing protective clothing and carrying sampling equipment.

Before climbing onto the vessel, perform a structural survey of the tank to ensure the sampler's

safety and accessibility prior to initiating field activities.

As in all opening of containers, take extreme caution to avoid ignition or combustion of volatile contents. All tools used must be constructed of a non-sparking material and electronic instruments must be intrinsically safe.

All sample locations should be surveyed for air quality prior to sampling. At no time should sampling continue with an LEL reading greater than 25%.

3.5 EQUIPMENT/APPARATUS

Storage tank materials include liquids, sludges, still bottoms, and solids of various structures. The type of sampling equipment chosen should be compatible with the waste. Samplers commonly used for tanks include: the bacon bomb sampler, the sludge judge, glass thief, bailer, COLIWASA, and subsurface grab sampler.

- sampling plan
- safety equipment
- tape measure
- weighted tape line or equivalent
- camera/film
- stainless steel bucket or bowl
- sample containers
- Ziploc plastic bags
- logbook
- labels
- field data sheets
- chain of custody forms
- flashlight (explosion proof)
- coolers
- ice
- decontamination supplies
- bacon bomb sampler
- sludge judge
- glass thief
- bailer
- COLIWASA
- subsurface grab sampler
- water/oil level indicator
- OVA (organic vapor analyzer or equivalent)
- explosimeter/oxygen meter
- high volume blower

3.6 REAGENTS

Reagents are not typically required for the preservation of waste samples. However, reagents will be utilized for decontamination of equipment. Decontamination solutions required are specified in ERT SOP #2006, Sampling Equipment Decontamination.

3.7 PROCEDURES

3.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Identify and mark all sampling locations.

3.7.2 Preliminary Inspection

1. Inspect the external structural characteristics of each tank and record in the site logbook Potential sampling points should be evaluated for safety, accessibility, and sample quality.

2. Prior to opening a tank for internal inspection, the tank sampling team should:

   - Review safety procedures and emergency contingency plans with the Safety Officer,

   - Ensure that the tank is properly grounded,

   - Remove all sources of ignition from the immediate area.

3. Each tank should be mounted using appropriate means. Remove manway covers using non-sparking tools.

4. Collect air quality measurements for each potential sample location using an explosimeter/oxygen meter for a lower explosive limit (LEL/O_2) reading and an OVA/HNU for an organic vapor concentration. Both readings should be taken from the tank headspace, above the sampling port, and in the breathing zone.

5. Prior to sampling, the tank headspace should be cleared of any toxic or explosive vapor concentration using a high volume blower. No work should start if LEL readings exceed 25%. At 10% LEL, work can continue but with extreme caution.

3.7.3 Sampling Procedures

1. Determine the depth of any and all liquid-solid interface, and depth of sludge using a weighted tape measure, probe line, sludge judge, or equivalent.

2. Collect liquid samples from 1-foot below the surface, from mid-depth of liquid, and from 1-foot above the bottom sludge layer. This can be accomplished with a subsurface grab sampler or bacon bomb. For liquids less than 5-feet in depth, use a glass thief or COLIWASA to collect the sample.

   If sampling storage tanks, vacuum trucks, or process vessels, collect at least one sample from each compartment in the tank. Samples should always be collected through an opened hatch at the top of the tank. Valves near the bottom should not be used, because of their questionable or unknown integrity. If such a valve cannot be closed once opened, the entire tank contents may be lost to the ground surface. Also, individual strata cannot be sampled separately through a valve near the bottom.

3. Compare the three samples for visual phase differences. If phase differences appear, systematic iterative sampling should be performed. By halving the distance between two discrete sampling points, one can determine the depth of the phase change.

4. If another sampling port is available, sample as above to verify the phase information

5. Measure the outside diameter of the tank and determine the volume of wastes using the depth measurements. (See Appendix C for calculations.)

6. Sludges can be collected using a bacon bomb sampler, glass thief, or sludge judge.

7. Record all information on the sample data sheet or site logbook. Label the container with the appropriate sample tag.

8. Decontaminate sampling equipment as per ERT SOP #2006, Sampling Equipment Decontamination.

3.7.4 Sampling Devices

Bacon Bomb Sampler

The bacon bomb sampler (Figure 9, Appendix B) is designed to collect material from various levels within a storage tank. It consists of a cylindrical body, usually made of chrome-plated brass and bronze with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger opens and closes the valve. A line is attached to the removable top cover which has a locking mechanism to keep the plunger closed after sampling.

1 Attach the sample line and the plunger line to the sampler.

2. Measure and then mark the sampling line at the desired depth.

3. Gradually lower the bacon bomb sampler by the sample line until the desired level is reached.

4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill before releasing the plunger line to seal off the sampler.

5. Retrieve the sampler by the sample line. Be careful not to pull up on the plunger line and thereby prevent accidental opening of the bottom valve.

6. Rinse or wipe off the exterior of the sampler body.

7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.

8. Cap the sample container tightly and place prelabeled sample container in a carrier.

9. Replace the bung or place plastic over the tank.

10. Log all samples in the site logbook and on field data sheets and label all samples.

11. Package samples and complete necessary paperwork.

12. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

Sludge Judge

A sludge judge (Figure 10, Appendix B) is used for obtaining an accurate reading of solids which can settle, in any liquid, to any depth. The sampler consists of 3/4-inch plastic pipe in 5-foot sections, marked at 1-foot increments, with screw-style fittings. The top section includes a nylon line for raising the sampler.

1. Lower the sludge judge to the bottom of the tank.

2. When the bottom has been reached, and the pipe has filled to surface level, tug slightly on the rope as you begin to raise the unit. This will seat the check valve, trapping the column of material.

3. When the unit has been raised clear of the tank liquid, the amount of sludge in the sample can be read using the 1-foot increments marked on the pipe sections.

4. By touching the pin extending from the bottom section against a hard surface, the material is released from the unit.

5. Cap the sample container tightly and place prelabeled sample container in a carrier.

6. Replace the bung or place plastic over the tank.

7. Log all samples in the site logbook and on field data sheets and label all samples

8. Package samples and complete necessary paperwork.

9. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

Subsurface Grab Sampler

Subsurface grab samplers (Figure 11, Appendix B) are designed to collect samples of liquids at various depths. The sampler is usually constructed of aluminum or stainless steel tubing with a polypropylene or Teflon head that attaches to a 1-liter sample container.

1. Screw the sample bottle onto the sampling head.

2. Lower the sampler to the desired depth.

3. Pull the ring at the top which opens the spring-loaded plunger in the head assembly

4. When the bottle is full, release the ring, lift sampler, and remove sample bottle.

5. Cap the sample container tightly and place prelabeled sample container in a carrier.

6. Replace the bung or place plastic over the tank.

7. Log all samples in the site logbook and on field data sheets and label all samples.

8. Package samples and complete necessary paperwork.

9. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

Glass Thief

The most widely used implement for sampling is a glass tube commonly referred to as a glass thief (Figure 7, Appendix B). This tool is simple, cost effective, quick, and collects a sample without having to decontaminate. Glass thieves are typically 6mm to 16mm I.D. and 48 inches long.

1. Remove cover from sample container.

2. Insert glass tubing almost to the bottom of the

tank or until a solid layer is encountered. About 1 foot of tubing should extend above the tank.

3. Allow the waste in the tank to reach its natural level in the tube.

4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with stopper.

5. Carefully remove the capped tube from the tank and insert the uncapped end in the sample container. Do not spill liquid on the outside of the sample container.

6. Release stopper and allow the glass thief to drain until the container is approximately 2/3 full.

7. Remove tube from the sample container, break it into pieces and place the pieces in the tank.

8. Cap the sample container tightly and place prelabeled sample container in a carrier.

9. Replace the bung or place plastic over the tank.

10. Log all samples in the site logbook and on field data sheets and label all samples.

11. Package samples and complete necessary paperwork.

12. Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

In many instances a tank containing waste material will have a sludge layer on the bottom. Slow insertion of the sample tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

Bailer

The positive-displacement volatile sampling bailer (manufactured by GPI or equivalent) (Figure 12, Appendix B) is perhaps the most appropriate for collecting water samples for volatile analysis. Other bailer types (messenger, bottom fill, etc.) are less desirable, but may be mandated by cost and site conditions. Generally, bailers can provide an acceptable sample, providing that the sampling personnel use extra care in the collection process.

1. Make sure clean plastic sheeting surrounds the tank.

2. Attach a line to the bailer.

3. Lower the bailer slowly and gently into the tank so as not to splash the bailer into the tank contents.

4. Allow the bailer to fill completely and retrieve the bailer from the tank.

5. Begin slowly pouring from the bailer.

6. Cap the sample container tightly and place prelabeled sample container in a carrier.

7. Replace the bung or place plastic over the tank.

8. Log all samples in the site logbook and on field data sheets and label all samples.

9. Package samples and complete necessary paperwork.

10. Transport sample to decontamination zone to prepare it for transport to an analytical laboratory.

COLIWASA

Some equipment is designed to collect a sample from the full depth of a tank and maintain it in the transfer tube until delivery to the sample bottle. These designs include primarily the Composite Liquid Waste Sampler (COLIWASA) (Figure 8, Appendix B) and modifications thereof. The COLIWASA is a much cited sampler designed to permit representative sampling of multiphase wastes from tanks and other containerized wastes. One configuration consists of a 152 cm by 4 cm I.D. section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

The major drawbacks associated with using a COLIWASA concern decontamination and costs The sampler is difficult if not impossible to decontaminate in the field and its high cost in relation to alternative procedures (glass tubes) make it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

1 Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

2 Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

4. Slowly withdraw the sample from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.

5 Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

6. Cap the sample container tightly and place prelabeled sample container in a carrier.

7 Replace the bung or place plastic over the tank.

8 Log all samples in the site logbook and on field data sheets and label all samples

9 Package samples and complete necessary paperwork

10 Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

3.8 CALCULATIONS

Refer to Appendix C for calculations to determine tank volumes.

3.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented

3.10 DATA VALIDATION

This section is not applicable to this SOP.

3.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and specific health and safety procedures. More specifically, the hazards associated with tank sampling may cause bodily injury, illness, or death to the worker. Failure to recognize potential hazards of waste containers is the cause of most accidents. It should be assumed that the most unfavorable conditions exist, and that the danger of explosion and poisoning will be present. Hazards specific to tank sampling are:

- Hazardous atmospheres can be flammable, toxic, asphyxiating, or corrosive.
- If activating electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated

to prevent inadvertent activation while workers are occupied.

- Communication is of utmost importance between the sampling worker and the standby person to prevent distress or injury going unnoticed. The Illuminating Engineers Society Lighting Handbook requires suitable illumination to provide sufficient visibility for work.

- Noise reverberation may disrupt verbal communication with standby personnel.

- Tank vibration may affect multiple body parts and organs of the sampler depending on vibration characteristics.

- General hazards include falling scaffolding, surface residues (which could cause electrical shock, incompatible material reactions, slips, or falls), and structural objects (including baffles/trays in horizontal/vertical tanks, and overhead structures).

4.0 CHIP, WIPE, AND SWEEP SAMPLING: SOP #2011

4.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) outlines the recommended protocol and equipment for collection of representative chip, wipe, and sweep samples to monitor potential surficial contamination.

This method of sampling is appropriate for surfaces contaminated with non-volatile species of analytes (i.e., PCB, PCDD, PCDF, metals, cyanide, etc.) Detection limits are analyte specific. Sample size should be determined based upon the detection limit desired and the amount of sample requested by the analytical laboratory. Typical sample area is 1 square foot. However, based upon sampling location, the area may need modification due to area configuration.

4.2 METHOD SUMMARY

Since surface situations vary widely, no universal sampling method can be recommended. Rather, the method and implements used must be tailored to suit a specific sampling site. The sampling location should be selected based upon the potential for contamination as a result of manufacturing processes or personnel practices.

Chip sampling is appropriate for porous surfaces and is generally accomplished with either a hammer and chisel, or an electric hammer. The sampling device should be laboratory cleaned and wrapped in clean, autoclaved aluminum foil until ready for use. To collect the sample, a measured and marked off area is chipped both horizontally and vertically to an even depth of 1/8 inch. The sample is then transferred to the proper sample container.

Wipe samples are collected from smooth surfaces to indicate surficial contamination; a sample location is measured and marked off. Sampling personnel wear a new pair of surgical gloves to open a sterile gauze pad, and then soak it with solvent. The solvent used is dependent on the surface being sampled. This pad is then stroked firmly over the sample surface, first vertically, then horizontally, to ensure complete coverage. The pad is then transferred to the sample container.

Sweep sampling is an effective method for the collection of dust or residue on porous or non-porous surfaces. To collect such a sample, an appropriate area is measured off. Then, while wearing a new pair of disposable surgical gloves, sampling personnel use a dedicated brush to sweep material into a dedicated dust pan. The sample is then transferred to the proper sample container.

Samples collected by all three methods are sent to the laboratory for analysis.

4.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Samples should be stored out of direct sunlight to reduce photodegredation and shipped on ice (4°C) to the laboratory performing the analysis. Appropriately-sized, laboratory-cleaned, glass sample jars should be used for sample collection. The amount of sample required is determined in concert with the analytical laboratory.

4.4 INTERFERENCES AND POTENTIAL PROBLEMS

This method has few significant interferences or problems. Typical problems result from rough porous surfaces which may be difficult to wipe, chip, or sweep.

4.5 EQUIPMENT/APPARATUS

- lab-clean sample containers of proper size and composition
- field and travel blanks
- site logbook
- sample analysis request forms
- chain of custody forms
- custody seals
- sample labels
- disposable surgical gloves
- sterile wrapped gauze pad (3 in. x 3 in.)
- appropriate pesticide (HPLC) grade solvent

- medium-sized, laboratory-cleaned paint brush
- medium-sized, laboratory-cleaned chisel
- autoclaved aluminum foil
- camera
- hexane (pesticide/HPLC grade)
- iso-octane
- distilled/deionized water

4.6 REAGENTS

Reagents are not required for preservation of chip, wipe or sweep samples. However, reagents will be utilized for decontamination of sampling equipment. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

4.7 PROCEDURES

4.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

4.7.2 Chip Sample Collection

Sampling of porous surfaces is generally accomplished by using a chisel and hammer or electric hammer. The sampling device should be laboratory cleaned or field decontaminated as per ERT SOP# 2006, Sampling Equipment Decontamination. It is then wrapped in cleaned, autoclaved aluminum foil. The sampler should remain in this wrapping until it is needed. Each sampling device should be used for only one sample.

1. Choose appropriate sampling points; measure off the designated area and photo document.

2. To facilitate later calculations, record surface area to be chipped.

3. Don a new pair of disposable surgical gloves.

4. Open a laboratory-cleaned chisel or equivalent sampling device.

5. Chip the sample area horizontally, then vertically to an even depth of approximately 1/8 inch.

6. Place the sample in an appropriately-prepared sample container with a Teflon-lined cap.

7. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.

8. Store samples out of direct sunlight and cool to 4°C.

9. Leave contaminated sampling device in the sampled material, unless decontamination is practical.

10. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

4.7.3 Wipe Sample Collection

Wipe sampling is accomplished by using a sterile gauze pad, adding a solvent in which the contaminant is most soluble, then wiping a pre-determined, pre-measured area. The sample is packaged in an amber jar to prevent photodegradation and packed in coolers for shipment to the lab. Each gauze pad is used for only one wipe sample.

1. Choose appropriate sampling points; measure off the designated area and photo document.

2. To facilitate later calculations, record surface area to be wiped.

3. Don a new pair of disposable surgical gloves.

4. Open new sterile package of gauze pad.

5. Soak the pad with the appropriate solvent.

6. Wipe the marked surface area using firm strokes. Wipe vertically, then horizontally to ensure complete surface coverage.

7. Place the gauze pad in an appropriately prepared sample container with a Teflon-lined cap.

8. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.

9. Store samples out of direct sunlight and cool to 4°C.

10. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

4.7.4 Sweep Sample Collection

Sweep sampling is appropriate for bulk contamination. This procedure utilizes a dedicated, hand-held sweeper brush to acquire a sample from a pre-measured area.

1. Choose appropriate sampling points; measure off the designated area and photo document.

2. To facilitate later calculations, record the surface area to be swept.

3. Don a new pair of disposable surgical gloves.

4. Sweep the measured area using a dedicated brush; collect the sample in a dedicated dust pan.

5. Transfer sample from dust pan to sample container.

6. Cap the sample container, attach the label and custody seal, and place in a double plastic bag. Record all pertinent data in the site logbook. Complete the sampling analysis request form and chain of custody form before taking the next sample.

7. Store samples out of direct sunlight and cool to 4°C.

8. Leave contaminated sampling device in the sample material, unless decontamination is practical.

9. Follow proper decontamination procedures, then deliver sample(s) to the laboratory for analysis.

4.8 CALCULATIONS

Results are usually provided in mg/g, μg/g or another appropriate weight per unit weight measurement. Results may also be given in a mass per unit area.

4.9 QUALITY ASSURANCE/ QUALITY CONTROL

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets or within the site logbook.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

The following specific quality assurance activities apply to wipe samples:

- A blank should be collected for each sampling event. This consists of a sterile gauze pad, wet with the appropriate solvent, and placed in a prepared sample container. The blank will help identify potential introduction of contaminants via

the sampling methods, the pad, solvent or sample container.

- Spiked wipe samples can also be collected to better assess the data being generated. These are prepared by spiking a piece of foil of known area with a standard of the analyte of choice. The solvent containing the standard is allowed to evaporate, and the foil is wiped in a manner identical to the other wipe samples.

Specific quality assurance activities for chip and sweep samples should be determined on a site-specific basis.

4.10 DATA VALIDATION

Review the quality control samples and use the data to qualify the environmental results.

4.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

5.0 WASTE PILE SAMPLING: SOP #2017

5.1 SCOPE AND APPLICATION

The objective of this Standard Operating Procedure (SOP) is to outline the equipment and methods used in collecting representative samples from waste piles, sludges or other solid or liquid waste mixed with soil.

5.2 METHOD SUMMARY

Stainless steel shovels or scoops should be used to clear away surface material before samples are collected. For samples at depth, a decontaminated auger may be required to advance the hole, then another decontaminated auger used for sample collection. For a sample core, thin-wall tube samplers or grain samplers may be used. Near surfaces samples can be collected with a clean stainless steel spoon or trowel.

All samples collected, except those for volatile organic analysis, should be placed into a Teflon-lined or stainless steel pail and mixed thoroughly before being transferred to an appropriate sample container.

5.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is generally not recommended. Refrigeration to 4°C is usually the best approach, supplemented by a minimal holding time.

Wide mouth glass containers with Teflon-lined caps are typically used for waste pile samples. Sample volume required is a function of the analytical requirements and should be specified in the work plan.

5.4 INTERFERENCES AND POTENTIAL PROBLEMS

There are several variables involved in waste sampling, including shape and size of piles, compactness, and structure of the waste material. Shape and size of waste material or waste piles vary greatly in areal extent and height. Since state and federal regulations often require a specified number of samples per volume of waste, size and shape must be used to calculate volume and to plan for the correct number of samples. Shape must also be accounted for when planning physical access to the sampling point and when selecting the appropriate equipment to successfully collect the sample at that location.

Material to be sampled may be homogeneous or heterogeneous. Homogeneous material resulting from known situations may not require an extensive sampling protocol. Heterogeneous and unknown wastes require more extensive sampling and analysis to ensure the different components are being represented.

The term "representative sample" is commonly used to denote a sample that has the properties and composition of the population from which it was collected, in the same proportions as found in the population. This can be misleading unless one is dealing with a homogenous waste from which one sample can represent the whole population.

The usual options for obtaining the most "representative sample" from waste piles are simple or stratified random sampling. Simple random sampling is the method of choice unless (1) there are known distinct strata; (2) one wants to prove or disprove that there are distinct strata; or (3) one is limited in the number of samples and desires to minimize the size of a "hot spot" that could go unsampled. If any of these conditions exist, stratified random sampling would be the better strategy.

This strategy, however, can be employed only if all points within the pile can be accessed. In such cases, the pile should be divided into a three-dimensional grid system; the grid sections assigned numbers; and the sampling points chosen using random-number tables or random-number generators. The only exceptions to this are situations in which representative samples cannot be collected safely or where the investigative team is trying to determine worst-case conditions.

If sampling is limited to certain portions of the pile, a statistically based sample will be representative only of that portion, unless the waste is homogenous.

5.5 EQUIPMENT/APPARATUS

Waste pile solids include powdered, granular, or block materials of various sizes, shapes, structure, and compactness. The type of sampler chosen should be compatible with the waste. Samplers commonly used for waste piles include: stainless steel scoops, shovels, trowels, spoons, and stainless steel hand augers, sampling triers, and grain samplers.

Waste pile sampling equipment check list:

- sampling plan
- maps/plot plan
- safety equipment, as specified in the health and safety plan
- compass
- tape measure
- survey stakes or flags
- camera and film
- stainless steel, plastic, or other appropriate homogenization bucket or bowl
- 1-quart mason jars w/Teflon liners
- Ziploc plastic bags
- logbook
- labels
- chain of custody forms and seals
- field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- canvas or plastic sheet
- spade or shovel
- spatula
- scoop
- plastic or stainless steel spoons
- trowel
- continuous flight (screw) auger
- bucket auger
- post hole auger
- extension rods
- T-handle
- thin-wall tube sampler
- sampling trier
- grain sampler

5.6 REAGENTS

No chemical reagents are used for the preservation of waste pile samples; however, decontamination solutions may be required. If decontamination of equipment is required, refer to ERT Standard Operating Procedure (SOP) #2006, Sampling Equipment Decontamination, and the site-specific work plan.

5.7 PROCEDURES

5.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes or flagging to identify and mark all sampling locations. Specific site factors, including extent and nature of contaminants, should be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

5.7.2 Sample Collection

SAMPLING WITH SHOVELS AND SCOOPS

Collection of samples from surface portions of the pile can be accomplished with tools such as spades, shovels, and scoops. Surface material can be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample.

Accurate, representative samples can be collected with this procedure depending on the care and

precision demonstrated by sample team members. Use of a flat, pointed mason trowel to cut a block of the desired material can be helpful when undisturbed profiles are required. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with implements such as garden trowels.

Use the following procedure to collect surface samples:

1. Carefully remove the top layer of material to the desired sample depth with a precleaned spade.

2. Using a precleaned stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of material from the area which came in contact with the spade.

3. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

SAMPLING WITH AUGERS AND THIN-WALL TUBE SAMPLERS

This system consists of an auger, a series of extensions, a "T" handle, and a thin-wall tube sampler (Figure 13, Appendix B). The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin-wall tube sampler. The system is then lowered down the borehole, and driven into the pile at the completion depth The system is withdrawn and the core collected from the thin-wall tube sampler.

Several augers are available. These include: bucket, continuous flight (screw), and post hole augers. Bucket augers are better for direct sample recovery since they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the flights, which are usually at 5-foot intervals. The continuous flight augers are satisfactory for use when a composite of the complete waste pile column is desired. Post hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy areas.

Use the following procedure for collecting waste pile samples with the auger:

1. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod.

2. Clear the area to be sampled of any surface debris. It may be advisable to remove the first 3 to 6 inches of surface material for an area approximately 6 inches in radius around the drilling location.

3. Begin augering, periodically removing and depositing accumulated materials onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from boring. When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.

5. Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.

6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the pile. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse.

7. Remove the tube sampler, and unscrew the drill rods.

8. Remove the cutting tip and the core from device.

9. Discard the top of the core (approximately 1-inch), as this represents material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container. Sample homogenization is not required.

10. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

SAMPLING WITH A TRIER

This system consists of a trier and a "T" handle. The auger is driven into the waste pile and used to extract a core sample from the appropriate depth.

Use the following procedure to collect waste pile samples with a sampling trier:

1. Insert the trier (Figure 14, Appendix B) into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes spillage of the sample. Extraction of the samples might require tilting of the sample containers.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are being collected, place samples from the other sampling intervals into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

SAMPLING WITH A GRAIN SAMPLER

The grain sampler (Figure 15, Appendix B) is used for sampling powdered or granular wastes or materials in bags, fiberdrums, sacks, similar containers or piles. This sampler is most useful when the solids are no greater than 0.6 cm (1/4 inch) in diameter.

This sampler consists of two slotted telescoping brass or stainless steel tubes. The outer tube has a conical, pointed tip at one end that permits the sampler to penetrate the material being sampled. The sampler is opened and closed by rotating the inner tube. Grain samplers are generally 61 to 100 cm (24 to 40 inch) long by 1.27 to 2.54 cm (1/2 to 1 inch) in diameter and are commercially available at laboratory supply houses.

Use the following procedures to collect waste pile samples with a grain sampler:

1. With the sampler in the closed position, insert it into the granular or powdered material or waste being sampled from a point near a top edge or corner, through the center, and to a point diagonally opposite the point of entry.

2. Rotate the sampler inner tube into the open position.

3. Wiggle the sampler a few times to allow material to enter the open slots.

4 With the sampler in the closed position, withdraw it from the material being sampled.

5. Place the sampler in a horizontal position with the slots facing upward.

6. Rotate the outer tube and slide it away from the inner tube.

7. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, plastic lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

5.8 CALCULATIONS

This section is not applicable to this SOP.

5.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

5.10 DATA VALIDATION

This section is not applicable to this SOP.

5.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

APPENDIX A

Drum Data Sheet Form

Drum Data Sheet Form

SOP #2009

Drum ID#: _____ Date Sampled: _____

Estimated Liquid Quantity: _____ Time: _____

Grid Location:* _____

Staging Location: _____

Sampler's Name: _____

Drum Condition: _____

Sampling Device· _____

Physical Appearance of the Drum/Bulk Contents· _____

Odor· _____

Color: _____

pH· _____ % Liquid: _____

Laboratory Analytical Data. _____ Date of Analysis: _____

Compatibility _____

Hazard: _____

Waste ID. _____

Treatment Disposal Recommendations _____

Approval

Lab _____ Date _____

Site Manager _____ Date. _____

* Area of site where drum was originally located

Based on di Napoli, 1982 Table originally printed in the Proceedings of the National Conference on Management of Uncontrolled Hazardous Waste Sites, 1982 Available from Hazardous Materials Control Research Institute, 9300 Columbia Blvd, Silver Spring, MD 20910

APPENDIX B

Figures

Figure 1: Universal Bung Wrench

SOP #2009

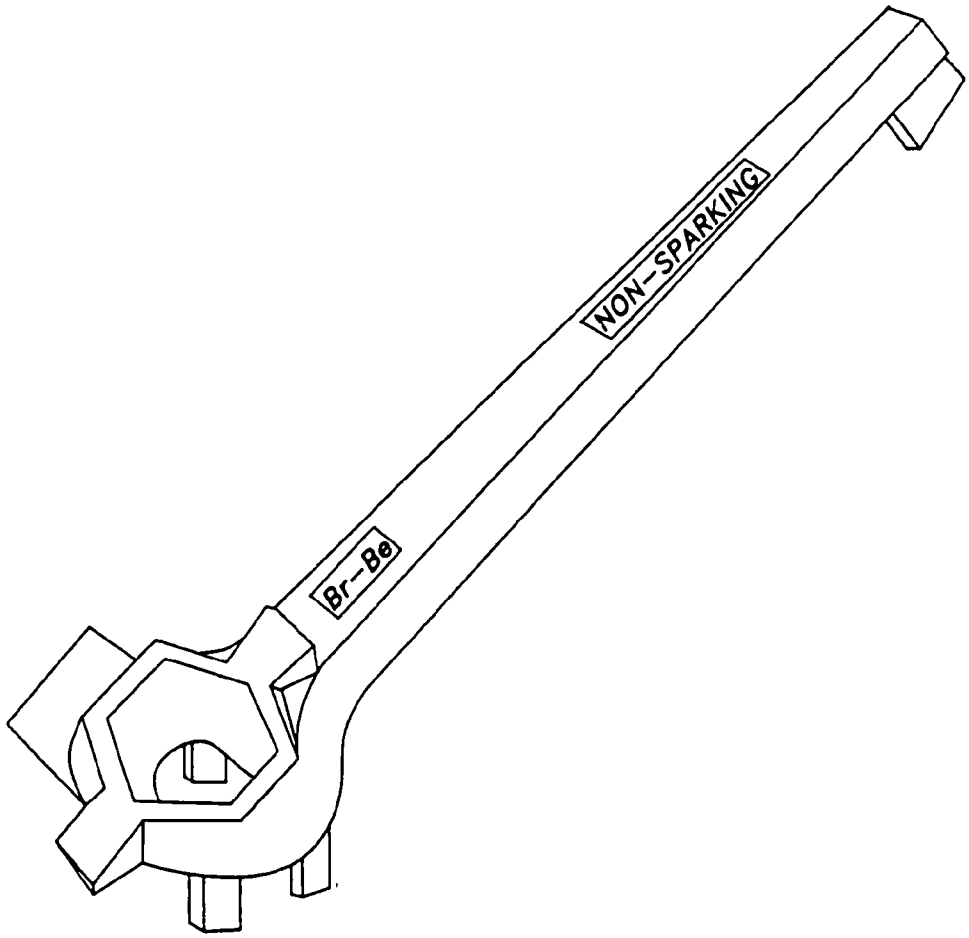


Figure 2: Drum Deheader

SOP #2009

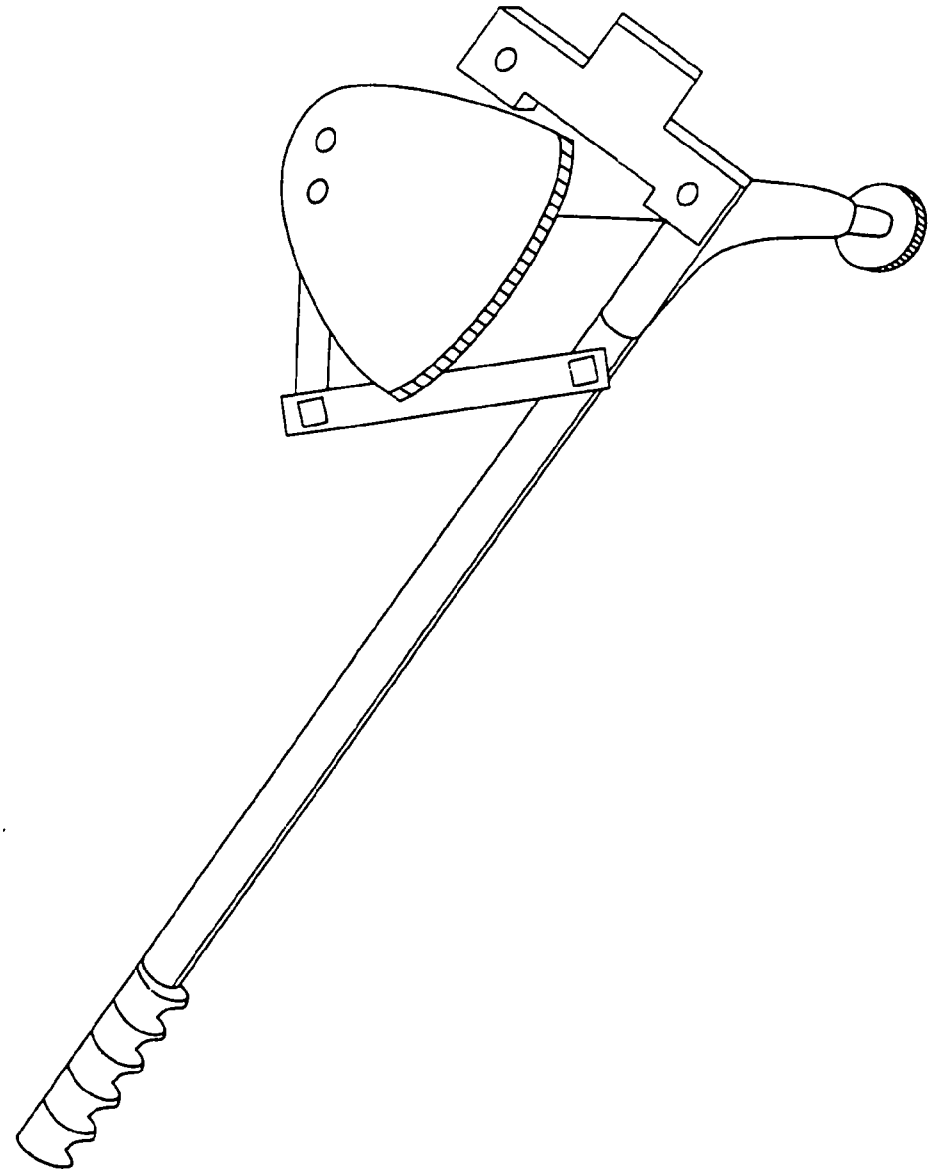


Figure 3: Hand Pick, Pickaxe, and Hand Spike

SOP #2009

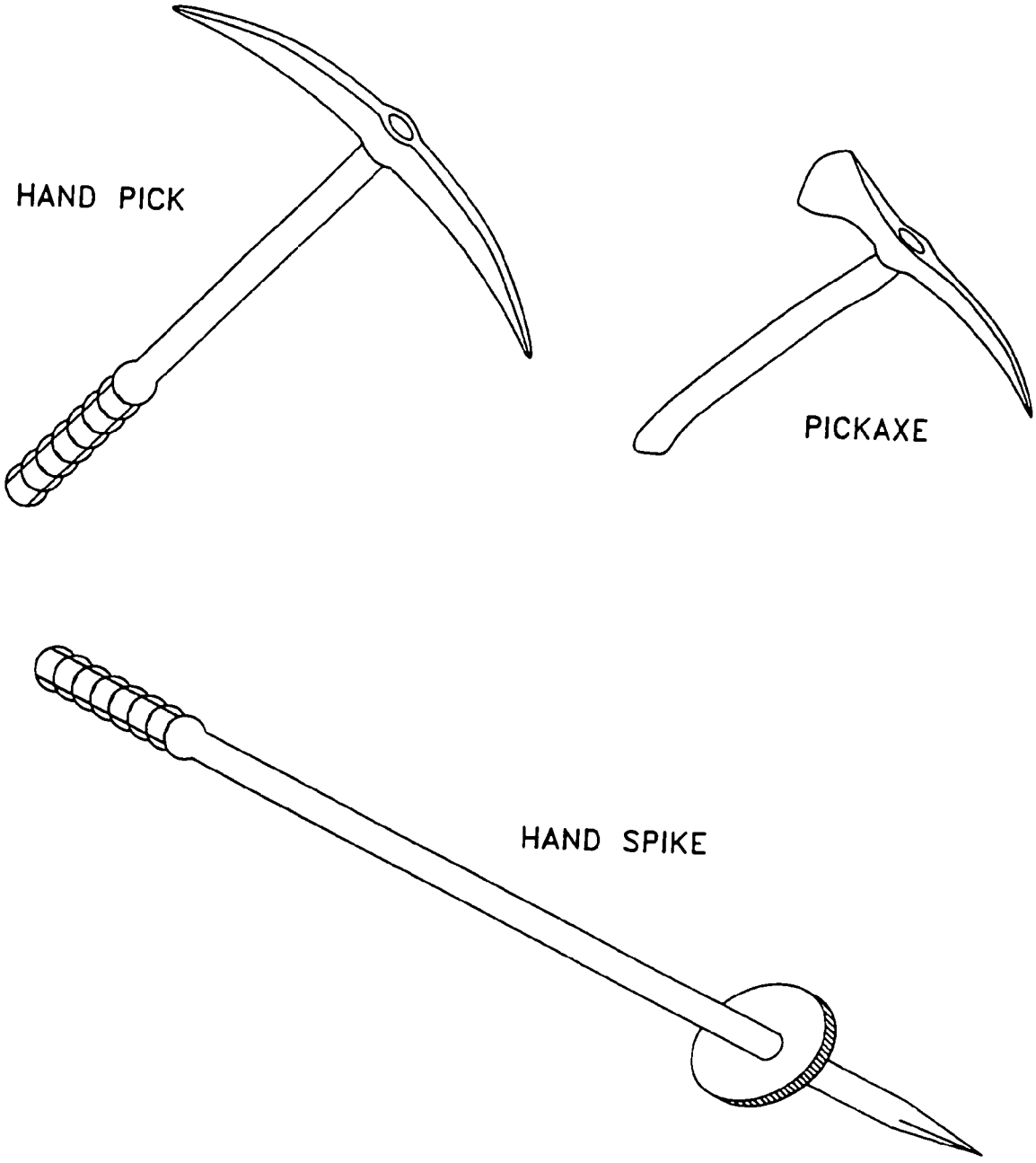


Figure 4: Backhoe Spike

SOP #2009

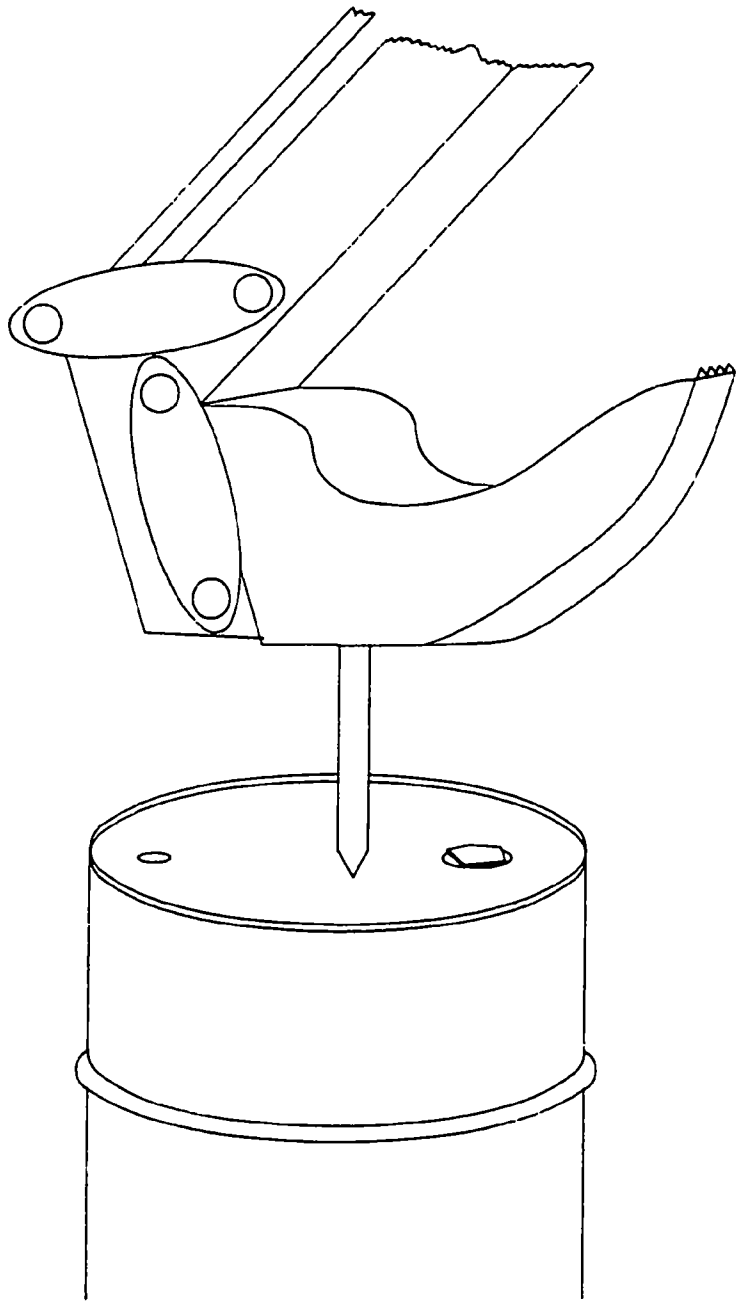


Figure 5: Hydraulic Drum Opener

SOP #2009

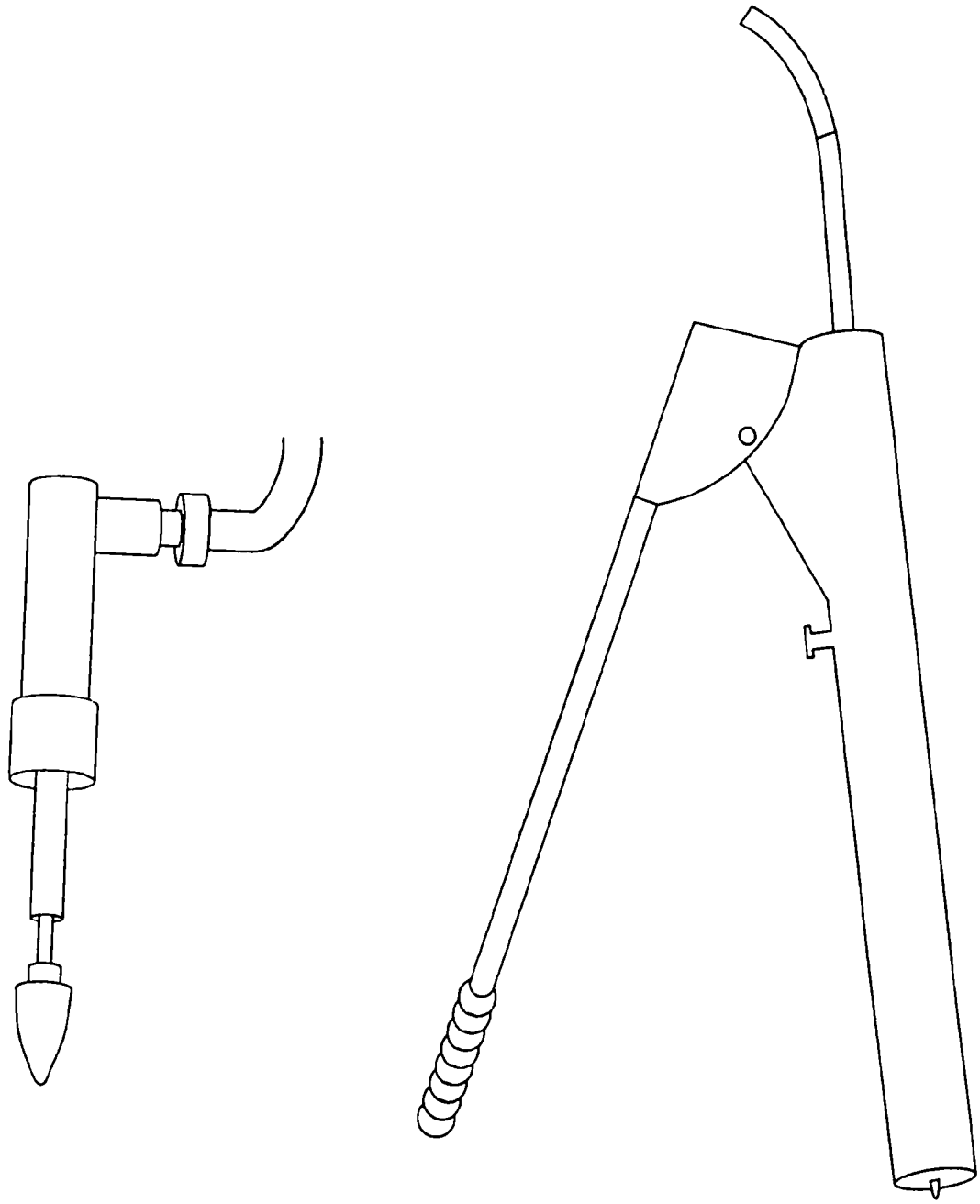


Figure 6: Pneumatic Bung Remover

SOP #2009

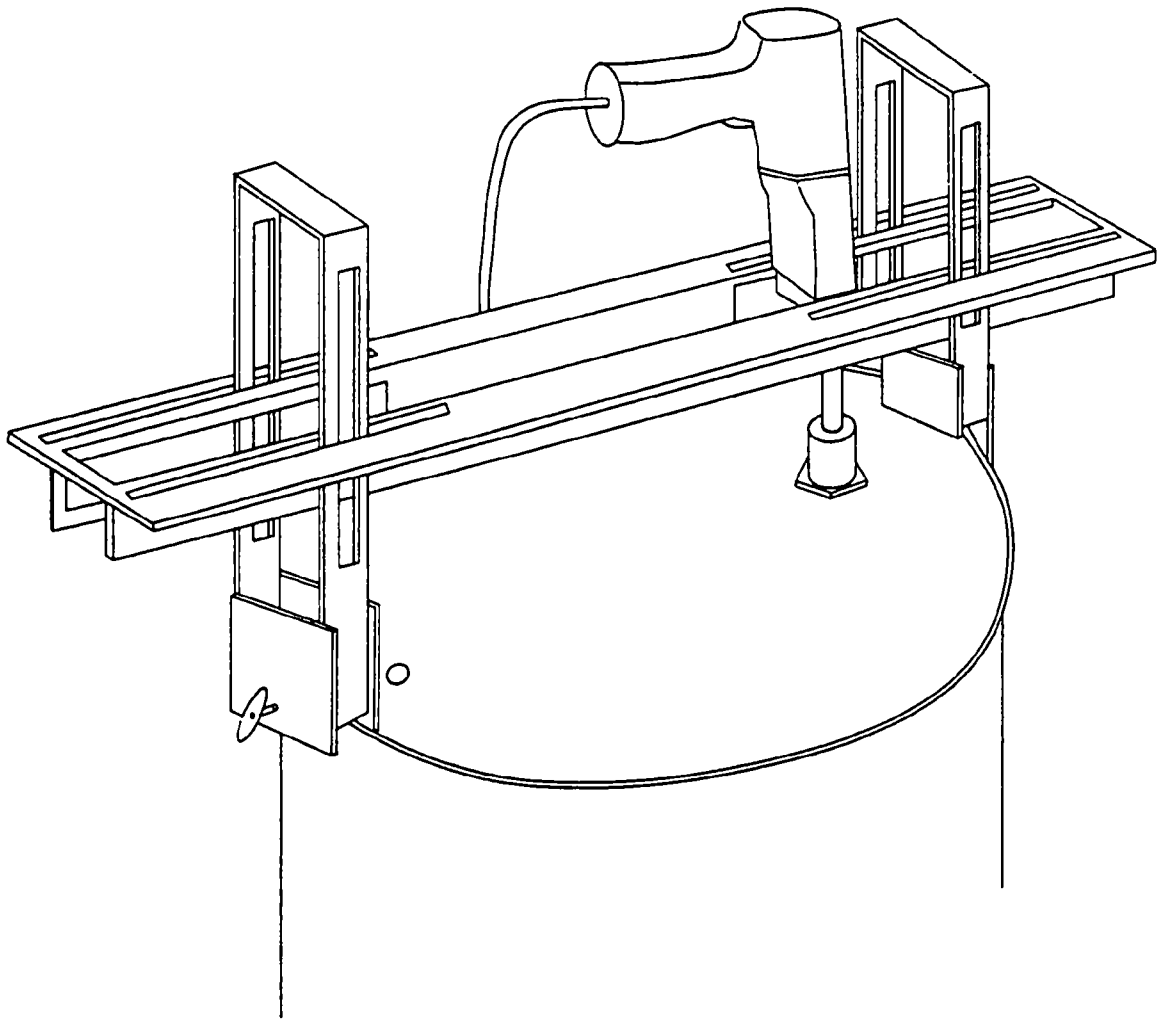
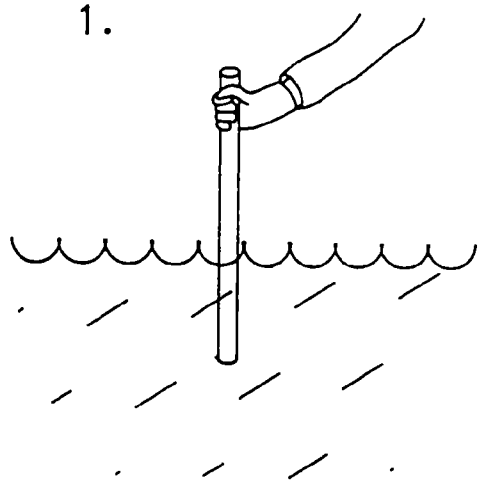


Figure 7: Glass Thief

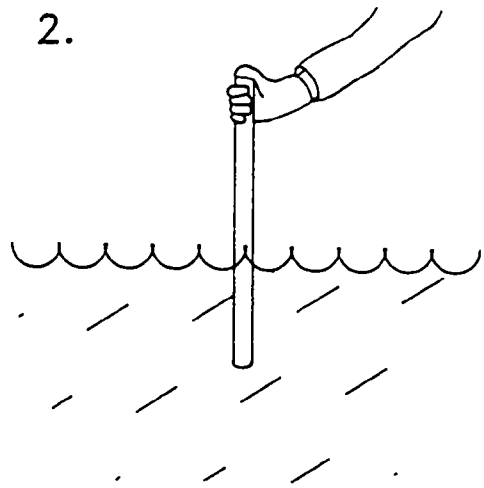
SOP# 2009

1.



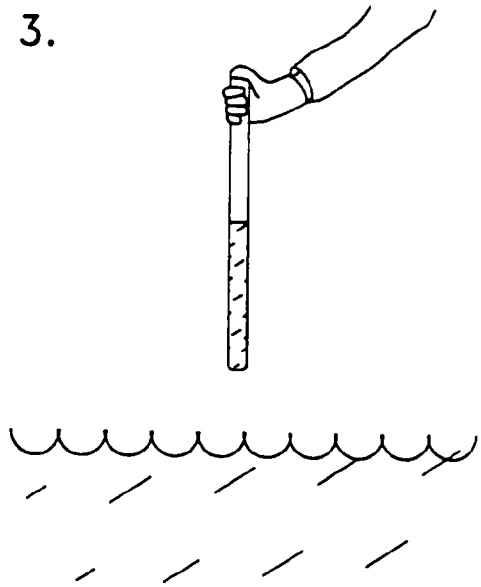
Insert open tube (thief) sampler in containerized liquid.

2.



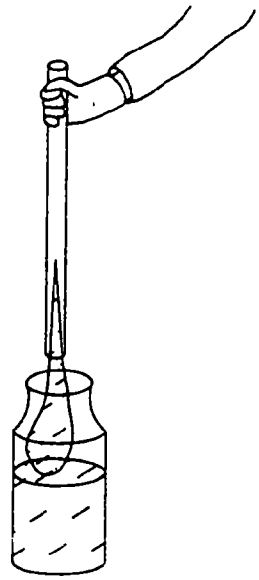
Cover top of sampler with gloved thumb.

3.



Remove open tube (thief) sampler from containerized liquid.

4.



Place open tube sampler over appropriate sample bottle and remove gloved thumb.

Figure 8: COLIWASA

SOP #2009

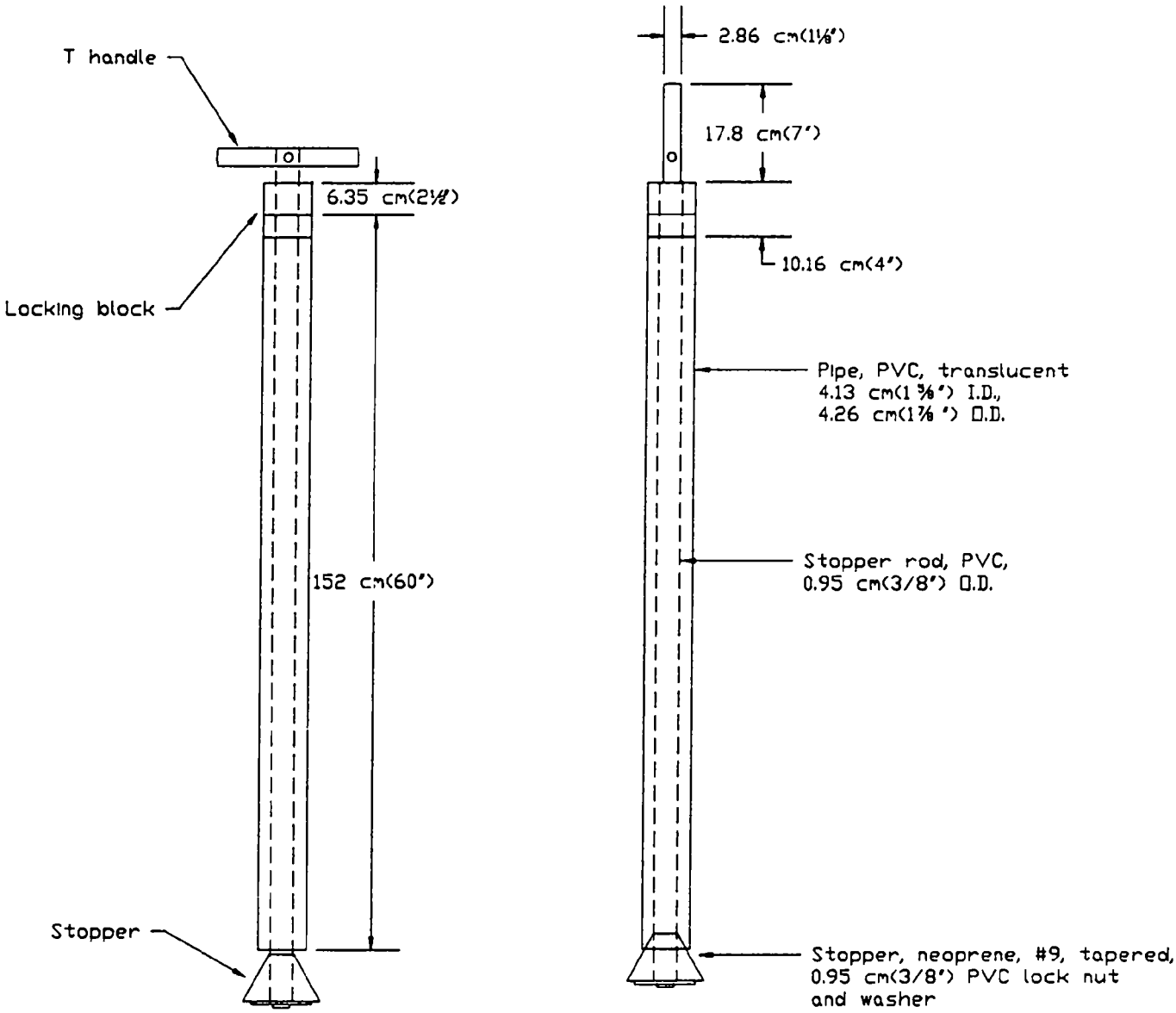


Figure 9: Bacon Bomb Sampler

SOP #2010

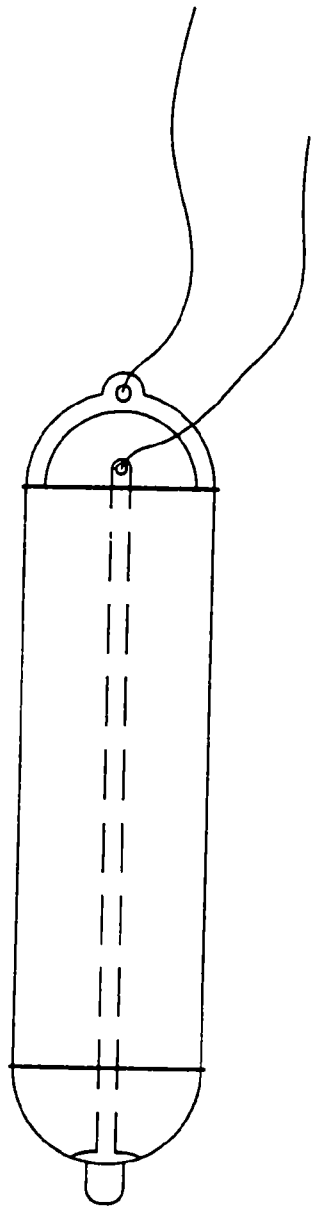


Figure 10: Sludge Judge

SOP #2010

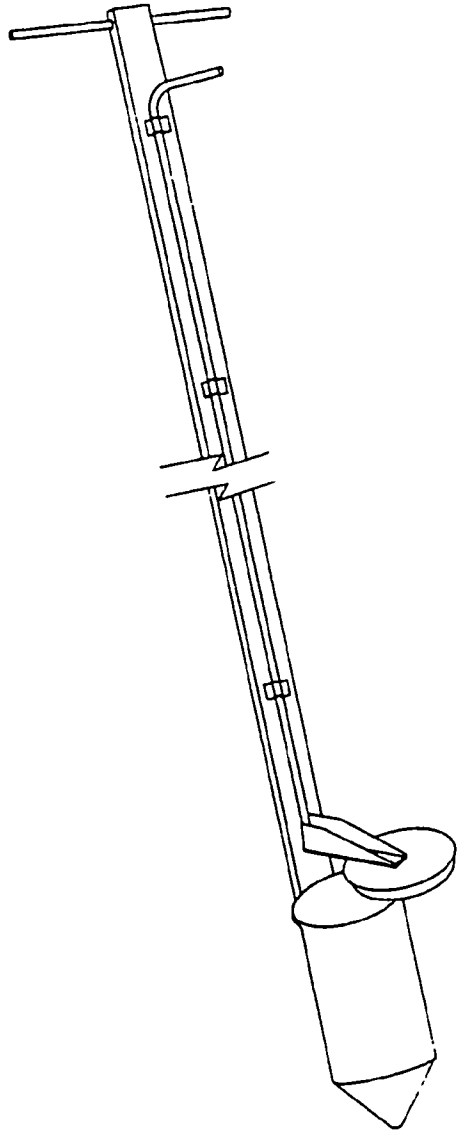


Figure 11: Subsurface Grab Sampler

SOP #2010

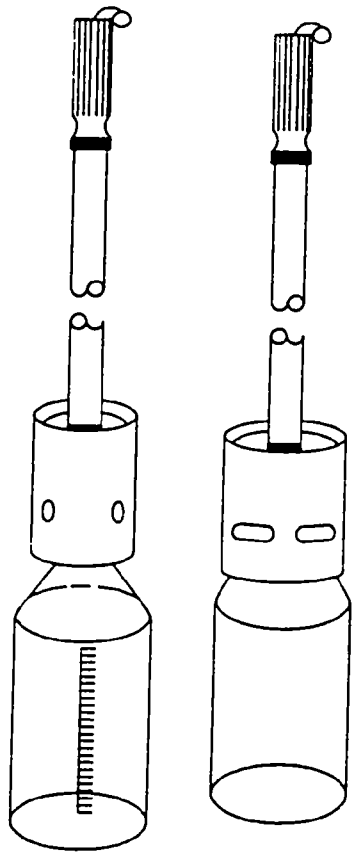


Figure 12: Bailer

SOP #2010

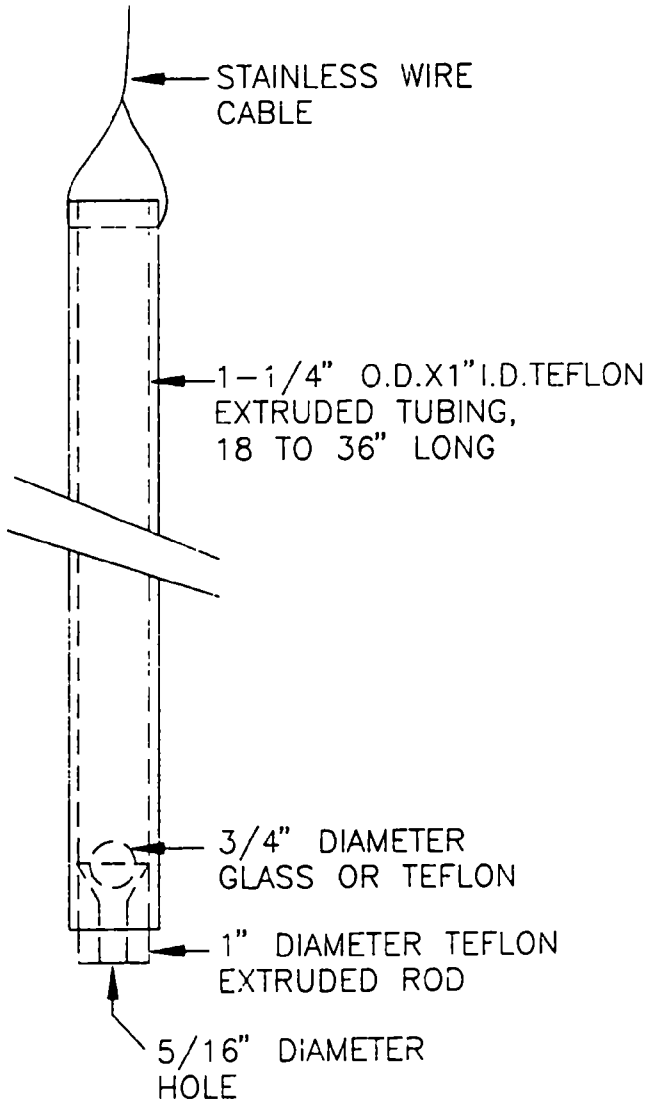
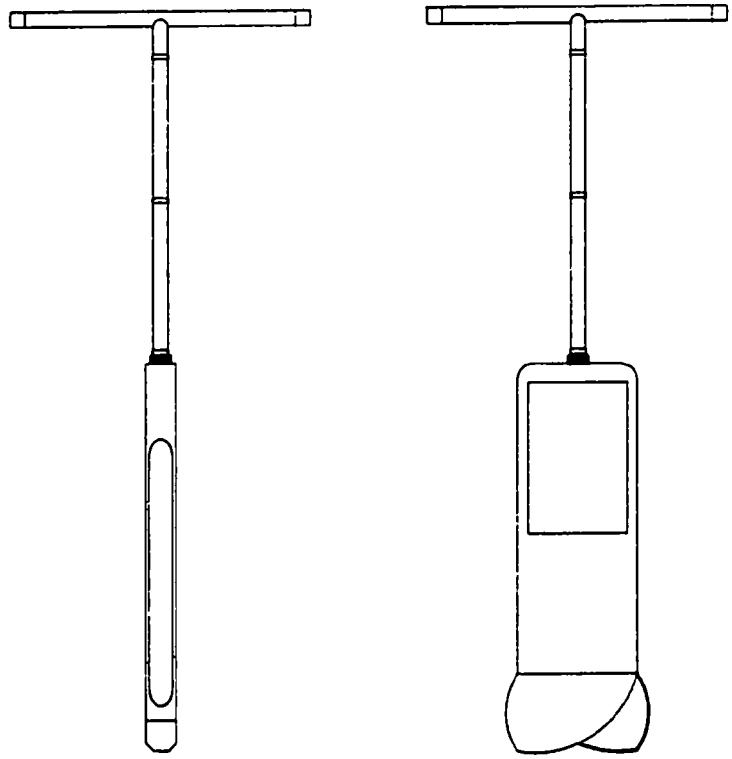


Figure 13: Sampling Augers

SOP #2017



TUBE AUGER

BUCKET AUGER

Figure 14: Sampling Trier

SOP #2017

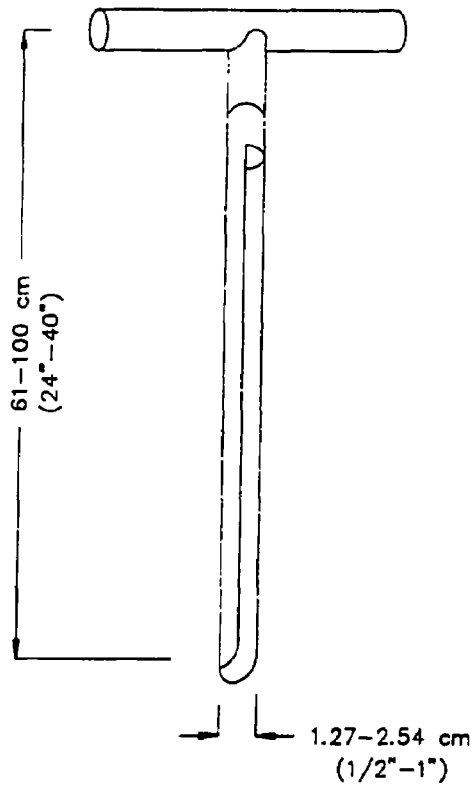
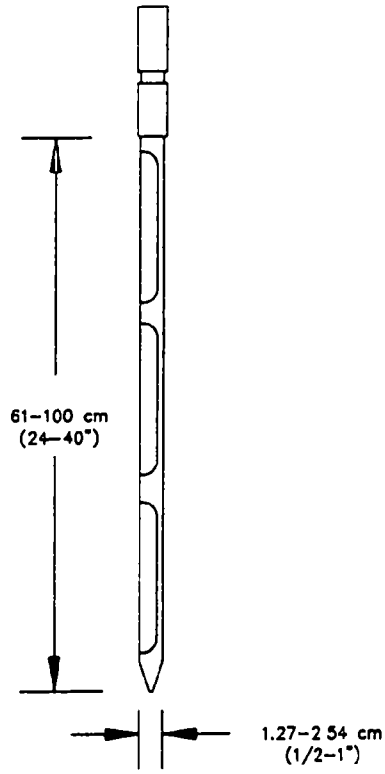


Figure 15: Grain Sampler

SOP #2017



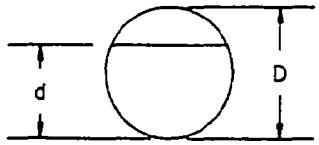
APPENDIX C

Calculations

Various Volume Calculations

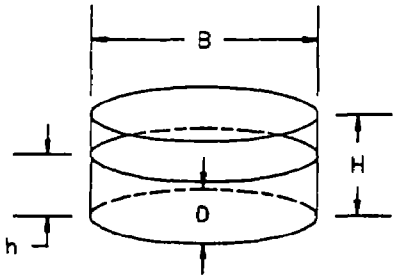
SOP #2010

SPHERE



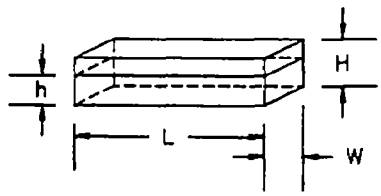
Total Volume
$V=1/6\ \pi D^3 = 0.523498D^3$
Partial Volume
$V=1/3\ \pi d^2\ (3/2\ D-d)$

ELLIPTICAL CONTAINER



Total Volume
$V=\pi BDH$
Partial Volume
$V=\pi BDh$

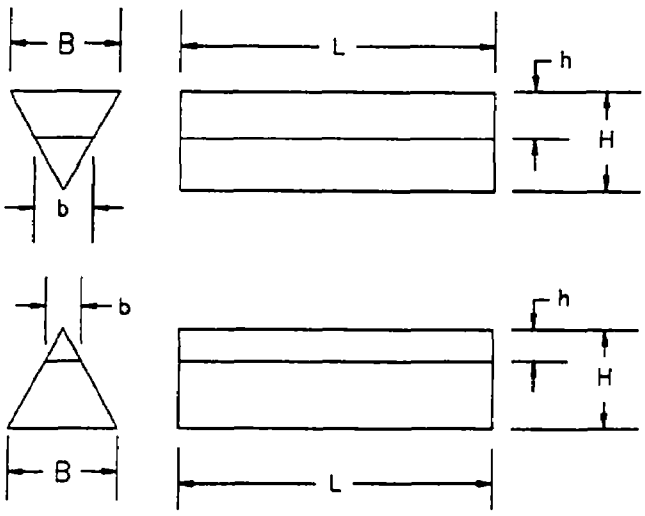
ANY RECTANGULAR CONTAINER



Total Volume
V=HLW
Partial Volume
V=hLW

TRIANGULAR CONTAINER

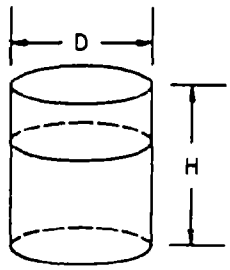
Total Volume
V=1/2 HBL



Case 1
Partial Volume
V=1/2 hBL

Case 2
Partial Volume
V=1/2 L(HB−hB)

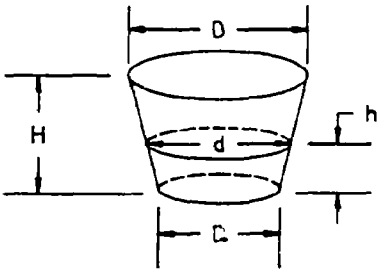
RIGHT CYLINDER



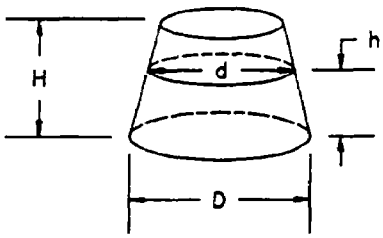
Total Volume
$V=1/4\ \pi D^2\ H$
Partial Volume
$V=1/4\ \pi D^2\ h$

FRUSTUM OF A CONE

Case 1



Case 2



Total Volume

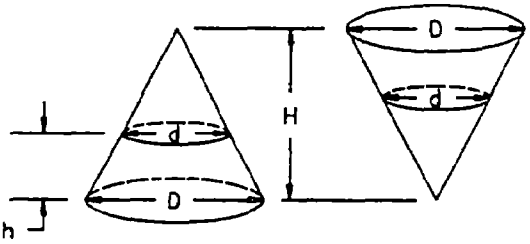
$V = \pi/12\ H(D_1^2 + D_1 D_2 + D_2^2)$

Partial Volume

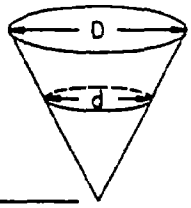
$V = \pi/12\ h(D_1^2 + D_1\ d + d^2)$

CONE

Case 1



Case 2



Total Volume

$V = \pi/12 \cdot D^2 H$

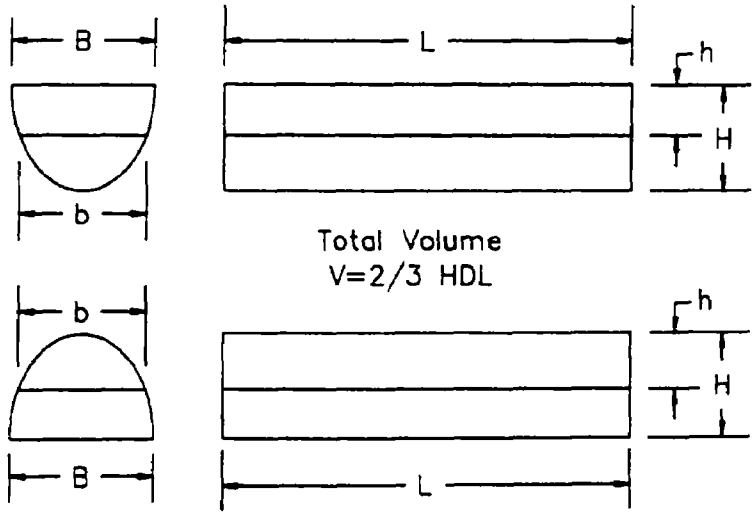
Partial Volume Case 1

$V = \pi/12 \cdot d^2 h$

Partial Volume Case 2

$V = \pi/12 \cdot (D^2 H - d^2 h)$

PARABOLIC CONTAINER



Case 1

Partial Volume

$V = 2/3\ hdL$

Case 2

Partial Volume

$V = 2/3\ (HD - hd) \cdot L$

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*U S Government Printing Office 1991 — 548-187/40582

United State
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268-1072

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No G-35

Official Business
Penalty for Private Use $300

EPA/540/P-91/008

United States
Environmental Protection
Agency

Office of Emergency and
Remedial Response
Washington, DC 20460

Superfund

EPA

Compendium of ERT Soil Sampling

GENERAL FIELD SAMPLING GUIDELINES

SOP#. 2001
DATE. 08/11/94
REV #· 0 0

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide general field sampling guidelines that will assist REAC personnel in choosing sampling strategies, location, and frequency for proper assessment of site characteristics This SOP is applicable to all field activities that involve sampling

These are standard (i e , typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S EPA endorsement or recommendation for use

2.0 METHOD SUMMARY

Sampling is the selection of a representative portion of a larger population, universe, or body Through examination of a sample, the characteristics of the larger body from which the sample was drawn can be inferred In this manner, sampling can be a valuable tool for determining the presence, type, and extent of contamination by hazardous substances in the environment

The primary objective of all sampling activities is to characterize a hazardous waste site accurately so that its impact on human health and the environment can be properly evaluated It is only through sampling and analysis that site hazards can be measured and the job of cleanup and restoration can be accomplished effectively with minimal risk The sampling itself must be conducted so that every sample collected retains its original physical form and chemical composition In this way, sample integrity is insured, quality assurance standards are maintained, and the sample can accurately represent the larger body of material under investigation

The extent to which valid inferences can be drawn from a sample depends on the degree to which the sampling effort conforms to the project's objectives For example, as few as one sample may produce adequate, technically valid data to address the project's objectives Meeting the project's objectives requires thorough planning of sampling activities, and implementation of the most appropriate sampling and analytical procedures These issues will be discussed in this procedure

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount of sample to be collected, and the proper sample container type (i e , glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest Sample preservation, containers, handling, and storage for air and waste samples are discussed in the specific SOPs for air and waste sampling techniques

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The nature of the object or materials being sampled may be a potential problem to the sampler If a material is homogeneous, it will generally have a uniform composition throughout In this case, any sample increment can be considered representative of the material On the other hand, heterogeneous samples present problems to the sampler because of changes in the material over distance, both laterally and vertically

Samples of hazardous materials may pose a safety threat to both field and laboratory personnel Proper health and safety precautions should be implemented when handling this type of sample

Environmental conditions, weather conditions, or non-target chemicals may cause problems and/or interferences when performing sampling activities or when sampling for a specific parameter Refer to the specific SOPs for sampling techniques

5.0 EQUIPMENT/APPARATUS

The equipment/apparatus required to collect samples must be determined on a site specific basis Due to the wide variety of sampling equipment available, refer to the specific SOPs for sampling techniques which include lists of the equipment/apparatus required for sampling

6.0 REAGENTS

Reagents may be utilized for preservation of samples and for decontamination of sampling equipment The preservatives required are specified by the analysis to be performed Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination

7.0 PROCEDURE

7.1 Types of Samples

In relation to the media to be sampled, two basic types of samples can be considered the environmental sample and the hazardous sample

Environmental samples are those collected from streams, ponds, lakes, wells, and are off-site samples that are not expected to be contaminated with hazardous materials They usually do not require the special handling procedures typically used for concentrated wastes However, in certain instances, environmental samples can contain elevated concentrations of pollutants and in such cases would have to be handled as hazardous samples

Hazardous or concentrated samples are those collected from drums, tanks, lagoons, pits, waste piles, fresh spills, or areas previously identified as contaminated, and require special handling procedures because of their potential toxicity or hazard These samples can be further subdivided based on their degree of hazard, however, care should be taken when handling and shipping any wastes believed to be concentrated regardless of the degree

The importance of making the distinction between environmental and hazardous samples is two-fold

(1) Personnel safety requirements Any sample thought to contain enough hazardous materials to pose a safety threat should be designated as hazardous and handled in a manner which ensures the safety of both field and laboratory personnel

(2) Transportation requirements Hazardous samples must be packaged, labeled, and shipped according to the International Air Transport Association (IATA) Dangerous Goods Regulations or Department of Transportation (DOT) regulations and U S EPA guidelines

7.2 Sample Collection Techniques

In general, two basic types of sample collection techniques are recognized, both of which can be used for either environmental or hazardous samples

Grab Samples

A grab sample is defined as a discrete aliquot representative of a specific location at a given point in time The sample is collected all at once at one particular point in the sample medium 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

Composite Samples

Composites are nondiscrete samples composed of more than one specific aliquot 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 problems by diluting isolated concentrations of some hazardous compounds below detection limits.

Compositing is often used for environmental samples and may be used for hazardous samples under certain conditions For example, compositing of hazardous waste is often performed after compatibility tests have

been completed to determine an average value over a number of different locations (group of drums) This procedure generates data that can be useful by providing an average concentration within a number of units, can serve to keep analytical costs down, and can provide information useful to transporters and waste disposal operations

For sampling situations involving hazardous wastes, grab sampling techniques are generally preferred because grab sampling minimizes the amount of time sampling personnel must be in contact with the wastes, reduces risks associated with compositing unknowns, and eliminates chemical changes that might occur due to compositing

7.3 Types of Sampling Strategies

The number of samples that should be collected and analyzed depends on the objective of the investigation There are three basic sampling strategies random, systematic, and judgmental sampling

Random sampling involves collection of samples in a nonsystematic fashion from the entire site or a specific portion of a site Systematic sampling involves collection of samples based on a grid or a pattern which has been previously established When judgmental sampling is performed, samples are collected only from the portion(s) of the site most likely to be contaminated Often, a combination of these strategies is the best approach depending on the type of the suspected/known contamination, the uniformity and size of the site, the level/type of information desired, etc

7.4 QA Work Plans (QAWP)

A QAWP is required when it becomes evident that a field investigation is necessary It should be initiated in conjunction with, or immediately following, notification of the field investigation This plan should be clear and concise and should detail the following basic components, with regard to sampling activities

- Objective and purpose of the investigation
- Basis upon which data will be evaluated
- Information known about the site including location, type and size of the facility, and length of operations/abandonment
- Type and volume of contaminated material, contaminants of concern (including concentration), and basis of the information/data
- Technical approach including media/matrix to be sampled, sampling equipment to be used, sample equipment decontamination (if necessary), sampling design and rationale, and SOPs or description of the procedure to be implemented
- Project management and reporting, schedule, project organization and responsibilities, manpower and cost projections, and required deliverables
- QA objectives and protocols including tables summarizing field sampling and QA/QC analysis and objectives

Note that this list of QAWP components is not all-inclusive and that additional elements may be added or altered depending on the specific requirements of the field investigation It should also be recognized that although a detailed QAWP is quite important, it may be impractical in some instances Emergency responses and accidental spills are prime examples of such instances where time might prohibit the development of site-specific QAWPs prior to field activities In such cases, investigators would have to rely on general guidelines and personal judgment, and the sampling or response plans might simply be a strategy based on preliminary information and finalized on site In any event, a plan of action should be developed, no matter how concise or informal, to aid investigators in maintaining a logical and consistent order to the implementation of their task

7.5 Legal Implications

The data derived from sampling activities are often introduced as critical evidence during litigation of a hazardous waste site cleanup Legal issues in which sampling data are important may include cleanup cost recovery, identification of pollution sources and responsible parties, and technical validation of remedial design methodologies Because of the potential for involvement in legal actions, strict adherence to technical and administrative SOPs is essential during both the development and implementation of sampling activities

Technically valid sampling begins with thorough planning and continues through the sample collection and analytical procedures Administrative requirements involve thorough, accurate

documentation of all sampling activities Documentation requirements include maintenance of a chain of custody, as well as accurate records of field activities and analytical instructions Failure to observe these procedures fully and consistently may result in data that are questionable, invalid and non-defensible in court, and the consequent loss of enforcement proceedings

8.0 CALCULATIONS

Refer to the specific SOPs for any calculations which are associated with sampling techniques

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

Refer to the specific SOPs for the type and frequency of QA/QC samples to be analyzed, the acceptance criteria for the QA/QC samples, and any other QA/QC activities - which are associated with sampling techniques

10.0 DATA VALIDATION

Refer to the specific SOPs for data validation activities that are associated with sampling techniques

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U S EPA, OSHA, and corporate health and safety procedures

SAMPLING EQUIPMENT DECONTAMINATION

SOP#. 2006
DATE. 08/11/94
REV. #. 0 0

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide a description of the methods used for preventing, minimizing, or limiting cross-contamination of samples due to inappropriate or inadequate equipment decontamination and to provide general guidelines for developing decontamination procedures for sampling equipment to be used during hazardous waste operations as per 29 Code of Federal Regulations (CFR) 1910 120 This SOP does not address personnel decontamination

These are standard (i e typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitation, or limitations imposed by the procedure In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U S Environmental Protection Agency (U S EPA) endorsement or recommendation for use

2.0 METHOD SUMMARY

Removing or neutralizing contaminants from equipment minimizes the likelihood of sample cross contamination, reduces or eliminates transfer of contaminants to clean areas, and prevents the mixing of incompatible substances

Gross contamination can be removed by physical decontamination procedures These abrasive and non-abrasive methods include the use of brushes, air and wet blasting, and high and low pressure water cleaning

The first step, a soap and water wash, removes all visible particulate matter and residual oils and grease This may be preceded by a steam or high pressure water wash to facilitate residuals removal The second step involves a tap water rinse and a distilled/deionized water rinse to remove the detergent An acid rinse provides a low pH media for trace metals removal and is included in the decontamination process if metal samples are to be collected It is followed by another distilled/deionized water rinse If sample analysis does not include metals, the acid rinse step can be omitted Next, a high purity solvent rinse is performed for trace organics removal if organics are a concern at the site Typical solvents used for removal of organic contaminants include acetone, hexane, or water Acetone is typically chosen because it is an excellent solvent, miscible in water, and not a target analyte on the Priority Pollutant List If acetone is known to be a contaminant of concern at a given site or if Target Compound List analysis (which includes acetone) is to be performed, another solvent may be substituted The solvent must be allowed to evaporate completely and then a final distilled/deionized water rinse is performed This rinse removes any residual traces of the solvent

The decontamination procedure described above may be summarized as follows

1 Physical removal
2 Non-phosphate detergent wash
3 Tap water rinse
4 Distilled/deionized water rinse
5 10% nitric acid rinse
6 Distilled/deionized water rinse
7 Solvent rinse (pesticide grade)
8 Air dry
9. Distilled/deionized water rinse

If a particular contaminant fraction is not present at the site, the nine (9) step decontamination procedure specified above may be modified for site specificity For example, the nitric acid rinse may be eliminated if metals are not of concern at a site Similarly, the solvent rinse may be eliminated if organics are not of

concern at a site Modifications to the standard procedure should be documented in the site specific work plan or subsequent report

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount of sample to be collected and the proper sample container type (i e , glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest.
More specifically, sample collection and analysis of decontamination waste may be required before beginning proper disposal of decontamination liquids and solids generated at a site This should be determined prior to initiation of site activities

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free (specifically for the contaminants of concern)
- The use of an untreated potable water supply is not an acceptable substitute for tap water Tap water may be used from any municipal or industrial water treatment system
- If acids or solvents are utilized in decontamination they raise health and safety, and waste disposal concerns
- Damage can be incurred by acid and solvent washing of complex and sophisticated sampling equipment

5.0 EQUIPMENT/APPARATUS

Decontamination equipment, materials, and supplies are generally selected based on availability Other considerations include the ease of decontaminating or disposing of the equipment Most equipment and supplies can be easily procured. For example, soft-bristle scrub brushes or long-handled bottle brushes can be used to remove contaminants Large galvanized wash tubs, stock tanks, or buckets can hold wash and rinse solutions Children's wading pools can also be used Large plastic garbage cans or other similar containers lined with plastic bags can help segregate contaminated equipment Contaminated liquid can be stored temporarily in metal or plastic cans or drums

The following standard materials and equipment are recommended for decontamination activities

5.1 Decontamination Solutions

- Non-phosphate detergent
- Selected solvents (acetone, hexane, nitric acid, etc)
- Tap water
- Distilled or deionized water

5.2 Decontamination Tools/Supplies

- Long and short handled brushes
- Bottle brushes
- Drop cloth/plastic sheeting
- Paper towels
- Plastic or galvanized tubs or buckets
- Pressurized sprayers (H_2O)
- Solvent sprayers
- Aluminum foil

5.3 Health and Safety Equipment

Appropriate personal protective equipment (i e , safety glasses or splash shield, appropriate gloves, aprons or coveralls, respirator, emergency eye wash)

5.4 Waste Disposal

- Trash bags
- Trash containers
- 55-gallon drums
- Metal/plastic buckets/containers for storage and disposal of decontamination solutions

6.0 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions Table 1 (Appendix A) lists solvent rinses which may be required for elimination of particular chemicals In

general, the following solvents are typically utilized for decontamination purposes

- C 10% nitric acid is typically used for inorganic compounds such as metals An acid rinse may not be required if inorganics are not a contaminant of concern
- C Acetone (pesticide grade)[1]
- C Hexane (pesticide grade)[1]
- C Methanol[1]

[1] - Only if sample is to be analyzed for organics

7.0 PROCEDURES

As part of the health and safety plan, a decontamination plan should be developed and reviewed The decontamination line should be set up before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include·

- C The number, location, and layout of decontamination stations
- C Decontamination equipment needed
- C Appropriate decontamination methods
- C Methods for disposal of contaminated clothing, equipment, and solutions
- C Procedures can be established to minimize the potential for contamination This may include (1) work practices that minimize contact with potential contaminants, (2) using remote sampling techniques, (3) covering monitoring and sampling equipment with plastic, aluminum foil, or other protective material, (4) watering down dusty areas, (5) avoiding laying down equipment in areas of obvious contamination, and (6) use of disposable sampling equipment

7.1 Decontamination Methods

All samples and equipment leaving the contaminated area of a site must be decontaminated to remove any contamination that may have adhered to equipment Various decontamination methods will remove contaminants by· (1) flushing or other physical action, or (2) chemical complexing to inactivate contaminants by neutralization, chemical reaction, disinfection, or sterilization

Physical decontamination techniques can be grouped into two categories abrasive methods and non-abrasive methods, as follows

7.1.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant The mechanical abrasive cleaning methods are most commonly used at hazardous waste sites The following abrasive methods are available

Mechanical

Mechanical methods of decontamination include using metal or nylon brushes The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushed, degree of brush contact, degree of contamination, nature of the surface being cleaned, and degree of contaminant adherence to the surface

Air Blasting

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities The distance between nozzle and surface cleaned, air pressure, time of application, and angle at which the abrasive strikes the surface will dictate cleaning efficiency Disadvantages of this method are the inability to control the amount of material removed and the large amount of waste generated

Wet Blasting

Wet blast cleaning involves use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area By using a very fine abrasive, the amount of materials removed can be carefully controlled

7.1 2 Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off a surface with pressure In general, the equipment surface is not removed using non-abrasive methods

Low-Pressure Water

This method consists of a container which is filled with water The user pumps air out of the container to create a vacuum A slender nozzle and hose allow the user to spray in hard-to-reach places

High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and a high-pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) and flow rates usually range from 20 to 140 liters per minute

Ultra-High-Pressure Water

This system produces a water jet that is pressured from 1,000 to 4,000 atmospheres This ultra-high-pressure spray can remove tightly-adhered surface films The water velocity ranges from 500 meters/second (m/s) (1,000 atm) to 900 m/s (4,000 atm). Additives can be used to enhance the cleaning action

Rinsing

Contaminants are removed by rinsing through dilution, physical attraction, and solubilization

Damp Cloth Removal

In some instances, due to sensitive, non-waterproof equipment or due to the unlikelihood of equipment being contaminated, it is not necessary to conduct an extensive decontamination procedure For example, air sampling pumps hooked on a fence, placed on a drum, or wrapped in plastic bags are not likely to become heavily contaminated A damp cloth should be used to wipe off contaminants which may have adhered to equipment through airborne contaminants or from surfaces upon which the equipment was set

Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents Unfortunately, standard sterilization methods are impractical for large equipment This method of decontamination is typically performed off-site

7.2 Field Sampling Equipment Decontamination Procedures

The decontamination line is setup so that the first station is used to clean the most contaminated item It progresses to the last station where the least contaminated item is cleaned The spread of contaminants is further reduced by separating each decontamination station by a minimum of three (3) feet Ideally, the contamination should decrease as the equipment progresses from one station to another farther along in the line

A site is typically divided up into the following boundaries. Hot Zone or Exclusion Zone (EZ), the Contamination Reduction Zone (CRZ), and the Support or Safe Zone (SZ) The decontamination line should be setup in the Contamination Reduction Corridor (CRC) which is in the CRZ Figure 1 (Appendix B) shows a typical contaminant reduction zone layout The CRC controls access into and out of the exclusion zone and confines decontamination activities to a limited area The CRC boundaries should be conspicuously marked The far end is the hotline, the boundary between the exclusion zone and the contamination reduction zone The size of the decontamination corridor depends on the number of stations in the decontamination process, overall dimensions of the work zones, and amount of space available at the site Whenever possible, it should be a straight line

Anyone in the CRC should be wearing the level of protection designated for the decontamination crew Another corridor may be required for the entry and exit of heavy equipment Sampling and monitoring equipment and sampling supplies are all maintained outside of the CRC Personnel don their equipment away from the CRC and enter the exclusion zone through a separate access control point at the hotline One person (or more) dedicated to decontaminating equipment is recommended

7.2 1 Decontamination Setup

Starting with the most contaminated station, the decontamination setup should be as follows

Station 1 Segregate Equipment Drop

Place plastic sheeting on the ground (Figure 2, Appendix B) Size will depend on amount of

equipment to be decontaminated Provide containers lined with plastic if equipment is to be segregated Segregation may be required if sensitive equipment or mildly contaminated equipment is used at the same time as equipment which is likely to be heavily contaminated

Station 2 Physical Removal With A High-Pressure Washer (Optional)

As indicated in 7 1 2, a high-pressure wash may be required for compounds which are difficult to remove by washing with brushes The elevated temperature of the water from the high-pressure washers is excellent at removing greasy/oily compounds High pressure washers require water and electricity.

A decontamination pad may be required for the high-pressure wash area An example of a wash pad may consist of an approximately 1 1/2 foot-deep basin lined with plastic sheeting and sloped to a sump at one corner A layer of sand can be placed over the plastic and the basin is filled with gravel or shell The sump is also lined with visqueen and a barrel is placed in the hole to prevent collapse A sump pump is used to remove the water from the sump for transfer into a drum

Typically heavy machinery is decontaminated at the end of the day unless site sampling requires that the machinery be decontaminated frequently A separate decontamination pad may be required for heavy equipment

Station 3 Physical Removal With Brushes And A Wash Basin

Prior to setting up Station 3, place plastic sheeting on the ground to cover areas under Station 3 through Station 10.
Fill a wash basin, a large bucket, or child's swimming pool with non-phosphate detergent and tap water Several bottle and bristle brushes to physically remove contamination should be dedicated to this station Approximately 10 - 50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination

Station 4 Water Basin

Fill a wash basin, a large bucket, or child's swimming pool with tap water Several bottle and bristle brushes should be dedicated to this station Approximately 10-50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination

Station 5 Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water Provide a 5-gallon bucket or basin to contain the water during the rinsing process Approximately 10-20 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination

Station 6 Nitric Acid Sprayers

Fill a spray bottle with 10% nitric acid An acid rinse may not be required if inorganics are not a contaminant of concern The amount of acid will depend on the amount of equipment to be decontaminated Provide a 5-gallon bucket or basin to collect acid during the rinsing process

Station 7 Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water Provide a 5-gallon bucket or basin to collect water during the rinsate process

Station 8 Organic Solvent Sprayers

Fill a spray bottle with an organic solvent After each solvent rinse, the equipment should be rinsed with distilled/deionized water and air dried Amount of solvent will depend on the amount of equipment to decontaminate Provide a 5-gallon bucket or basin to collect the solvent during the rinsing process

Solvent rinses may not be required unless organics are a contaminant of concern, and may be eliminated from the station sequence

Station 9 Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water Provide a 5-gallon bucket or basin to collect water during the rinsate process

Station 10 Clean Equipment Drop

Lay a clean piece of plastic sheeting over the bottom

plastic layer This will allow easy removal of the plastic in the event that it becomes dirty Provide aluminum foil, plastic, or other protective material to wrap clean equipment

7.2 2 Decontamination Procedures

Station 1 Segregate Equipment Drop

Deposit equipment used on-site (i e , tools, sampling devices and containers, monitoring instruments radios, clipboards, etc.) on the plastic drop cloth/sheet or in different containers with plastic liners Each will be contaminated to a different degree Segregation at the drop reduces the probability of cross contamination Loose leaf sampling data sheets or maps can be placed in plastic zip lock bags if contamination is evident

Station 2 Physical Removal With A High-Pressure Washer (Optional)

Use high pressure wash on grossly contaminated equipment. Do not use high- pressure wash on sensitive or non-waterproof equipment

Station 3 Physical Removal With Brushes And A Wash Basin

Scrub equipment with soap and water using bottle and bristle brushes Only sensitive equipment (i e., radios, air monitoring and sampling equipment) which is waterproof should be washed. Equipment which is not waterproof should have plastic bags removed and wiped down with a damp cloth Acids and organic rinses may also ruin sensitive equipment. Consult the manufacturers for recommended decontamination solutions

Station 4 Equipment Rinse

Wash soap off of equipment with water by immersing the equipment in the water while brushing Repeat as many times as necessary.

Station 5 Low-Pressure Rinse

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer.

Station 6 Nitric Acid Sprayers (required only if metals are a contaminant of concern)

Using a spray bottle rinse sampling equipment with nitric acid Begin spraying (inside and outside) at one end of the equipment allowing the acid to drip to the other end into a 5-gallon bucket A rinsate blank may be required at this station Refer to Section 9

Station 7 Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer

Station 8 Organic Solvent Sprayers

Rinse sampling equipment with a solvent Begin spraying (inside and outside) at one end of the equipment allowing the solvent to drip to the other end into a 5-gallon bucket Allow the solvent to evaporate from the equipment before going to the next station A QC rinsate sample may be required at this station

Station 9 Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure washer

Station 10 Clean Equipment Drop

Lay clean equipment on plastic sheeting Once air dried, wrap sampling equipment with aluminum foil, plastic, or other protective material

7.2 3 Post Decontamination Procedures

1 Collect high-pressure pad and heavy equipment decontamination area liquid and waste and store in appropriate drum or container A sump pump can aid in the collection process Refer to the Department of Transportation (DOT) requirements for appropriate containers based on the contaminant of concern

2 Collect high-pressure pad and heavy equipment decontamination area solid waste and store in appropriate drum or container Refer to the DOT requirements for appropriate containers based on the contaminant of concern

3 Empty soap and water liquid wastes from basins and buckets and store in appropriate

drum or container Refer to the DOT requirements for appropriate containers based on the contaminant of concern

4 Empty acid rinse waste and place in appropriate container or neutralize with a base and place in appropriate drum pH paper or an equivalent pH test is required for neutralization Consult DOT requirements for appropriate drum for acid rinse waste

5 Empty solvent rinse sprayer and solvent waste into an appropriate container Consult DOT requirements for appropriate drum for solvent rinse waste

6 Using low-pressure sprayers, rinse basins, and brushes Place liquid generated from this process into the wash water rinse container

7 Empty low-pressure sprayer water onto the ground

8 Place all solid waste materials generated from the decontamination area (i e , gloves and plastic sheeting, etc) in an approved DOT drum Refer to the DOT requirements for appropriate containers based on the contaminant of concern

9 Write appropriate labels for waste and make arrangements for disposal. Consult DOT regulations for the appropriate label for each drum generated from the decontamination process

8.0 CALCULATIONS

This section is not applicable to this SOP

9.0 QUALITYASSURANCE/ QUALITY CONTROL

A rinsate blank is one specific type of quality control sample associated with the field decontamination process This sample will provide information on the effectiveness of the decontamination process employed in the field

Rinsate blanks are samples obtained by running analyte free water over decontaminated sampling equipment to test for residual contamination The blank water is collected in sample containers for handling, shipment, and analysis These samples are treated identical to samples collected that day A rinsate blank is used to assess cross contamination brought about by improper decontamination procedures Where dedicated sampling equipment is not utilized, collect one rinsate blank per day per type of sampling device samples to meet QA2 and QA3 objectives

If sampling equipment requires the use of plastic tubing it should be disposed of as contaminated and replaced with clean tubing before additional sampling occurs

10.0 DATA VALIDATION

Results of quality control samples will be evaluated for contamination This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow OSHA, U S EPA, corporate, and other applicable health and safety procedures

Decontamination can pose hazards under certain circumstances Hazardous substances may be incompatible with decontamination materials For example, the decontamination solution may react with contaminants to produce heat, explosion, or toxic products Also, vapors from decontamination solutions may pose a direct health hazard to workers by inhalation, contact, fire, or explosion

The decontamination solutions must be determined to be acceptable before use Decontamination materials may degrade protective clothing or equipment, some solvents can permeate protective clothing If decontamination materials do pose a health hazard, measures should be taken to protect personnel or substitutions should be made to eliminate the hazard The choice of respiratory protection based on contaminants of concern from the site may not be appropriate for solvents used in the decontamination process

Safety considerations should be addressed when using abrasive and non-abrasive decontamination

equipment Maximum air pressure produced by abrasive equipment could cause physical injury Displaced material requires control mechanisms

Material generated from decontamination activities requires proper handling, storage, and disposal Personal Protective Equipment may be required for these activities

Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard (i e , acetone, alcohol, and trisodiumphosphate)

In some jurisdictions, phosphate containing detergents (i.e., TSP) are banned

12.0 REFERENCES

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, February, 1988

A Compendium of Superfund Field Operations Methods, EPA 540/p-87/001

Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, USEPA Region IV, April 1, 1986

Guidelines for the Selection of Chemical Protective Clothing, Volume 1, Third Edition, American Conference of Governmental Industrial Hygienists, Inc , February, 1987

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, October, 1985

APPENDIX A

Table

Table 1 Soluble Contaminants and Recommended Solvent Rinse

TABLE 1 Soluble Contaminants and Recommended Solvent Rinse		
SOLVENT[1]	EXAMPLES OF SOLVENTS	SOLUBLE CONTAMINANTS
Water	Deionized water Tap water	Low-chain hydrocarbons Inorganic compounds Salts Some organic acids and other polar compounds
Dilute Acids	Nitric acid Acetic acid Boric acid	Basic (caustic) compounds (e.g., amines and hydrazines)
Dilute Bases	Sodium bicarbonate (e g , soap detergent)	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents [2]	Alcohols Ethers Ketones Aromatics Straight chain alkalines (e.g , hexane) Common petroleum products (e.g , fuel, oil, kerosene)	Nonpolar compounds (e g., some organic compounds)
Organic Solvent[2]	Hexane	PCBs

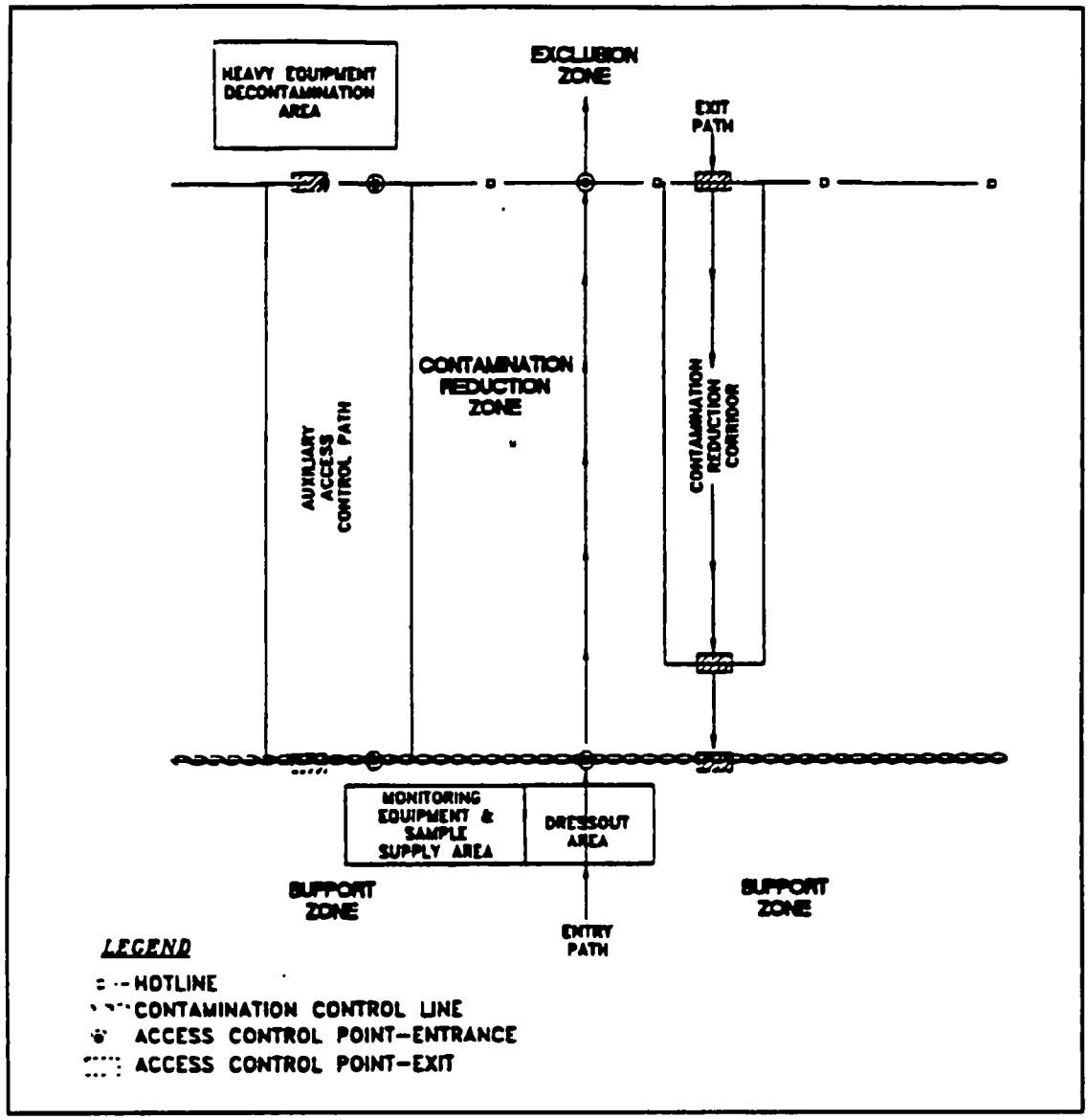
[1] - Material safety data sheets are required for all decontamination solvents or solutions as require by the Hazard Communication Standard

[2] - WARNING: Some organic solvents can permeate and/or degrade the protective clothing

APPENDIX B

Figures

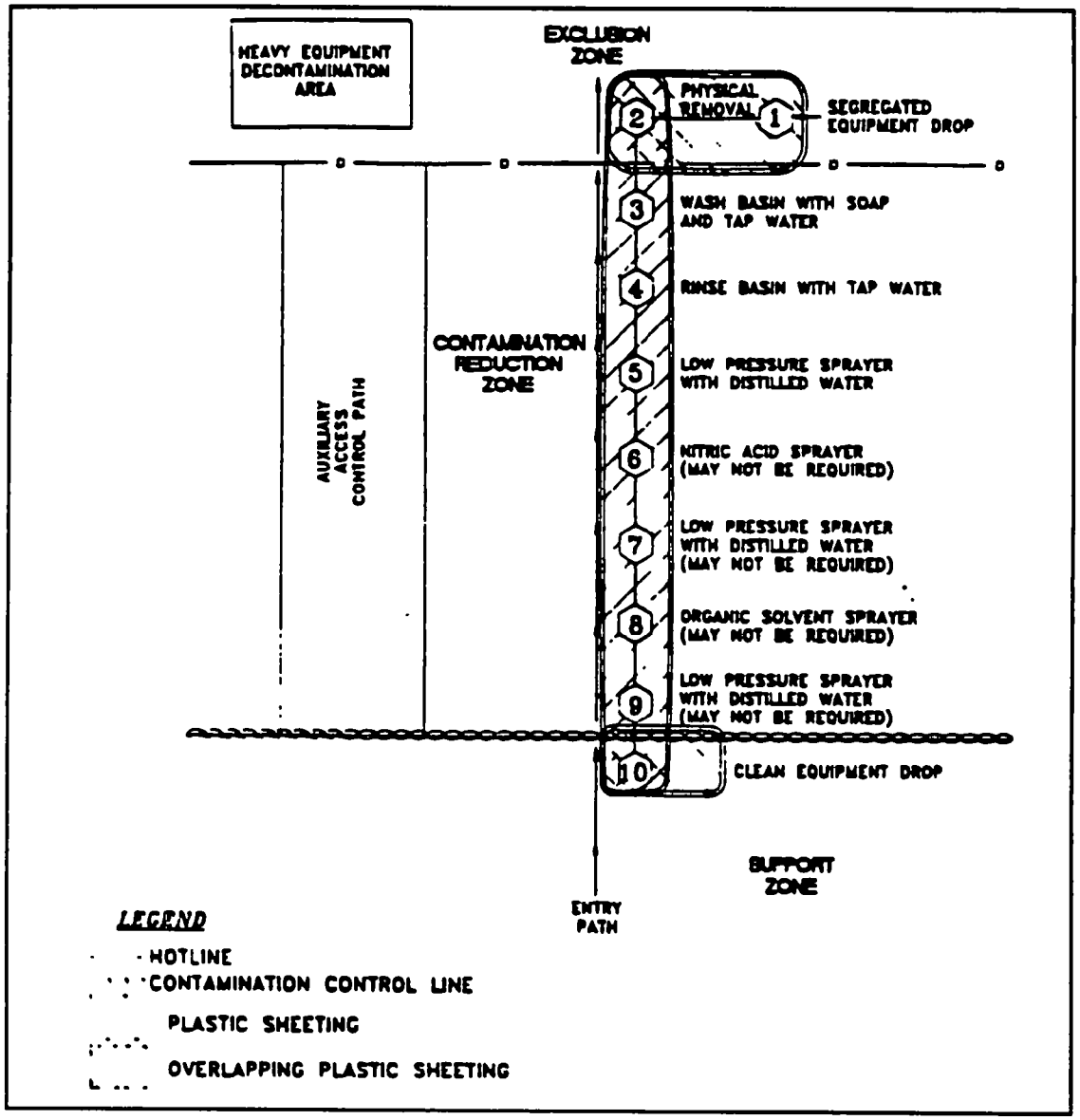
Figure 1 Contamination Reduction Zone Layout



APPENDIX B (Cont'd.)

Figures

Figure 2 Decontamination Layout



SOIL SAMPLING

SOP#: 2012
DATE: 11/16/94
REV. #: 0 0

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to describe the procedures for the collection of representative soil samples Analysis of soil samples may determine whether concentrations of specific pollutants exceed established action levels, or if the concentrations of pollutants present a risk to public health, welfare, or the environment

These are standard (i e , typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U S Environmental Protection Agency (EPA) endorsement or recommendation for use

2.0 METHOD SUMMARY

Soil samples may be collected using a variety of methods and equipment The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed vs undisturbed), and the soil type Near-surface soils may be easily sampled using a spade, trowel, and scoop Sampling at greater depths may be performed using a hand auger, continuous flight auger, a trier, a split-spoon, or, if required, a backhoe

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Chemical preservation of solids is not generally recommended Samples should, however, be cooled and protected from sunlight to minimize any potential reaction

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems associated with soil sampling These include cross contamination of samples and improper sample collection Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment If this is not possible or practical, then decontamination of sampling equipment is necessary Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample or inadequate homogenization of the samples where required, resulting in variable, non-representative results

5.0 EQUIPMENT/APPARATUS

Soil sampling equipment includes the following

- Sampling plan
- Maps/plot plan
- Safety equipment, as specified in the Health and Safety Plan
- Survey equipment
- Tape measure
- Survey stakes or flags
- Camera and film
- Stainless steel, plastic, or other appropriate homogenization bucket, bowl or pan
- Appropriate size sample containers
- Ziplock plastic bags
- Logbook
- Labels
- Chain of Custody records and seals
- Field data sheets
- Cooler(s)
- Ice
- Vermiculite
- Decontamination supplies/equipment
- Canvas or plastic sheet
- Spade or shovel

C Spatula
C Scoop
C Plastic or stainless steel spoons
C Trowel
C Continuous flight (screw) auger
C Bucket auger
C Post hole auger
C Extension rods
C T-handle
C Sampling trier
C Thin wall tube sampler
C Split spoons
C Vehimeyer soil sampler outfit
  - Tubes
  - Points
  - Drive head
  - Drop hammer
  - Puller jack and grip
C Backhoe

6.0 REAGENTS

Reagents are not used for the preservation of soil samples Decontamination solutions are specified in the Sampling Equipment Decontamination SOP and the site specific work plan

7.0 PROCEDURES

7.1 Preparation

1 Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies required

2 Obtain necessary sampling and monitoring equipment

3 Decontaminate or pre-clean equipment, and ensure that it is in working order

4 Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

5 Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan

6 Use stakes, flagging, or buoys to identify and mark all sampling locations Specific site factors, including extent and nature of contaminant should be considered when selecting sample location If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions All staked locations will be utility-cleared by the property owner prior to soil sampling

7.2 Sample Collection

7 2 1 Surface Soil Samples

Collection of samples from near-surface soil can be accomplished with tools such as spades, shovels, trowels, and scoops Surface material can be removed to the required depth with this equipment, then a stainless steel or plastic scoop can be used to collect the sample

This method can be used in most soil types but is limited to sampling near surface areas Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required Care should be exercised to avoid use of devices plated with chrome or other materials Plating is particularly common with garden implements such as potting trowels

The following procedure is used to collect surface soil samples

1 Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade

2 Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area which came in contact with the spade

3 If volatile organic analysis is to be performed, transfer the sample directly into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly Place the remainder of the sample into a stainless steel, plastic, or

other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval Then, either place the sample into appropriate, labeled containers and secure the caps tightly, or, if composite samples are to be collected, place a sample from another sampling interval or location into the homogenization container and mix thoroughly When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

7.2.2 Sampling at Depth with Augers and Thin Wall Tube Samplers

This system consists of an auger, or a thin-wall tube sampler, a series of extensions, and a "T" handle (Figure 1, Appendix A) The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger If a core sample is to be collected, the auger tip is then replaced with a thin wall tube sampler The system is then lowered down the borehole, and driven into the soil to the completion depth The system is withdrawn and the core is collected from the thin wall tube sampler

Several types of augers are available, these include. bucket type, continuous flight (screw), and post-hole augers Bucket type augers are better for direct sample recovery since they provide a large volume of sample in a short time When continuous flight augers are used, the sample can be collected directly from the flights The continuous flight augers are satisfactory for use when a composite of the complete soil column is desired Post-hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy soil and cannot be used below a depth of three feet

The following procedure will be used for collecting soil samples with the auger

1 Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod

2 Clear the area to be sampled of any surface debris (e g , twigs, rocks, litter) It may be advisable to remove the first three to six inches of surface soil for an area approximately six inches in radius around the drilling location

3 Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods It also facilitates refilling the hole, and avoids possible contamination of the surrounding area

4 After reaching the desired depth, slowly and carefully remove the auger from boring When sampling directly from the auger, collect the sample after the auger is removed from the boring and proceed to Step 10

5 Remove auger tip from drill rods and replace with a pre-cleaned thin wall tube sampler Install the proper cutting tip

6 Carefully lower the tube sampler down the borehole Gradually force the tube samplerinto soil Care should be taken to avoid scraping the borehole sides Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse

7 Remove the tube sampler, and unscrew the drill rods

8 Remove the cutting tip and the core from the device

9 Discard the top of the core (approximately 1 inch), as this possibly represents material collected before penetration of the layer of concern Place the remaining core into the appropriate labeled sample container Sample homogenization is not required

10 If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval Then, either place the sample into appropriate, labeled containers and secure the

caps tightly, or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly

When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly

11 If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples

12 Abandon the hole according to applicable State regulations Generally, shallow holes can simply be backfilled with the removed soil material

7 2 3 Sampling at Depth with a Trier

The system consists of a trier, and a "T" handle The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth

The following procedure will be used to collect soil samples with a sampling trier

1 Insert the trier (Figure 2, Appendix A) into the material to be sampled at a 0° to 45° angle from horizontal This orientation minimizes the spillage of sample

2 Rotate the trier once or twice to cut a core of material

3. Slowly withdraw the trier, making sure that the slot is facing upward

4 If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval Then, either place the sample into appropriate, labeled containers and secure the caps tightly, or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly

7 2 4 Sampling at Depth with a Split Spoon (Barrel) Sampler

The procedure for split spoon sampling describes the collection and extraction of undisturbed soil cores of 18 or 24 inches in length A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted

When split spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-67 (reapproved 1974)

The following procedures will be used for collecting soil samples with a split spoon

1 Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the head piece on top

2 Place the sampler in a perpendicular position on the sample material

3 Using a well ring, drive the tube Do not drive past the bottom of the head piece or compression of the sample will result

4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth

5 Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel The amount of recovery and soil type should be recorded on the boring log If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half, longitudinally This sampler

is typically available in 2 and 3 1/2 inch diameters However, in order to obtain the required sample volume, use of a larger barrel may be required

6 Without disturbing the core, transfer it to appropriate labeled sample container(s) and seal tightly

7 2 5 Test Pit/Trench Excavation

These relatively large excavations are used to remove sections of soil, when detailed examination of soil characteristics (horizontal, structure, color, etc) are required It is the least cost effective sampling method due to the relatively high cost of backhoe operation

The following procedures will be used for collecting soil samples from test pit/trench excavations

1 Prior to any excavation with a backhoe, it is important to ensure that all sampling locations are clear of utility lines, subsurface pipes and poles (subsurface as well as above surface)

2 Using the backhoe, a trench is dug to approximately three feet in width and approximately one foot below the cleared sampling location Place excavated soils on plastic sheets Trenches greater than five feet deep must be sloped or protected by a shoring system, as required by OSHA regulations

3. A shovel is used to remove a one to two inch layer of soil from the vertical face of the pit where sampling is to be done

4 Samples are taken using a trowel, scoop, or coring device at the desired intervals Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling In many instances, samples can be collected directly from the backhoe bucket

5 If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval Then, either place the sample into appropriate, labeled containers and secure the caps tightly, or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly

6 Abandon the pit or excavation according to applicable state regulations Generally, shallow excavations can simply be backfilled with the removed soil material

8.0 CALCULATIONS

This section is not applicable to this SOP

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures However, the following QA procedures apply

1 All data must be documented on field data sheets or within site logbooks

2 All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented

10.0 DATA VALIDATION

This section is not applicable to this SOP

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials,

follow U S EPA, OHSA and corporate health and safety procedures

12.0 REFERENCES

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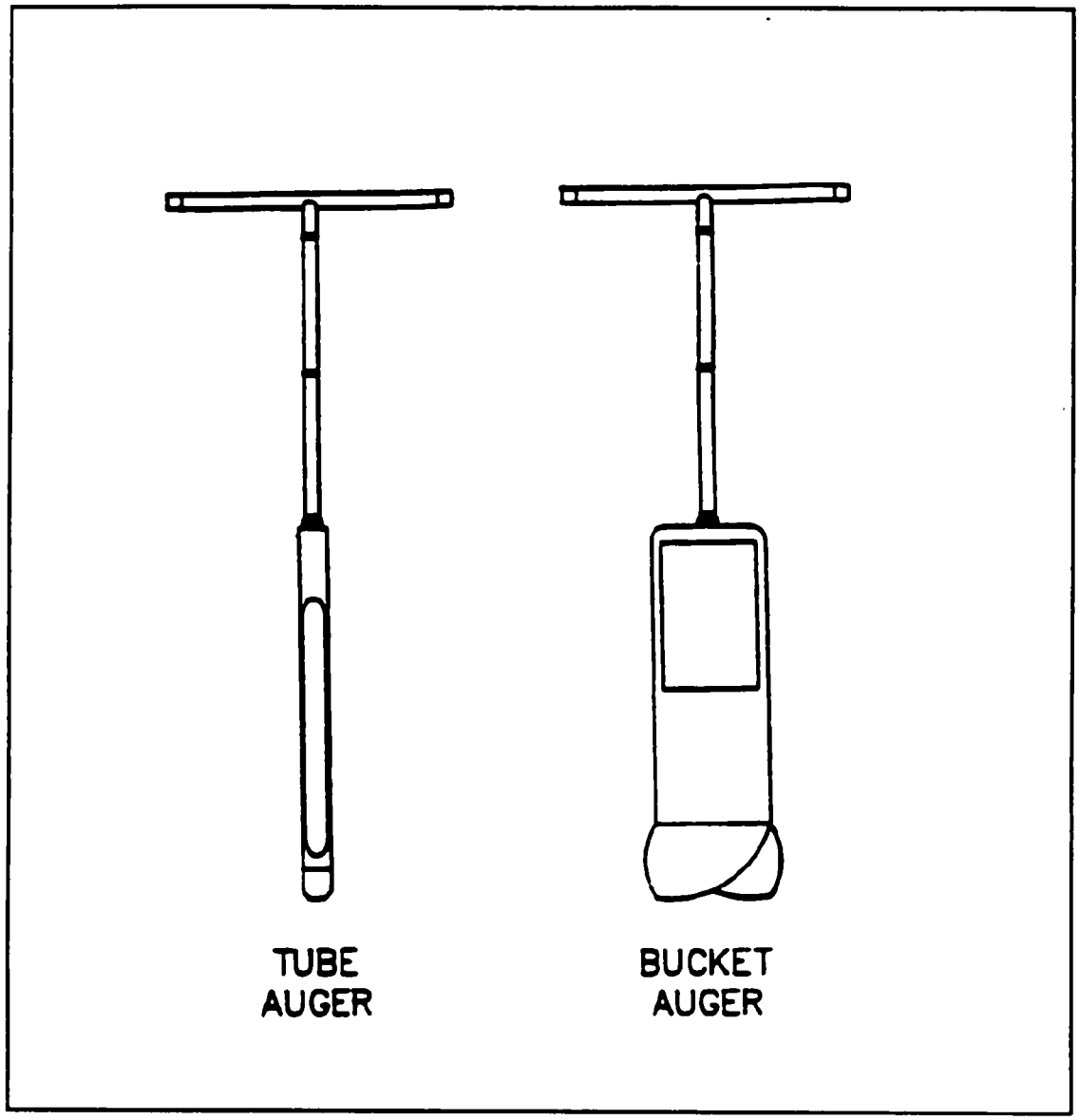
APPENDIX A

Figures

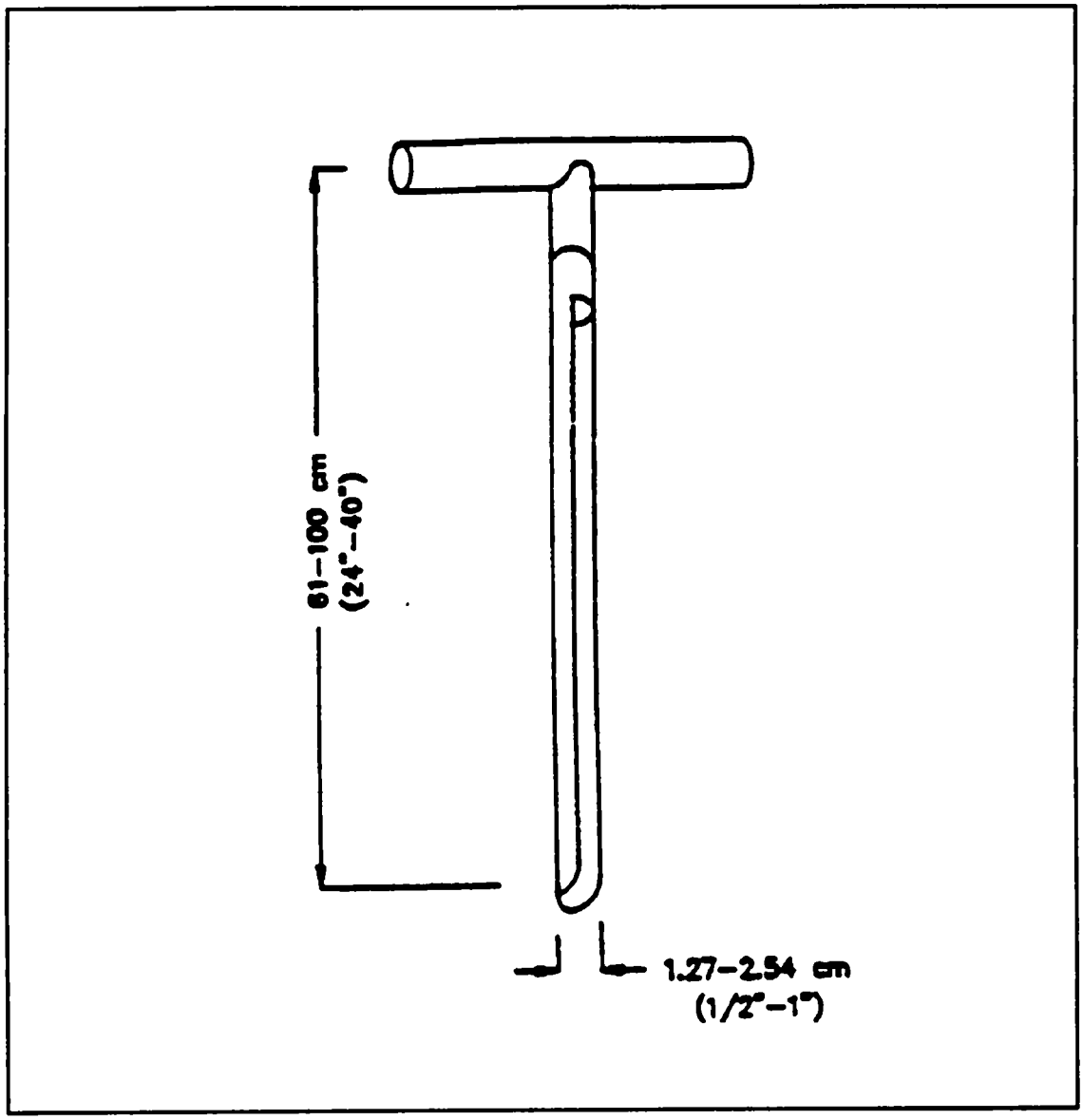
FIGURE 1 Sampling Augers



APPENDIX A (Cont'd)

Figures

FIGURE 2 Sampling Tner



SOIL GAS SAMPLING

SOP#: 2042
DATE: 06/01/96
REV. #. 0 0

1.0 SCOPE AND APPLICATION

Soil gas monitoring provides a quick means of waste site evaluation Using this method, underground contamination can be identified, and the source, extent, and movement of the pollutants can be traced

This standard operating procedure (SOP) outlines the methods used by U.S EPA/ERT in installing soil gas wells, measuring organic vapor levels in the soil gas using a Photoionization Detector (PID), Flame Ionization Detector (FID) and/or other air monitoring devices, and sampling the soil gas using Tedlar bags, Tenax sorbent tubes, and/or Summa canisters

These are standard (i e , typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S EPA endorsement or recommendation for use

2.0 METHOD SUMMARY

A 3/8" diameter hole is driven into the ground to a depth of four to five feet using a commercially available slam bar Soil gas can also be sampled at other depths by the use of a longer bar or bar attachments A 1/4" O D stainless steel probe is inserted into the hole The hole is then sealed around the top of the probe using modeling clay The gas contained in the interstitial spaces of the soil is sampled by pulling the sample through the probe using an air sampling pump The sample may be stored in Tedlar bags, drawn through sorbent cartridges, or analyzed directly using a direct reading instrument The air sampling pump is not used for Summa canister sampling of soil gas Sampling is achieved by soil gas equilibration with the evacuated Summa canister

Other field air monitoring devices, such as the combustible gas indicator (MSA CGI/02 Meter, Model 260) and the Organic Vapor Analyzer (Foxboro OVA, Model 128), can also be used dependent on specific site conditions Measurement of soil temperature using a temperature probe may also be desirable Bagged samples are usually analyzed in a field laboratory using a portable Photovac GC

Power driven sampling probes may be utilized when soil conditions make sampling by hand unfeasible (i e , frozen ground, very dense clays, pavement, etc) Commercially available soil gas sampling probes (hollow, 1/2 = O D steel probes) can be driven to the desired depth using a power hammer (e g , Bosch Demolition Hammer or Geoprobe™) Samples can be drawn through the probe itself, or through Teflon tubing inserted through the probe and attached to the probe point Samples are collected and analyzed as described above

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Tedlar Bags

Soil gas samples are generally contained in 1 0-L Tedlar bags Bagged samples are best stored in dark plastic bags placed in coolers to protect the bags from any damage that may occur in the field or in transit In addition, coolers insure the integrity of the samples by keeping them at a cool temperature and out of direct sunlight Samples should be analyzed as soon as possible, preferably within 24 - 48 hours

3.2 Tenax Tubes

Bagged samples can also be drawn onto Tenax or

other sorbent tubes to undergo lab GC/MS analysis If Tenax tubes are to be utilized, special care must be taken to avoid contamination Handling of the tubes should be kept to a minimum and only while wearing nylon or other lint-free gloves. After sampling, each tube should be stored in a clean, sealed culture tube, the ends packed with clean glass wool to protect the sorbent tube from breakage The culture tubes should be kept cool and wrapped in aluminum foil to prevent any photodegradation of samples (see Section 7 4)

3.3 Summa Canisters

The Summa canisters used for soil gas sampling have a 6 liter sample capacity and are certified clean by GC/MS analysis before being utilized in the field After sampling is completed, they are stored and shipped in travel cases

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 PID Measurements

A number of factors can affect the response of a PID (such as the HNu PI 101) High humidity can cause lamp fogging and decreased sensitivity This can be significant when soil moisture levels are high, or when a soil gas well is actually in groundwater High concentrations of methane can cause a downscale deflection of the meter High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpenes in wooded areas, will also affect instrument response

Other field screening instruments can be affected by interferences Consult the manufacturers manuals

4.2 FID Measurements

A number of factors can affect the response of an FID (such as the OVA model 128) High humidity can cause the FID to flame out or not ignite at all This can be significant when soil moisture levels are high, or when a soil gas well is actually in groundwater The FID can only read organic based compounds (they must contain carbon in the molecular structure) The FID also responds poorly to hydrocarbons and halogenated hydrocarbons (such as gasoline, propane fuel). High and low temperature, electrical fields and FM radio transmission will also affect instrument response

4.3 Factors Affecting Organic Concentrations in Soil Gas

Concentrations in soil gas are affected by dissolution, adsorption, and partitioning Partitioning refers to the ratio of component found in a saturated vapor above an aqueous solution to the amount in the solution, this can, in theory, be calculated using the Henry's Law constants Contaminants can also be adsorbed onto inorganic soil components or "dissolved" in organic components These factors can result in a lowering of the partitioning coefficient

Soil "tightness" or amount of void space in the soil matrix, will affect the rate of recharging of gas into the soil gas well.

Existence of a high, or perched, water table, or of an impermeable underlying layer (such as a clay lens or layer of buried slag) may interfere with sampling of the soil gas Knowledge of site geology is useful in such situations, and can prevent inaccurate sampling

4.4 Soil Probe Clogging

A common problem with this sampling method is soil probe clogging A clogged probe can be identified by using an in-line vacuum gauge or by listening for the sound of the pump laboring This problem can usually be eliminated by using a wire cable to clear probe (see Section 7 1 3)

4.5 Underground Utilities

Prior to selecting sample locations, an underground utility search is recommended The local utility companies can be contacted and requested to mark the locations of their underground lines Sampling plans can then be drawn up accordingly Each sample location should also be screened with a metal detector or magnetometer to verify that no underground pipes or drums exist

5.0 EQUIPMENT/APPARATUS

5.1 Slam Bar Method

- Slam Bar (1 per sampling team)
- Soil gas probes, stainless steel tubing, 1/4" O D , 5 ft length
- Flexible wire or cable used for clearing the

tubing during insertion into the well

- C "Quick Connect" fittings to connect sampling probe tubing, monitoring instruments, and Gilian pumps to appropriate fittings on vacuum box
- C Modeling clay
- C Vacuum box for drawing a vacuum around Tedlar bag for sample collection (1 per sampling team)
- C Gilian pump Model HFS113A adjusted to approximately 3 0 L/min (1 to 2 per sample team)
- C 1/4" Teflon tubing, 2 ft to 3 ft lengths, for replacement of contaminated sample line
- C 1/4" Tygon tubing, to connect Teflon tubing to probes and quick connect fittings
- C Tedlar bags, 1 0 L, at least 1 bag per sample point
- C Soil Gas Sampling labels, field data sheets, logbook, etc
- C PID/FID, or other field air monitoring devices, (1 per sampling team)
- C Ice chest, for carrying equipment and for protection of samples (2 per sampling team)
- C Metal detector or magnetometer, for detecting underground utilities/pipes/drums (1 per sampling team).
- C Photovac GC, for field-lab analysis of bagged samples
- C Summa canisters (plus their shipping cases) for sample, storage and transportation
- C Large dark plastic garbage bags

5.2 Power Hammer Method

- C Bosch demolition hammer
- C 1/2" O D steel probes, extensions, and points.
- C Dedicated aluminum sampling points
- C Teflon tubing, 1/4"
- C "Quick Connect" fittings to connect sampling probe tubing, monitoring instruments, and Gilian pumps to appropriate fittings on vacuum box
- C Modeling clay
- C Vacuum box for drawing a vacuum around Tedlar bag for sample collection (1 per sampling team).
- C Gilian pump Model HFS113A adjusted to approximately 3 0 L/min (1 to 2 per sample team)
- C 1/4" Teflon tubing, 2 ft to 3 ft lengths, for replacement of contaminated sample line
- C 1/4" Tygon tubing, to connect Teflon tubing to probes and quick connect fittings
- C Tedlar bags, 1 0 L, at least 1 bag per sample point
- C Soil Gas Sampling labels, field data sheets, logbook, etc
- C HNu Model P1101, or other field air monitoring devices, (1 per sampling team)
- C Ice chest, for carrying equipment and for protection of samples (2 per sampling team)
- C Metal detector or magnetometer, for detecting underground utilities/pipes/drums (1 per sampling team)
- C Photovac GC, for field-lab analysis of bagged samples
- C Summa canisters (plus their shipping cases) for sample, storage and transportation
- C Generator w/extension cords
- C High lift jack assembly for removing probes

5.3 Geoprobe™ Method

The Geoprobe is a hydraulically-operated sampling device mounted in a customized four-wheel drive vehicle The sampling device can be deployed from the truck and positioned over a sample location The base of the sampling device is positioned on the ground The weight of the vehicle is hydraulically raised on the base As the weight of the vehicle is transferred to the probe, the probe is pushed into the ground A built-in hammer mechanism allows the probe to be driven past some dense stratigraphic horizons When the probe reaches the sample depth, up to 50 feet under favorable geologic situations, samples can be collected

Soil gas can be collected from specific depths in two general ways One method involves withdrawing a sample directly from the probe rods, after evacuating a sufficient volume of air from the probe rods The other method involves collecting a sample through tubing attached by an adaptor to the bottom probe rod section Correctly used, this method provides more reliable results Manufacturer's instructions and the SOP for the Model 5400 Geoprobe™ Operation should be followed when using this method

6.0 REAGENTS

- C PID/FID or calibration gases for field air monitoring devices (such as methane and

isobutylene)

- C Deionized organic-free water, for decontamination.
- C Methanol, HPLC grade, for decontamination
- C Ultra-zero grade compressed air, for field blanks
- C Standard gas preparations for Photovac GC calibration and Tedlar bag spikes
- C Propane Torch (for decontamination of steel probes)

7.0 PROCEDURES

7.1 Soil Gas Well Installation

1 Initially a hole slightly deeper than the desired depth is made For sampling up to 5 feet, a 5-ft single piston slam bar is used For deeper depths, a piston slam bar with threaded 4-foot-long extensions can be used Other techniques can be used, so long as holes are of narrow diameter and no contamination is introduced

2. After the hole is made, the slam bar is carefully withdrawn to prevent collapse of the walls of the hole The soil gas probe is then inserted

3. It is necessary to prevent plugging of the probe, especially for deeper holes A metal wire or cable, slightly longer than the probe, is placed in the probe prior to inserting into the hole The probe is inserted to full depth, then pulled up three to six inches, then cleared by moving the cable up and down The cable is removed before sampling

4 The top of the sample hole is sealed at the surface against ambient air infiltration by using modeling clay molded around the probe at the surface of the hole

5 If conditions preclude hand installation of the soil gas wells, the power driven system may be employed The generator powered demolition hammer is used to drive the probe to the desired depth (up to 12 Ft may be attained with extensions) The probe is pulled up 1-3 inches if the retractable point is used No clay is needed to seal the hole After sampling, the probe is retrieved using the high lift jack assembly

6 If semi-permanent soil gas wells are required, the dedicated aluminum probe points are used These points are inserted into the bottom of the power driven probe and attached to the Teflon tubing The probe is inserted as in step 5 When the probe is removed, the point and Teflon tube remain in the hole, which may be sealed by backfilling with clean sand, soil, or bentonite

7.2 Screening with Field Instruments

1 The well volume must be evacuated prior to sampling Connect the Gilian pump, adjusted to 3 0 L/min, to the sample probe using a section of Teflon tubing as a connector The pump is turned on, and a vacuum is pulled through the probe for approximately 15 seconds Longer time is required for sample wells of greater depths

2 After evacuation, the monitoring instrument(s) (i e HNu or OVA) is connected to the probe using a Teflon connector When the reading is stable, or peaks, the reading is recorded on soil gas data sheets

3 Of course, readings may be above or below the range set on the field instruments The range may be reset, or the response recorded as a greater than or less than figure Recharge rate of the well with soil gas must be considered when resampling at a different range setting

7.3 Tedlar Bag Sampling

1 Follow step 7 2 1 to evacuate well volume If air monitoring instrument screening was performed prior to sample taking, evacuation is not necessary

2 Use the vacuum box and sampling train (Figure 1) to take the sample The sampling train is designed to minimize the introduction of contaminants and losses due to adsorption All wetted parts are either Teflon or stainless steel The vacuum is drawn indirectly to avoid contamination from sample pumps

3 The Tedlar bag is placed inside the vacuum box, and attached to the sampling port The sample probe is attached to the sampling port via Teflon tubing and a "Quick Connect" fitting

4 A vacuum is drawn around the outside of the bag, using a Gilian pump connected to the vacuum box evacuation port, via Tygon tubing and a "Quick Connect" fitting The vacuum causes the bag to inflate, drawing the sample

5 Break the vacuum by removing the Tygon line from the pump Remove the bagged sample from the box and close valve Record data on data sheets or in logbooks Record the date, time, sample location ID, and the PID/FID instrument reading(s) on sample bag label

CAUTION Labels should not be pasted directly onto the bags, nor should bags be labeled directly using a marker or pen Inks and adhesive may diffuse through the bag material, contaminating the sample Place labels on the edge of the bags, or tie the labels to the metal eyelets provided on the bags. Markers with inks containing volatile organics (i.e., permanent ink markers) should not be used

Chain of Custody Sheets must accompany all samples submitted to the field laboratory for analysis

7.4 Tenax Tube Sampling

Samples collected in Tedlar bags may be adsorbed onto Tenax tubes for further analysis by GC/MS

7.4 1 Additional Apparatus

A Syringe with a luer-lock tip capable of drawing a soil gas or air sample from a Tedlar bag onto a Tenax/CMS sorbent tube The syringe capacity is dependent upon the volume of sample begin drawn onto the sorbent tube

B Adapters for fitting the sorbent tube between the Tedlar bag and the sampling syringe The adapter attaching the Tedlar bag to the sorbent tube consists of a reducing union (1/4" to 1/16" O D -- Swagelok cat # SS-400-6-ILV or equivalent) with a length of 1/4" O D Teflon tubing replacing the nut on the 1/6" (Tedlar bag) side A 1/4" I D silicone O-ring replaces the ferrules in the nut on the 1/4" (sorbent tube) side of the union

The adapter attaching the sampling syringe to the sorbent tube consists of a reducing union (1/4" to 1/16" O D -- Swagelok Cat # SS-400-6-ILV or equivalent) with a 1/4" I D silicone O-ring replacing the ferrules in the nut on the 1/4" (sorbent tube) side and the needle of a luer-lock syringe needle inserted into the 1/16" side (Held in place with a 1/16" ferrule) The luer-lock end of the needle can be attached to the sampling syringe It is useful to have a luer-lock on/off valve situated between the syringe and the needle

C Two-stage glass sampling cartridge (1/4" O D. x 1/8" I D x 5 1/8") contained in a flame-sealed tube (Manufacturer Supelco Custom Tenax/Spherocarb Tubes) containing two sorbent sections retained by glass wool

Front section 150 mg of Tenax-GC
Back section 150 mg of CMS (Carbonized Molecular Sieve)

These tubes are prepared and cleaned in accordance with EPA Method EMSL/RTP-SOP-EMD-013 by the vendor. The vendor sends ten tubes per lot made to the REAC GC/MS Laboratory and they are tested for cleanliness, precision, and reproductability

D Teflon-capped culture tubes or stainless steel tube containers for sorbent tube storage and shipping These containers should be conditioned by baking at 120 degrees C for at least two hours The culture tubes should contain a glass wool plug to prevent sorbent tube breakage during transport Reconditioning of the containers should occur between uses or after extended periods of disuse (i e , two weeks or more)

E Nylon gloves or lint-free cloth (Hewlett Packard Part # 8650-0030 or equivalent)

7 4 2 Sample Collection

Handle sorbent tubes with care, using nylon gloves (or other lint-free material) to avoid contamination

Immediately before sampling, break one end of the sealed tube and remove the Tenax cartridge

Connect the valve on the Tedlar bag to the sorbent tube adapter Connect the sorbent tube to the sorbent tube adapter with the Tenax (white granular) side of the tube facing the Tedlar bag Connect the sampling syringe assembly to the CMS (black) side of the sorbent tube. Fittings on the adapters should be finer-tight Open the valve on the Tedlar bag Open the on/off valve of the sampling syringe Depending on work plan stipulations, at least 10% of the soil gas samples analyzed by this GC method must be submitted for confirmational GC/MS analysis (according to modified methods TO-1 [Tenax absorbent] and TO-2 [Carbon Molecular Sieve (CMS) absorbent]) Each soil gas sample must be absorbed on replicate Tenax/CMS tubes The volume absorbed on a Tenax/CMS tube is dependent on the total concentration of the compounds measured by the photovac/GC or other applicable GC

Total Concentration (ppm)	Sample Volume (mL)
>10	Use Serial Dilution
10	10 - 50
5	20-100
1	100-250

After sampling, remove the tube from the sampling train with gloves or a clean cloth DO NOT LABEL OR WRITE ON THE TENAX/CMS TUBE

Place the sorbent tube in a conditioned stainless steel tube holder or culture tube. Culture tube caps should be sealed with Teflon tape.

7 4.3 Sample Labeling

Each sample tube container (not tube) must be labeled with the site name, sample station number, date sampled, and volume sampled

Chain of custody sheets must accompany all samples to the laboratory

7 4 4 Quality Assurance (QA)

Before field use, a QA check should be performed on each batch of sorbent tubes by analyzing a tube by thermal desorption/cryogenic trapping GC/MS

At least one blank sample must be submitted with each set of samples collected at a site This trip blank must be treated the same as the sample tubes except no sample will be drawn through the tube

Sample tubes should be stored out of UV light (i e , sunlight) and kept on ice until analysis Samples should be taken in duplicate, when possible

7.5 Summa Canister Sampling

1 Follow step 7 2 1 to evacuate well volume If PID/FID readings were taken prior to taking a sample, evacuation is not necessary

2 Attach a certified clean, evacuated 6-liter Summa canister via the 1/4" Teflon tubing

3 Open valve on Summa canister The soil gas sample is drawn into the canister by pressure equilibration The approximate sampling time for a 6 liter canister is 20 minutes

4 Site name, sample location, number, and date must be recorded on a chain of custody form and on a blank tag attached to the canister

8.0 CALCULATIONS

8.1 Field Screening Instruments

Instrument readings are usually read directly from the meter In some cases, the background level at the soil gas station may be subtracted

Final Reading = Sample Reading - Background

8.2 Photovac GC Analysis

Calculations used to determine concentrations of individual components by Photovac GC analysis are beyond the scope of this SOP and are covered in ERT SOP #2109, *Photovac GC Analysis for Soil Water and Air/Soil Gas*

9.0 CALIBRATION

9.1 Field Instruments

It is recommended that the manufacturers' manuals be consulted for correct use and calibration of all instrumentation

9.2 Gilian Model HFS113A Air Sampling Pumps

Flow should be set at approximately 3 0 L/min, accurate flow adjustment is not necessary Pumps should be calibrated prior to bringing into the field

10.0 QUALITY ASSURANCE/ QUALITY CONTROL

10.1 Sample Probe Contamination

Sample probe contamination is checked between each sample by drawing ambient air through the probe via a Gilian pump and checking the response of the FID/PID If readings are higher than background, replacement or decontamination is necessary

Sample probes may be decontaminated simply by drawing ambient air through the probe until the HNu reading is at background More persistent contamination can be washed out using methanol and water, then air drying For persistent volatile contamination, use of a portable propane torch may be needed Using a pair of pliers to hold the probe, run the torch up and down the length of the sample probe for approximately 1-2 minutes Let the probe cool before handling When using this method, make sure to wear gloves to prevent burns Having more than one probe per sample team will reduce lag times between sample stations while probes are decontaminated.

10.2 Sample Train Contamination

The Teflon line forming the sample train from the probe to the Tedlar bag should be changed on a daily basis If visible contamination (soil or water) is drawn into the sampling train, it should be changed immediately When sampling in highly contaminated areas, the sampling train should be purged with ambient air, via a Gilian pump, for approximately 30 seconds between each sample After purging, the sampling train can be checked using an FID or PID, or other field monitoring device, to establish the cleanliness of the Teflon line

10.3 FID/PID Calibration

The FID and PIDs should be calibrated at least once a day using the appropriate calibration gases

10.4 Field Blanks

Each cooler containing samples should also contain one Tedlar bag of ultra-zero grade air, acting as a field blank The field blank should accompany the samples in the field (while being collected) and when they are delivered for analysis A fresh blank must be provided to be placed in the empty cooler pending additional sample collection One new field blank per cooler of samples is required A chain of custody sheet must accompany each cooler of samples and should include the blank that is dedicated to that group of samples

10.5 Trip Standards

Each cooler containing samples should contain a Tedlar bag of standard gas to calibrate the analytical instruments (Photovac GC, etc) This trip standard will be used to determine any changes in concentrations of the target compounds during the course of the sampling day (e g , migration through the sample bag, degradation, or adsorption) A fresh trip standard must be provided and placed in each cooler pending additional sample collection A chain of custody sheet should accompany each cooler of samples and should include the trip standard that is dedicated to that group of samples

10.6 Tedlar Bag Check

Prior to use, one bag should be removed from each lot (case of 100) of Tedlar bags to be used for sampling and checked for possible contamination as follows the test bag should be filled with ultra-zero grade air, a sample should be drawn from the bag and analyzed via Photovac GC or whatever method is to be used for sample analysis This procedure will ensure sample container cleanliness prior to the start of the sampling effort

10.7 Summa Canister Check

From each lot of four cleaned Summa canisters, one is to be removed for a GC/MS certification check If the canister passes certification, then it is re-evacuated and all four canisters from that lot are available for sampling

If the chosen canister is contaminated, then the entire lot of four Summas must be recleaned, and a single canister is re-analyzed by GC/MS for certification

10.8 Options

10.8.1 Duplicate Samples

A minimum of 5% of all samples should be collected in duplicate (i e , if a total of 100 samples are to be collected, five samples should be duplicated) In choosing which samples to duplicate, the following criteria applies· if, after filling the first Tedlar bag, and, evacuating the well for 15 seconds, the second HN (or other field monitoring device being used) reading matches or is close to (within 50%) the first reading, a duplicate sample may be taken

10.8.2 Spikes

A Tedlar bag spike and Tenax tube spike may be desirable in situations where high concentrations of contaminants other than the target compounds are found to exist (landfills, etc) The additional level of QA/QC attained by this practice can be useful in determining the effects of interferences caused by these non-target compounds Summa canisters containing samples are not spiked.

11.0 DATA VALIDATION

11.1 Blanks (Field and Tedlar Bag Check)

For each target compound, the level of concentration found in the sample must be greater than three times the level (for that compound) found in the field blank which accompanied that sample to be considered valid The same criteria apply to target compounds detected in the Tedlar bag pre-sampling contamination check

12.0 HEALTH AND SAFETY CONSIDERATIONS

Due to the remote nature of sampling soil gas, special considerations can be taken with regard to health and safety Because the sample is being drawn from underground, and no contamination is introduced into the breathing zone, soil gas sampling usually occurs in Level D Ambient air is constantly monitored using the HNu PI101 to obtain background readings during the sampling procedure As long as the levels in ambient air do not rise above background, no upgrade of the level of protection is needed

When conducting soil gas sampling, leather gloves should be worn, and proper slam bar techniques should be implemented (bend knees) Also, an underground utility search should be performed prior to sampling (See Section 4 5)

13.0 REFERENCES

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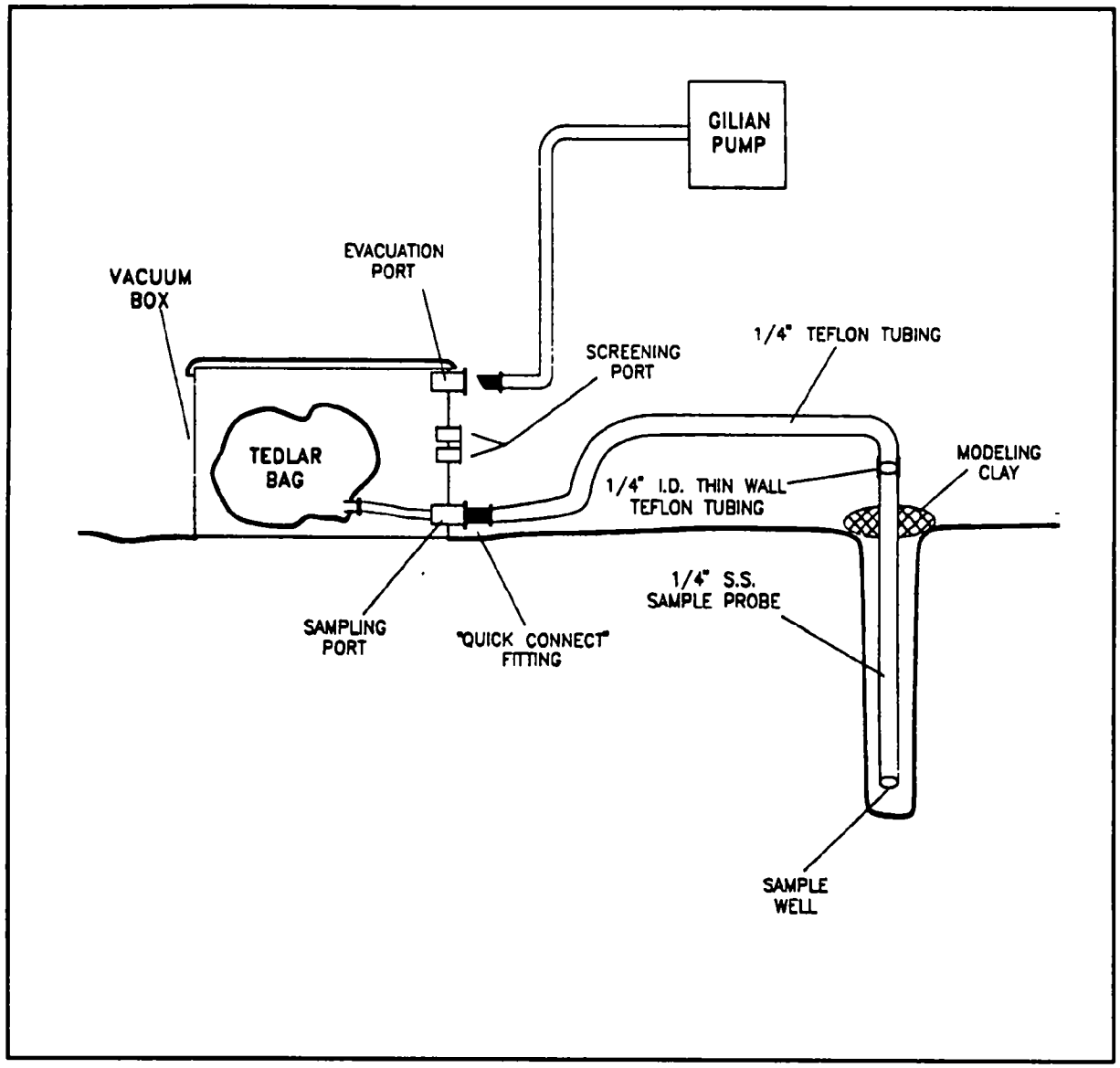
APPENDIX A

Figure

FIGURE 1 Sampling Train Schematic



APPENDIX B

HNu Field Protocol

Field Procedure

The following sections detail the procedures that are to be followed when using the HNu in the field

Startup Procedure

a Before attaching the probe, check the function switch on the control panel to ensure that it is in the off position. Attach the probe by plugging it into the interface on the top of the readout module Use care in aligning the prongs in the probe cord with the plug in, don't force

b Turn the function switch to the battery check position The needle on the meter should read within or above the green battery are on the scale If not, recharge the battery If the red indicator light comes on, the battery needs recharging

c Turn the function switch to any range setting Look into the end of the probe for no more than two to three seconds to see if the lamp is on If it is on, it will give a purple glow Do not stare into the probe any longer than three seconds Long term exposure to UV light can damage eyes Also, listen for the hum of the fan motor

d To ZERO the instrument, turn the function switch to the standby position and rotate the zero adjustment until the meter reads zero A calibration gas is not needed since this is an electronic zero adjustment. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted, if necessary Wait 15 to 20 seconds to ensure that the zero reading is stable If necessary, readjust the zero

Operational Check

a Follow the startup procedure

b With the instrument set on the 0-20 range, hold a solvent-based major market near the probe tip If the meter deflects upscale, the instrument is working

Field Calibration Procedure

a Follow the startup procedure and the operational check

b Set the function switch to the range setting for the concentration of the calibration gas

c Attach a regulator (HNu 101-351) to a disposable cylinder of isobutylene gas (HNu 101-351) Connect the regulator to the probe of the HNu with a piece of clean Tygon tubing Turn on the value on the regulator

d After fifteen seconds, adjust the span dial until the meter reading equals the concentration of the calibration gas used Be careful to unlock the span dial before adjusting it If the span has to be set below 3 0, calibration internally or return to equipment maintenance for repair

e Record in the field logbook the instrument ID no (EPA decal or serial number if the instrument is a rental), the initial and final span settings, the date and time, concentration and type of calibration has used, and the name of the person who calibrated the instrument

Operation

a Follow the startup procedure, operational check, and calibration check

b. Set the function switch to the appropriate range If the concentration of gases or vapors is unknown, set the function switch to the 0-20 ppm range Adjust it if necessary

c. While taking care not to permit the HNu to be exposed to excessive moisture, dirt, or contamination, monitor the work activity as specified in the Site Health and Safety Plan

d When the activity is completed or at the end of the day, carefully clean the outside of the HNu with a damp disposable towel to remove any visible dirt Return the HNu to a secure area and place on charge

e With the exception of the probe's inlet and exhaust, the HNu can be wrapped in clear plastic to prevent it form becoming contaminated and to prevent water from getting inside in the event of precipitation.

MODEL 5400 GEOPROBE™ OPERATION

SOP#: 2050
DATE: 03/27/96
REV #. 0 0

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to describe the collection of representative soil, soil-gas, and groundwater samples using a Model 5400 Geoprobe™ sampling device Any deviations from these procedures should be documented in the site/field logbook and stated in project deliverables

Mention of trade names or commercial products does not constitute U S Environmental Protection Agency (U S EPA) endorsement or recommendation for use

2.0 METHOD SUMMARY

The Geoprobe™ sampling device is used to collect soil, soil-gas and groundwater samples at specific depths below ground surface (BGS) The Geoprobe™ is hydraulically powered and is mounted in a customized four-wheel drive vehicle The base of the sampling device is positioned on the ground over the sampling location and the vehicle is hydraulically raised on the base As the weight of the vehicle is transferred to the probe, the probe is pushed into the ground A built-in hammer mechanism allows the probe to be driven through dense materials Maximum depth penetration under favorable circumstances is about 50 feet Components of the Model 5400 Geoprobe™ are shown in Figures 1 through 6 (Appendix A)

Soil samples are collected with a specially-designed sample tube The sample tube is pushed and/or vibrated to a specified depth (approximately one foot above the intended sample interval) The interior plug of the sample tube is removed by inserting small-diameter threaded rods The sample tube is then driven an additional foot to collect the samples. The probe sections and sample tube are then withdrawn and the sample is extruded from the tube into sample jars

Soil gas can be collected in two ways One method involves withdrawing a sample directly from the probe rods, after evacuating a sufficient volume of air from the probe rods The other method involves collecting a sample through tubing attached by an adaptor to the bottom probe section Correctly used, the latter method provides more reliable results

Slotted lengths of probe can be used to collect groundwater samples if the probe rods can be driven to the water table Groundwater samples are collected using either a peristaltic pump or a small bailer

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

Refer to specific ERT SOPs for procedures appropriate to the matrix, parameters and sampling objector

Applicable ERT SOPs include.

ERT #2012, Soil Sampling

ERT #2007, Groundwater Well Sampling

ERT #2042, Soil Gas Sampling

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

A preliminary site survey should identify areas to be avoided with the truck All underground utilities should be located and avoided during sampling Begin sampling activities with an adequate fuel supply

Decontamination of sampling tubes, probe rods, adaptors, non-expendable points and other equipment that contacts the soil is necessary to prevent cross-contamination of samples During sampling, the bottom portion and outside of the sampling tubes can be contaminated with soil from other depth intervals

Care must be taken to prevent soil which does not represent the sampled interval form being incorporated into the sample Excess soil should be carefully wiped from the outside surface of the sampling tube and the bottom 3 inches of the sample should be discarded before extruding the sample into a sample jar

The amount of sample to be collected and the proper sample container type (i e., glass, plastic), chemical preservation, and storage requirements are dependent upon the parameter(s) of interest Guidelines for the containment, preservation, handling and storage of soil-gas samples are described in ERT SOP #2042, Soil-Gas Sampling

Obtaining sufficient volume of soil for multiple analyses from one sample location may present a problem. The Geoprobe™ soil sampling system recovers a limited volume of soil and it is not possible to reenter the same hole and collect additional soil When multiple analyses are to be performed on soil samples collected with the Geoprobe™, it is important that the relative importance of the analyses be identified. Identifying the order of importance will ensure that the limited sample volume will be used for the most crucial analyses.

5.0 EQUIPMENT/APPARATUS

Sampling with the Geoprobe™ involves use of the equipment listed below Some of the equipment is used for all sample types, others are specific to soil (S), soil gas (SG), or groundwater (GW) as noted

- C Geoprobe™ sampling device
- C Threaded probe rods (36", 24", and 12" lengths)
- C Drive Caps
- C Pull Caps
- C Rod Extractor
- C Expendable Point Holders
- C Expendable Drive Points
- C Solid Drive Points
- C Extension Rods
- C Extension Rod Couplers
- C Extension Rod Handle
- C Hammer Anvil
- C Hammer Latch
- C Hammer Latch Tool
- C Drill Steels
- C Carbide-Tipped Drill Bit
- C Mill-Slotted Well Point (GW)
- C Threaded Drive Point (GW)
- C Well Mini-Bailer (GW)
- C Tubing Bottom Check Valve (GW)
- C 3/8" O D Low Density Polyethylene Tubing (GW, SG)
- C Gas Sampling Adaptor and Cap (SG)
- C Teflon Tape
- C Neoprene "O" - Rings (SG)
- C Vacuum System (mounted in vehicle) (SG)
- C Piston Tip (S)
- C Piston Rod (S)
- C Piston Stop (S)
- C Sample Tube (11 5" in length) (S)
- C Vinyl Ends Caps (S)
- C Sample Extruder (S)
- C Extruder Pistons (Wooden Dowels) (S)
- C Wire Brush
- C Brush Adapters
- C Cleaning Brush (Bottle)

6.0 REAGENTS

Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination

7.0 PROCEDURES

Portions of the following sections have been condensed from the Model 5400 Geoprobe™ Operations Manual(1) Refer to this manual for more detailed information concerning equipment specifications, general maintenance, tools, throttle control, clutch pump, GSK-58 Hammer, and trouble-shooting A copy of this manual will be maintained with the Geoprobe™ and on file in the Quality Assurance (QA) office

7.1 Preparation

1 Determine extent of the sampling effort, sample matrices to be collected, and types and amounts of equipment and supplies required to complete the sampling effort

2 Obtain and organize necessary sampling and monitoring equipment

3 Decontaminate or pre-clean equipment, and ensure that it is in working order

4 Perform a general site survey prior to site

entry in accordance with the site-specific Health and Safety Plan

5. Use stakes or flagging to identify and mark all sampling locations All sample locations should be cleared for utilities prior to sampling.

7.2 Setup of Geoprobe™

1 Back carrier vehicle to probing location

2 Shift the vehicle to park and shut off ignition

3 Set parking brake and place chocks under rear tires

4 Attach exhaust hoses so exhaust blows downwind of the sampling location (this is particularly important during soil gas sampling)

5 Start engine using the remote ignition at the Geoprobe™ operator position

6 Activate hydraulic system by turning on the Electrical Control Switch located on the Geoprobe™ electrical control panel (Figure 1, Appendix A) When positioning the probe, always use the SLOW speed The SLOW speed switch is located on the hydraulic control panel (Figure 2, Appendix A)

Important: Check for clearance on vehicle roof before folding Geoprobe™ out of the carrier vehicle.

7 Laterally extend the Geoprobe™ from the vehicle as far as possible by pulling the EXTEND control lever toward the back of the vehicle while the Geoprobe™ is horizontal

8 Using the FOOT control, lower the Derrick Slide so it is below cylinder (A) before folding the Geoprobe™ out of the carrier vehicle (Figure 3, Appendix A) This will ensure clearance at the roof of the vehicle

9 Use the FOLD, FOOT, and EXTEND controls to place Geoprobe™ to the exact probing location Never begin probing in the fully extended position

10 Using the FOLD control, adjust the long axis of the probe cylinder so that it is perpendicular (visually) to the ground surface

11 Using the FOOT control, put the weight of the vehicle on the probe unit Do not raise the rear of the vehicle more than six inches

Important: Keep rear vehicle wheels on the ground surface when transferring the weight of the vehicle to the probe unit. Otherwise, vehicle may shift when probing begins.

12. When the probe axis is vertical and the weight of the vehicle is on the probe unit, probing is ready to begin

7.3 Drilling Through Surface Pavement or Concrete

1 Position carrier vehicle to drilling location

2 Fold unit out of carrier vehicle

3 Deactivate hydraulics

4 Insert carbide-tipped drill bit into hammer

5 Activate HAMMER ROTATION control by turning knob counter-clockwise (Figure 4, Appendix A) This allows the drill bit to rotate when the HAMMER control is pressed

6 Press down on HAMMER control to activate counterclockwise rotation

7 Both the HAMMER control and the PROBE control must be used when drilling through the surface (Figure 4, Appendix A) Fully depress the HAMMER control, and incrementally lower the bit gradually into the pavement by periodically depressing the PROBE control

8 When the surface has been penetrated, turn the HAMMER Control Valve knob

clockwise to deactivate hammer rotation and remove the drill bit from the HAMMER

Important: Be sure to deactivate the rotary action before driving probe rods.

7.4 Probing

1 Position the carrier vehicle to the desired sampling location and set the vehicle parking brake

2 Deploy Geoprobe™ Sampling Device

3 Make sure the hydraulic system is turned off

4 Lift up latch and insert hammer anvil into hammer - push latch back in (Figure 5, Appendix A).

5 Thread the drive cap onto the male end of the probe rod

6. Thread an expendable point holder onto the other end of the first probe rod

7 Slip an expendable drive point into point holder.

8 Position the leading probe rod with expendable drive point in the center of the derrick foot and directly below the hammer anvil.

Important: Positioning the first probe rod is critical in order to drive the probe rod vertically. Therefore, both the probe rod and the probe cylinder shaft must be in the vertical position (Figure 6, Appendix A).

9 To begin probing, activate the hydraulics and push the PROBE Control downward When advancing the first probe rod, always use the SLOW speed Many times the probe rods can be advanced using only the weight of the carrier vehicle When this is the case, only the PROBE control is used

Important: When advancing rods, always keep the probe rods parallel to the probe cylinder shaft (Figure 6, Appendix A). This is done by making minor adjustments with the FOLD control. Failure to keep probe rods parallel to probe cylinder shaft may result in broken rods and increased difficulty in achieving desired sampling depth.

7.5 Probing - Percussion Hammer

The percussion hammer must be used in situations where the weight of the vehicle is not sufficient to advance the probe rods

1 Make sure the Hammer Rotation Valve is closed

2 Using the PROBE control to advance the rod, press down the HAMMER control to allow percussion to drive the rods (Figure 2, Appendix A)

Important: Always keep static weight on the probe rod or the rod will vibrate and chatter while you are hammering, causing rod threads to fracture and break.

3 Keep the hammer tight to the drive cap so the rod will not vibrate

4 Periodically stop hammering and check if the probe rods can be advanced by pushing only

5 Any time the downward progress of the probe rods is refused, the derrick foot may lift off of the ground surface When this happens, reduce pressure on the PROBE control. Do not allow the foot to rise more than six inches off the ground or the vehicle's wheels may lift off the ground surface, causing the vehicle to shift (Figure 6, Appendix A)

6 As the derrick foot is raised off the ground surface, the probe cylinder may not be in a perpendicular position If this happens, use the FOLD control to correct the probe cylinder position

7.6 Probing - Adding Rods

1 Standard probe rods are three feet in length If the desired depth is more than three feet,

another rod must be threaded onto the rod that has been driven into the ground In order to ensure a vacuum-tight seal (soil-gas sampling), two wraps of teflon tape around the thread is recommended

2. Using the PROBE control, raise the probe cylinder as high as possible

Important: Always deactivate hydraulics when adding rods.

3 Deactivate hydraulics

4 Unthread the drive cap from the probe rod that is in the ground

5 Wrap teflon tape around the threads

6. Thread the drive cap onto the male end of the next probe rod to be used

7. After threading the drive cap onto the rod to be added, thread the rod onto the probe rod that has been driven into the ground Make sure threads have been teflon taped. Continue probing

8 Continue these steps until the desired sampling depth has been reached

7.7 Probing/Pulling Rods

1 Once the probe rods have been driven to depth, they can also be pulled using the Geoprobe™ Machine

2 Turn off the hydraulics

3 Lift up latch and take the hammer anvil out of the hammer.

4. Replace the drive cap from the last probe rod driven with a pull cap

5 Lift up the hammer latch.

6 Activate the hydraulics.

7 Hold down on the PROBE control, and move the probe cylinder down until the latch can be closed over the pull cap

Important: If the latch will not close over the pull cap, adjust the derrick assembly by using the extend control. This will allow you to center the pull cap directly below the hammer latch.

8 Retract the probe rods by pulling up on the PROBE control

Important: Do not raise the probe cylinder all the way when pulling probe rods or it will be impossible to detach a rod that has been pulled out. However, it is necessary to raise the probe cylinder far enough to allow the next probe section to be pulled.

9 After retracting the first probe rod, lower the probe cylinder only slightly to ease the pressure off of the hammer latch

10 Attach a clamping device to the base of the rods where it meets the ground to prevent rods from falling back into the hole

11 Raise the hammer latch

12 Hold the PROBE control up and raise the probe cylinder as high as possible

13. Unthread the pull cap from the retracted rod

14 Unthread the retracted rod

15 Thread the pull cap onto the next rod that is to be pulled

16 Continue these steps until all the rods are retracted from the hole

17 Decontaminate all portions of the equipment that have been in contact with the soil, soil gas and groundwater

7.8 Soil-Gas Sampling Without Interior Tubing

1 Follow procedures outlined in Sections 7 1 through 7 6

2 Remove hammer anvil from hammer

3 Thread on pull cap to end of probe rod

4 Retract rod approximately six inches Retraction of the rod disengages expendable drive point and allows for soil vapor to enter rod

5 Unthread pull cap and replace it with a gas sampling cap Cap is furnished with barbed hose connector

Important: Shut engine off before taking sample (exhaust fumes can cause faulty sample data).

6 Turn vacuum pump on and allow vacuum to build in tank

7 Open line control valve For each rod used, purge 300 liters of volume Example Three rods used = 900 liters = .900 on gauge

8 After achieving sufficient purge volume, close valve and allow sample line pressure gauge to return to zero This returns sample train to atmospheric pressure

9 The vapor sample can now be taken

1. Pinch hose near gas sampling cap to prevent any outside vapors from entering the rods

2 Insert syringe needle into center of barbed hose connector and withdraw vapor sample

10 To maintain suction at the sampling location, periodically drain the vacuum tank

11 To remove rods, follow procedures outlined in Section 7.7

7.9 Soil-Gas Sampling With Post-Run Tubing (PRT)

1. Follow procedures outlined in Sections 7 1 through 7 6

2 Retract rod approximately six inches Retraction of rod disengages expendable drive point and allows for soil vapor to enter rod

3 Remove pull cap from the end of the probe rod

4 Position the Geoprobe™ to allow room to work.

5 Secure PRT Tubing Adapter with "O" - Ring to selected tubing

6 Insert the adapter end of the tubing down the inside diameter of the probe rods

7 Feed the tubing down the hole until it hits bottom on the expendable point holder Cut the tubing approximately two feet from the top probe rod

8 Grasp excess tubing and apply some downward pressure while turning it in a counter-clockwise motion to engage the adapter threads with the expendable point holder

9 Pull up lightly on the tubing to test engagement of threads

10 Connect the outer end of the tubing to silicon tubing and vacuum hose (or other sampling apparatus)

11 Follow the appropriate sampling procedure (ERT SOP #2042, Soil Gas Sampling) to collect a soil-gas sample

12 After collecting a sample, disconnect the tubing from the vacuum hose or sampling system

13. Pull up firmly on the tubing until it releases from the adapter at the bottom of the hole

14 Extract the probe rods from the ground and recover the expendable point holder with the attached adapter

15 Inspect the "O"-ring at the base of the adapter to verify that proper sealing was achieved during sampling. The "O"-ring should be compressed.

Note: If the "O"-ring is not compressed, vapors from within the probe sections may have been collected rather than vapors from the intended sample interval.

7.10 Soil Sampling

1 Follow procedures outlined in Sections 7 1 through 7 6

2 Assemble soil-sampling tube

1 Thread piston rod into piston tip

2 Insert piston tip into sample tube, seating piston tip into cutting edge of sample tube.

3 Thread drive head into threaded end of sample tube.

4. Thread piston stop pin into drive head Stop pin should be tightened with wrench so that it exerts pressure against the piston rod

3 Attach assembled sampler onto leading probe rod

4 Drive the sampler with the attached probe rods to the top of the interval to be sampled

5. Move probe unit back from the top of the probe rods to allow work room

6 Remove drive cap and lower extension rods into inside diameter of probe rods using couplers to join rods together

7 Attach extension rod handle to top extension rod.

8. Rotate extension rod handle clockwise until the leading extension rod is threaded into the piston stop in downhole

9. Continue to rotate extension rod handle clockwise until reverse-threaded stop-pin has disengaged from the drive head

10 Remove extension rods and attached stop-pin from the probe rods

11 Replace drive cap onto top probe rod

12 Mark the top probe rod with a marker or tape at the appropriate distance above the ground surface (dependent on sample tube length).

13 Drive probe rods and sampler the designated distance Be careful not to overdrive the sampler which could compact the soil sample in the tube, making it difficult to extrude

Important: Documentation of sample location should include both surface and subsurface identifiers. Example: Correct Method - Sample Location S-6, 12.0' - 13.0'. Incorrect Method - Sample Location S-6, 12.0'.

14 Retract probe rods from the hole and recover the sample tube Inspect the sample tube to confirm that a sample was recovered

15 Disassemble sampler Remove all parts

16 Position extruder rack on the foot of the Geoprobe™ derrick

17 Insert sample tube into extruder rack with the cutting end up

18 Insert hammer anvil into hammer

19 Position the extruder piston (wood dowel) and push sample out of the tube using the PROBE control on the Geoprobe™ Collect the sample as it is extruded in an appropriate sample container.

Caution: use care when performing this task. Apply downward pressure gradually. Use of excessive force could result in injury to operator or damage to tools. Make sure proper diameter extruder piston is used.

20 To remove rods follow procedures outlined in Section 7 7

7.11 Groundwater Sampling

1 Follow Sections 7 1 thorough 7 6 with the following exception the Mill-Slotted Well Rod with attached threaded drive point should be the first section probed into the ground Multiple sections of mill-slotted well rods can be used to provide a greater vertical section into which groundwater can flow.

2 Probe to a depth at which groundwater is expected

3 Remove Drive Cap and insert an electric water-level indicator to determine if water has entered the slotted sections of probe rod Refer to ERT SOP #2043, Water Level Measurement, to determine water level

4 If water is not detected in the probe rods, replace the drive cap and continue probing. Stop after each additional probe length and determine if groundwater has entered the slotted rods

5 After the probe rods have been driven into the saturated zone, sufficient time should be allowed for the water level in the probe rods to stabilize

Note: It will be difficult if not impossible to collect a groundwater sample in aquifer material small enough to pass through the slots (<0.02 inch diameter).

6 Groundwater samples may be collected with the 20-mL well Mini-Bailer or a pumping device If samples are being collected for volatile organic analysis (VOA), the 20-mL Well Mini-Bailer should be used If samples are being collected for a variety of analyses, VOA samples should be collected first using the bailer Remaining samples can be collected by pumping water to the surface Withdrawing water with the pump is more efficient than collecting water with the 20-mL well Mini-Bailer.

Important: Documentation of sample location should include both surface and subsurface identifiers. Example: Sample Location GW-6, 17'-21' bgs, water level in probe rods is 17 feet bgs, and the leading section of probe rod is 21 feet bgs. The water sample is from this zone, not from 17 feet bgs or 21 feet bgs.

7 Remove rods following procedures outlined in Section 7 7

8.0 CALCULATIONS

Calculating Vapor Purge Volume for Soil-Gas Sampling without Interior Tubing

Volume of Air to be Purged (Liters) = 300 x Number of Rods in the Ground

Volume in Liters/1000 = Reading on Vacuum Pump Instrument Gauge

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general QA procedures apply

1 All data must be documented on field data sheets or within site logbooks

2 All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented

10.0 DATA VALIDATION

This section is not applicable to this SOP

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U S EPA, OSHA and the REAC site specific Health and Safety Plan The following is a list of health and safety precautions which specifically apply to Geoprobe™ operation

1 Always put vehicle in "park", set emergency the brake, and place chocks under the tires, before engaging remote ignition

2 If vehicle is parked on a loose or soft surface, do not fully raise rear of vehicle with probe foot, as vehicle may fall or move

3 Always extend the probe unit out from the vehicle and deploy the foot to clear vehicle roof line before folding the probe unit out

4 Operators should wear OSHA approved steel-toed shoes and keep feet clear of probe foot

5 Operator should wear ANSI approved hard hats

6. Only one person should operate the probe machine and the assemble or disassemble probe rods and accessories

7 Never place hands on top of a rod while it is under the machine

8 Turn off the hydraulic system while changing rods, inserting the hammer anvil, or attaching accessories

9. Operator must stand on the control side of the probe machine, clear of the probe foot and mast, while operating controls

10 Wear safety glasses at all times during the operation of this machine

11 Never continue to exert downward pressure on the probe rods when the probe foot has risen six inches off the ground

12 Never exert enough downward pressure on a probe rod so as to lift the rear tires of the vehicle off the ground.

13 Always remove the hammer anvil or other tool from the machine before folding the machine to the horizontal position

14 The vehicle catalytic converter is hot and may present a fire hazard when operating over dry grass or combustibles

15 Geoprobe™ operators must wear ear protection OSHA approved ear protection for sound levels exceeding 85 dba is recommended

16 Locations of buried or underground utilities and services must be known before starting to drill or probe

17 Shut down the hydraulic system and stop the vehicle engine before attempting to clean or service the equipment

18 Exercise extreme caution when using extruder pistons (wooden dowels) to extrude soil from sample tubes Soil in the sample tube may be compacted to the point that the extruder piston will break or shatter before it will push the sample out

19 A dry chemical fire extinguisher (Type ABC) should be kept with the vehicle at <u>all</u> times

12.0 REFERENCES

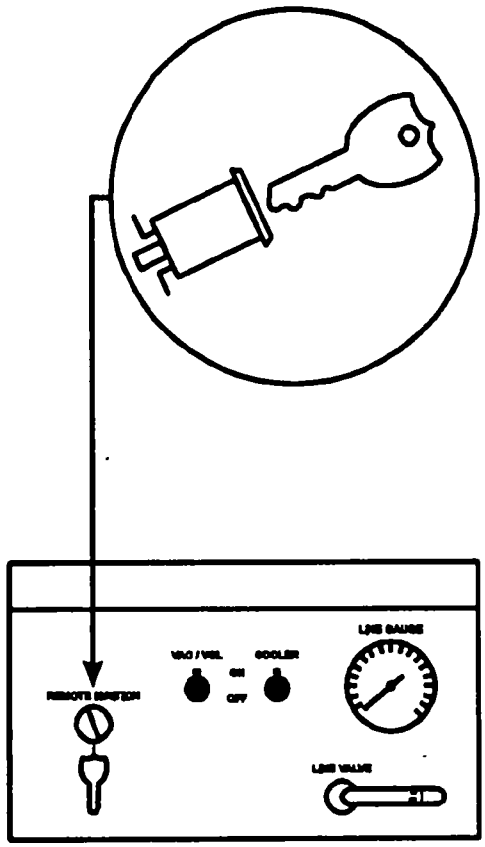
1 Model 5400 Geoprobe™ Operations Manual Geoprobe™ Systems, Salina, Kansas July 27, 1990

2 Geoprobe™ Systems - 1995-96 Tools and Equipment Catalog

APPENDIX A

Figures

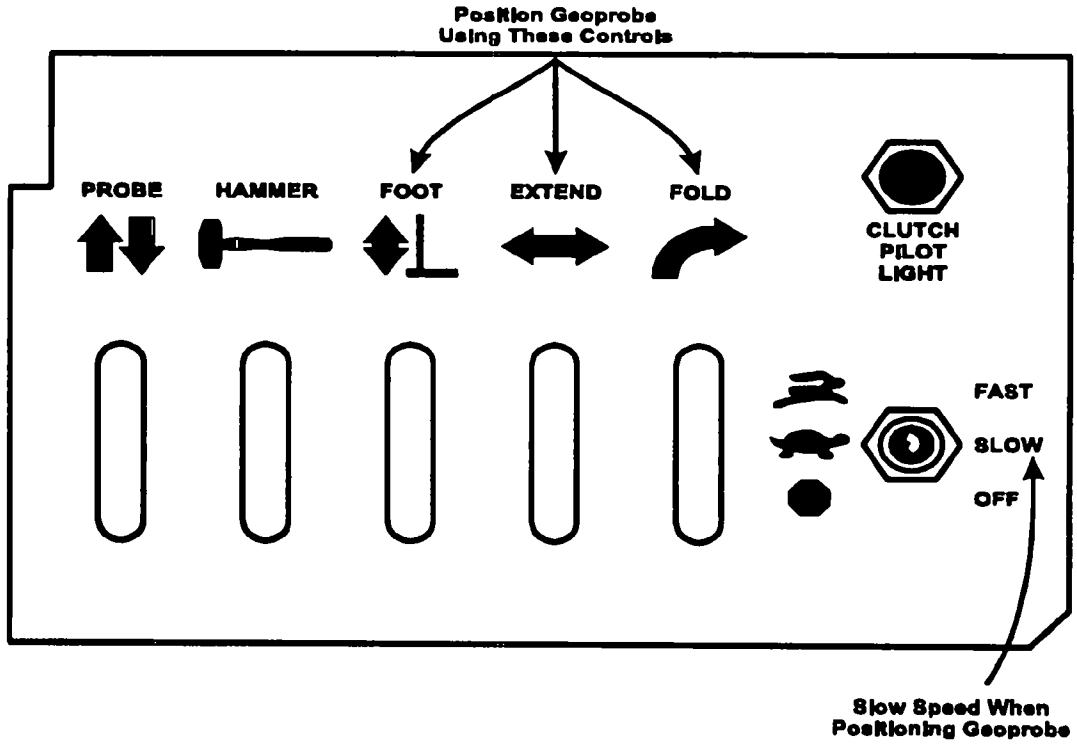
FIGURE 1 Electrical Control Panel



APPENDIX A (Cont'd)

Figures

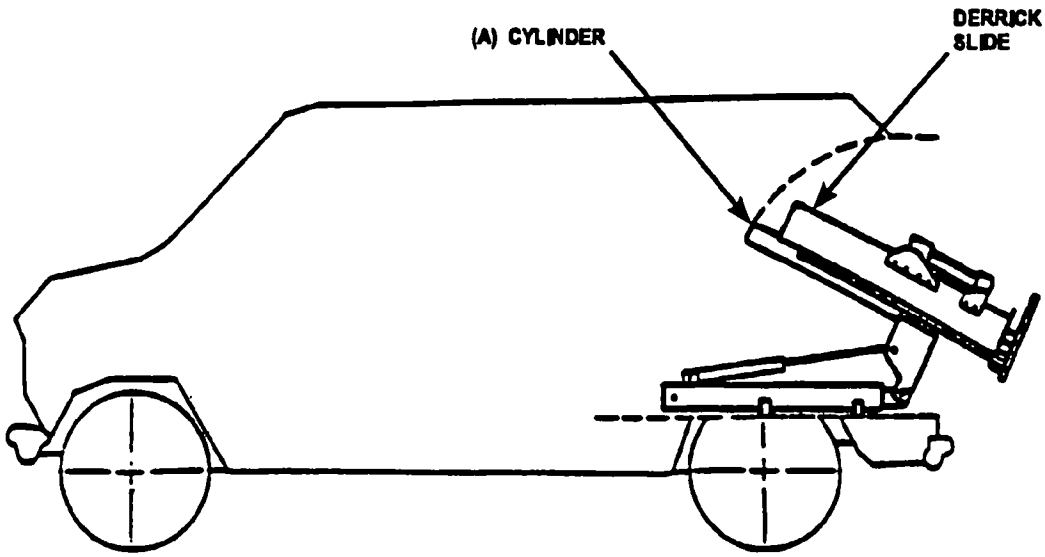
FIGURE 2 Hydraulic Control Panel



APPENDIX A (Cont'd)

Figures

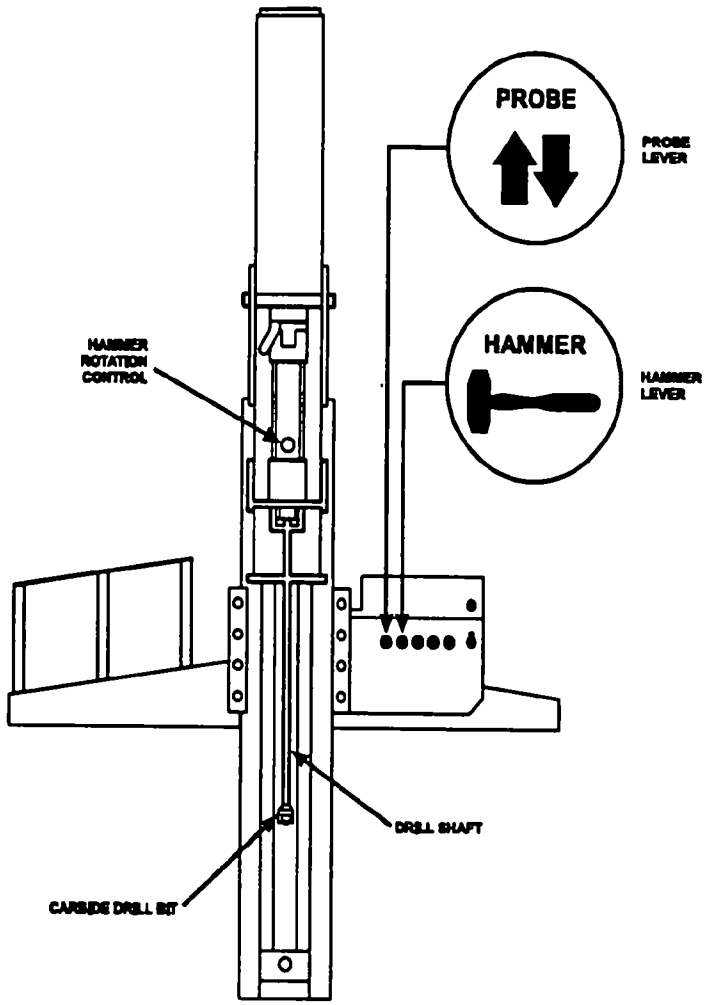
FIGURE 3 Deployment of Geoprobe™ from Sampling Vehicle



APPENDIX A (Cont'd)

Figures

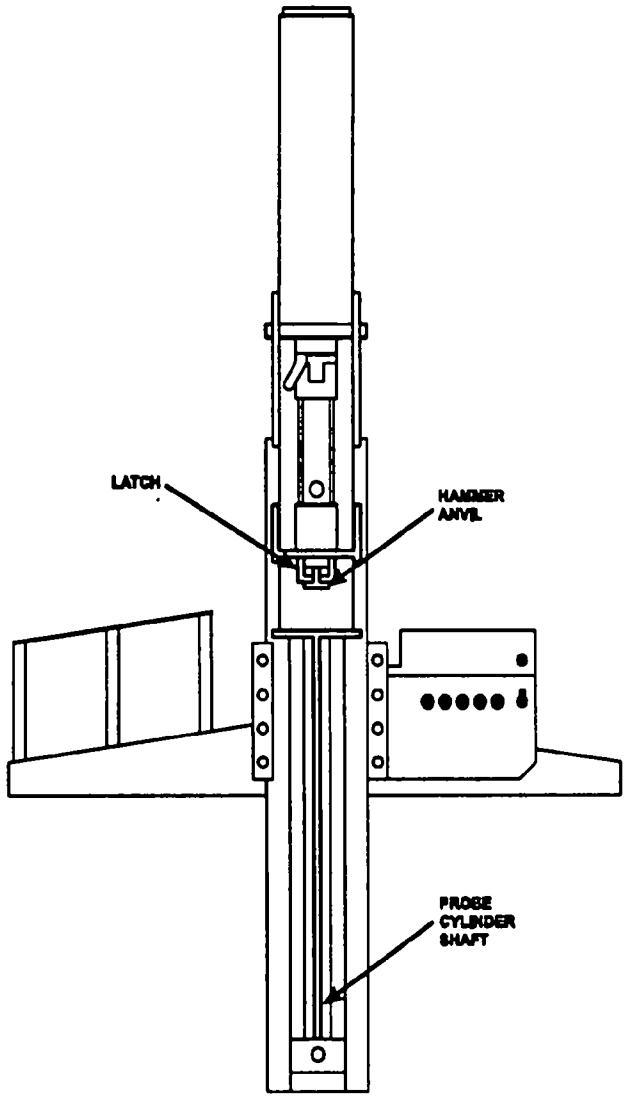
FIGURE 4 Geoprobe™ Setup for Drilling Through Concrete and Pavement



APPENDIX A (Cont'd)

Figures

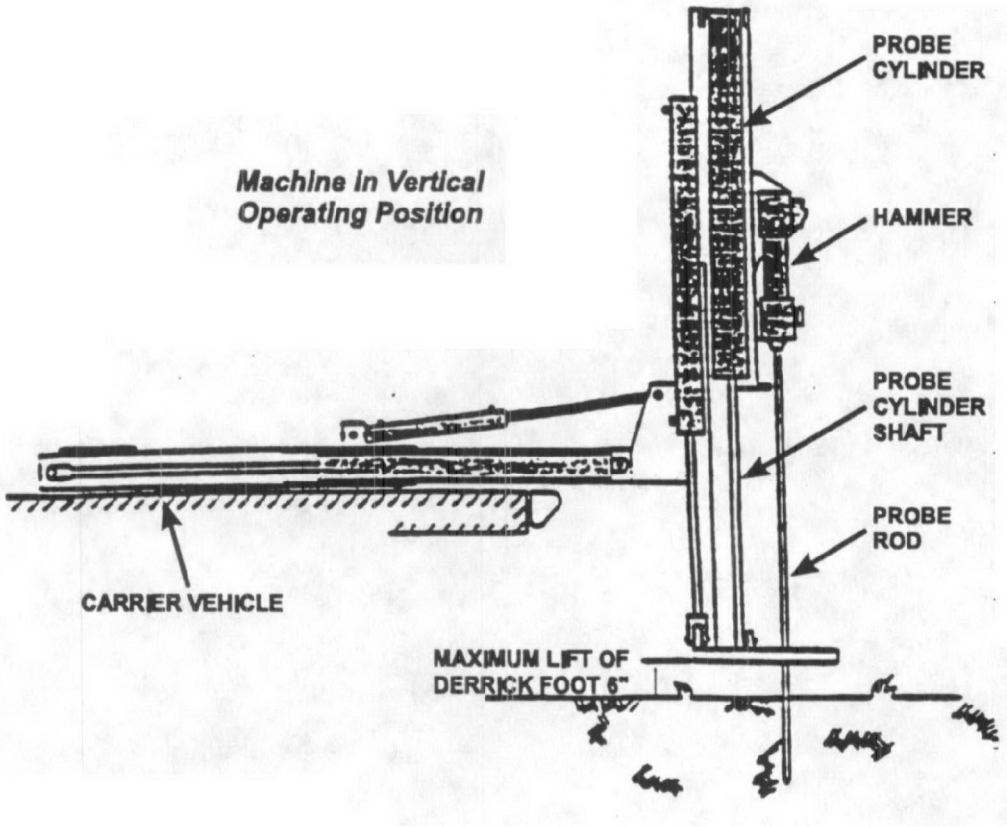
FIGURE 5 Inserting Hammer Anvil



APPENDIX A (Cont'd)

Figures

FIGURE 6. Probe Cylinder Shaft and Probe Rod - Parallel and Vertical



TEDLAR BAG SAMPLING

SOP# 2102
DATE 10/21/94
REV. # 0 0

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to define the use of Tedlar bags in collecting gaseous grab samples Tedlar bags are used to collect both volatile and semi-volatile organic compounds, including halogenated and non-halogenated species The sensitivity of the method is primarily dependent on the analytical instrument and the compounds being investigated

These are standard (i e , typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure In all instances, the ultimate procedures employed should be documented and associated with the final report

Mention of trade names or commercial products does not constitute U S Environmental Protection Agency (U S EPA) endorsement or recommendation for use

2.0 METHOD SUMMARY

When collecting gaseous samples for analysis it is often necessary to obtain a representative grab sample of the media in question The Tedlar bag collection system allows for this and consists of the following items

- C the Tedlar bag complete with necessary fittings
- C a box in which the vacuum is created
- C a sampling pump to create the necessary vacuum
- C an appropriate Teflon and Tygon tubing

The Tedlar bag is placed into the vacuum box and the fitting is inserted into Teflon tubing The Teflon tubing is the path through which the gaseous media will travel The pump is attached to the Tygon tubing, which is part of the vacuum fitting on the vacuum box The pump evacuates the air in the vacuum box, creating a pressure differential causing the sample to be drawn into the bag The sample introduced into the Tedlar bag never passes through the pump The flow rate for the pump must be defined prior to sampling (usually 3 liters/minute [L/min] for bag sampling)

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The Tedlar bags most commonly used for sampling have a 1-liter volume When the sampling procedure is concluded, the Tedlar bags are stored in either a clean cooler or a trash bag to prevent photodegradation It is essential that sample analysis be undertaken within 48 hours, as after that time compounds may escape or become altered

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Contamination is a major concern since many of the compounds in question will be present in the parts per billion range In order to minimize the risk of cross contamination, the following factors should be considered.

1 Proximity of the bags to sources of potential contamination during transportation and storage The further away from the source(s) the bags are, the less likely the chances of external contamination

2 Bags must be attached only to clean Teflon tubing

3 Once the bag has been collected, affix the sample label to the edge of the bag Adhesives found in the label may permeate the bag if placed on the body of the bag Fill out labels with a ballpoint pen as permanent

markers contain volatile compounds that may contaminate the sample

4 Due to the chemical structure of Tedlar, highly polar compounds will adhere to the inner surface of the bag Also, low molecular weight compounds may permeate the bag Real-time monitors such as the organic vapor analyzer (OVA), photoionization detector (HNU), and combustible gas indicator (CGI) are used as screening devices prior to sampling The information gathered is written on the sample label to inform the individuals performing the sample analysis

The Tedlar bag sampling system is straightforward and easy to use However, there are several things to be aware of when sampling

1 The seal between the top half and the bottom half of the vacuum box must be air tight in order to allow the system to work

2 Check the O-ring gasket to see if it is in place with the proper fit O-rings that have been stretched out will not remain in place, thus requiring constant realignment

3. Check that all the fittings associated with the vacuum joints are securely in place The fittings can be pushed loose when inserting the valve stem into the Teflon tubing

4 Occasionally, a corner of the Tedlar bag will jut out between the two halves of the vacuum box, thus impairing the seal Since the bags will hold only a given volume, over-inflation will cause the bags to burst

5.0 EQUIPMENT/APPARATUS

The following items must be operational to perform Tedlar bag sampling

- C Vacuum box - must be clean, Teflon tubing replaced, and equipped with extra O-rings
- C Pump(s) - must be charged, in good working order, and set with the appropriate flow rate of 3 L/min
- C Tedlar bags - must be free of visible contamination and preferably new
- C Chain of Custody records, custody seals
- C Sample labels
- C Air Sampling Worksheets
- C Opaque trash bags

6.0 REAGENTS

This section is not applicable to this SOP

7.0 PROCEDURES

7.1 Preparation

1 Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed

2 Obtain necessary sampling and monitoring equipment

3 Decontaminate or pre-clean equipment, and ensure that it is in working order

4 Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate

5 Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan

6 Use stakes or flagging to identify and mark all sampling locations If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions

7.2 Field Operation

Tedlar bags are stored in boxes of ten The valve is in the open position when stored Occasionally, a piece of debris will clog the valve, necessitating the closing of the valve stem to clear The valve stem is closed by pulling the stem out If the valve stem is difficult to pull, it helps to spin the valve stem simultaneously

1 Remove the Tedlar bag from the carton

2 Insert the valve stem into the Teflon tube which runs through the vacuum box (Figure 1, Appendix A)

3 Place the Tedlar bag in the vacuum box Seal the vacuum box by applying pressure to the top and bottom (ensure that the O-ring is in place and unobstructed).

4 Connect the sampling pump to the evacuation tube

5 Connect the intake tube to the desired source or place the intake tube into the media of concern

6 Turn on the sampling pump

7. Allow the bag to fill (visual observation and sound of laboring pump)

8 Turn off the sampling pump and remove the evacuation tube from the pump

9 Remove bag and pull the valve stem out

10 Lock the valve stem

11 Label the bag using either a tag or a sticker placed on the edge of the bag Do not write on the bag itself

12 Place Tedlar bag in a clean cooler or opaque trash bag to prevent photodegradation

7.3 Post-Operation

1 Once the samples are collected, transfer bags to the laboratory for analysis

2 When transferring the Tedlar bags, a chain of custody form must accompany the samples Personnel should be aware that some of the compounds of concern will degrade within a few hours of sampling

3 For the time prior to analysis, samples may be stored in a clean cooler or opaque trash bag with a trip blank (a Tedlar bag filled with "zero air") and the chain of custody form

8.0 CALCULATIONS

This section is not applicable to this SOP

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general QA procedures apply

1 All data must be documented on field data sheets or within site logbooks

2. All instrumentation must be operated in accordance with operating instruction as supplied by the manufacturer, unless otherwise specified in the work plan Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented

Depending upon the Quality Assurance Work Plan (QAWP) requirements, a background sample consisting of upgradient/downgradient, beginning/ending of day or combination, may be collected It may also be desirable to change sample train tubing between sample locations
Tedlar bag standards must be filled on site to identify the contaminants' degradation from the time the sample is collected until analysis Trip blanks, Tedlar bags filled with "zero air", must accompany sample bags at a minimum rate of one per day to identify possible contamination during handling For each lot of Tedlar bags, a minimum of one bag must be filled with "zero air" and then analyzed for the parameter(s) of interest to detect contamination due to the Tedlar bag itself which may produce false positive results Duplicate Tedlar bags should be collected at a minimum rate of five percent of the total number of samples or one per sampling event

10.0 DATA VALIDATION

Results of the quality control samples (trip and lot blanks) will be evaluated for contamination This information will be utilized to qualify the environmental sample results according to the project's data quality objectives

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U S EPA, OSHA, and corporate health and safety procedures

12.0 REFERENCES

Gilian Instrument Corp , Instruction Manual for Hi Flow Sampler HFS113, HFS113T, HFS113U, HFS113UT, 1983.

NJDEP, Field Sampling Procedures Manual, Hazardous Waste Programs, February, 1988

Roy F Weston, Inc , Weston Instrumentation Manual, Volume I, 1987

U S EPA, Characterization of Hazardous Waste Sites A Methods Manual Volume II, Available Sampling Methods; 2nd Edition, EPA-600/ 4-84-076, December, 1984

APPENDIX A

Figure

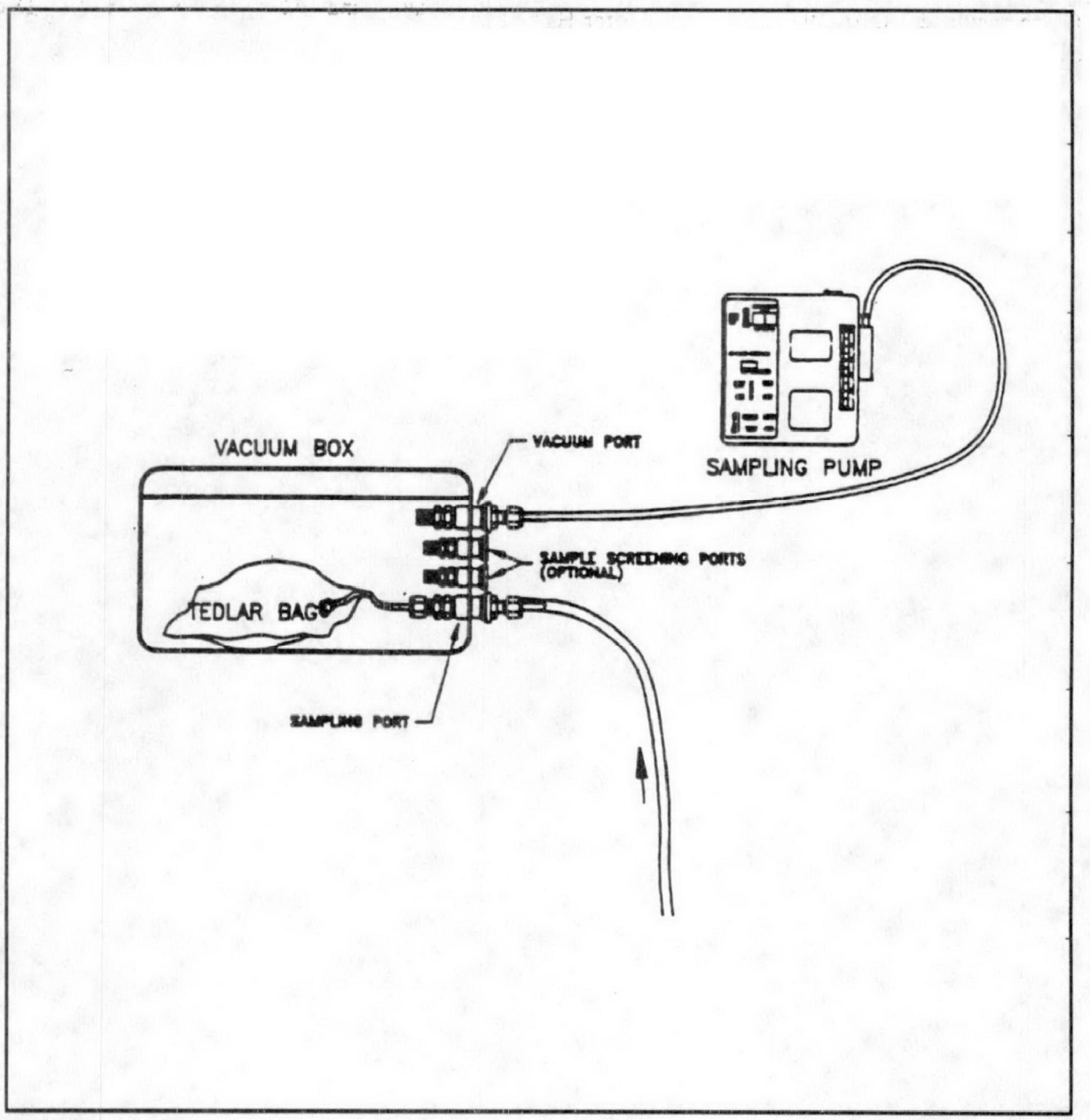



FIGURE 1 - Tedlar Bag Sampling Apparatus