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FINAL WORK PLAN FOR PRELIMINARY ASSESSMENT SITE INVESTIGATION AND REMEDIAL INVESTIGATION FEASIBILITY STUDY AT PLANT 4 VOLUME 2 OF 4 NAS FORT WORTH TX

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DEPARTMENT OF THE AIR FORCE
UNITED STATES OF AMERICA

ADMINISTRATIVE RECORD
COVER SHEET

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Air Force Plant 4

Preliminary Assessment/
Site Inspection and
Remedial Investigations/
Feasibility Studies

Volume II

Final Sampling and Analysis Plan

Prepared for
U.S. Department of the Air Force
Headquarters Aeronautics Systems Division
Wright-Patterson Air Force Base, Ohio

Submitted by UNC Geotech under
DOE Contract No. DE–AC07–86ID12584 for the
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FINAL SAMPLING AND ANALYSIS PLAN

for the

Preliminary Assessment/Site Inspection

and

Remedial Investigations/Feasibility Studies

at

Air Force Plant No. 4

August 1990

Prepared for

Department of the Air Force
Headquarters Aeronautics Systems Division
Wright-Patterson Air Force Base, Ohio

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CONTENTS

Page

SECTION 1.0 INTRODUCTION 1

SECTION 2.0 SITE BACKGROUND 2

2.1 General Background Information 2
2.1.1 Location 2
2.1.2 Geologic and Hydrologic Setting 2
2.1.3 Installation History 5
2.2 Previous Work 6

SECTION 3.0 SAMPLING OBJECTIVES. 8

3.1 Introduction 8
3.2 Data Quality Objectives 11
3.3 Sampling Rationale and Design 12
3.3.1 Assembly Building/Parts Plant 12
3.3.1.1 Findings 12
3.3.1.2 Sampling and Analysis Objectives 12
3.3.1.3 Sampling and Analytical Design 23
3.3.2 Underground Storage Tanks (Removed) 24
3.3.2.1 Findings 24
3.3.2.2 Sampling and Analysis Objectives 24
3.3.2.3 Sampling and Analytical Design 24
3.3.3 Landfill No. 1 25
3.3.3.1 Findings 25
3.3.3.2 Sampling and Analysis Objectives 25
3.3.3.3 Sampling and Analytical Design 26
3.3.4 Landfill No. 3 26
3.3.4.1 Findings 26
3.3.4.2 Sampling and Analysis Objectives 28
3.3.4.3 Sampling and Analytical Design 28
3.3.5 Landfill No. 4 30
3.3.5.1 Findings 30
3.3.5.2 Sampling and Analysis Objectives 31
3.3.5.3 Sampling and Analytical Design 31
3.3.6 FDTA No. 2 31
3.3.6.1 Findings 31
3.3.6.2 Sampling and Analysis Objectives 33
3.3.6.3 Sampling and Analytical Design 33
3.3.7 FDTA No. 5 33
3.3.7.1 Findings 33
3.3.7.2 Sampling and Analysis Objectives 36
3.3.7.3 Sampling and Analytical Design 36
3.3.8 FDTA No. 6 36
3.3.8.1 Findings 36
3.3.8.2 Sampling and Analysis Objectives 37
3.3.8.3 Sampling and Analytical Design 37
3.3.9 Chrome Pit No. 3 37
3.3.9.1 Findings 37
3.3.9.2 Sampling and Analysis Objectives 37
3.3.9.3 Sampling and Analytical Design 40

CONTENTS (Continued)

Page

3.3.10 Die Yard Chemical Pits 40
3.3.10.1 Findings 40
3.3.10.2 Sampling and Analysis Objectives 42
3.3.10.3 Sampling and Analytical Design 42
3.3.11 FSA No. 1 42
3.3.11.1 Findings 42
3.3.11.2 Sampling and Analysis Objectives 45
3.3.11.3 Sampling and Analytical Design 45
3.3.12 FSA No. 2 46
3.3.12.1 Findings 46
3.3.12.2 Sampling and Analysis Objectives 46
3.3.12.3 Sampling and Analytical Design 48
3.3.13 FSA No. 3 48
3.3.13.1 Findings 48
3.3.13.2 Sampling and Analysis Objectives 48
3.3.13.3 Sampling and Analytical Design 50
3.3.14 Former Fuel Storage Area 51
3.3.14.1 Findings 51
3.3.14.2 Sampling and Analysis Objectives 51
3.3.14.3 Sampling and Analytical Design 51
3.3.15 Jet Engine Test Stand 51
3.3.15.1 Findings 51
3.3.15.2 Sampling and Analysis Objectives 51
3.3.15.3 Sampling and Analytical Design 54
3.3.16 Waste Water Collection Basins 54
3.3.16.1 Findings 54
3.3.16.2 Sampling and Analysis Objectives 55
3.3.16.3 Sampling and Analytical Design 55
3.3.17 East Parking Lot/ Flight Line Area 55
3.3.17.1 Findings 55
3.3.17.2 Sampling and Analysis Objectives 58
3.3.17.3 Sampling and Analytical Design 58
3.3.18 Site-Wide Investigations 58
3.3.18.1 Lake Worth 58
3.3.18.1.1 Findings 58
3.3.18.1.2 Sampling and Analysis Objectives 59
3.3.18.1.3 Sampling and Analytical Design . 59
3.3.18.2 Air Quality Monitoring 59
3.3.18.2.1 Findings 59
3.3.18.2.2 Sampling and Analysis Objectives 61
3.3.18.2.3 Sampling and Analytical Design . 61
3.3.18.3 Continuous Groundwater Elevation Monitoring 61
3.3.18.3.1 Findings 61
3.3.18.3.2 Sampling and Analysis Objectives 61
3.3.18.3.3 Sampling and Analytical Design . 61
3.3.18.4 Paluxy Aquifer System Characterization . . 62
3.3.18.4.1 Findings 62
3.3.18.4.2 Sampling and Analysis Objectives 62
3.3.18.4.3 Sampling and Analytical Design . 62
3.3.18.5 Ecological Sampling 62
3.3.18.5.1 Findings 62
3.3.18.5.2 Sampling and Analysis Objectives 63

CONTENTS (Continued) Page

3.3.18.5.3 Sampling and Analytical Design . 63
3.3.18.6 Meandering Road Creek 63
3.3.18.6.1 Findings 63
3.3.18.6.2 Sampling and Analysis Objectives 63
3.3.18.6.3 Sampling and Analytical Design . 64
3.3.18.7 Background Sampling 64
3.3.18.7.1 Findings 64
3.3.18.7.2 Sampling and Analysis Objectives 64
3.3.18.7.3 Sampling and Analytical Design . 65
3.3.18.8 Leachability Testing 65
3.3.18.8.1 Findings 65
3.3.18.8.2 Sampling and Analysis Objectives 65
3.3.18.8.3 Sampling and Analysis Design . . 65
3.3.18.9 Common Ions 66
3.3.18.9.1 Findings 66
3.3.18.9.2 Sampling and Analysis Objectives 66
3.3.18.9.3 Sampling and Analysis Design . . 66

4.0 GENERAL FIELD INVESTIGATION PROCEDURES 67

4.1 Introduction 67
4.2 Soil and Sediment Sampling 67
4.2.1 Surface Soil Sampling (or shallow subsurface) 67
4.2.1.1 Barrel Auger 67
4.2.2 Subsurface Soil Sampling 79
4.2.2.1 Split-Barrel Sampler 79
4.2.3 Barreled Drill Cuttings 80
4.2.4 Lake Worth and Meandering Road Creek Sediment Sampling . 80
4.3 Soil Gas Sampling 81
4.4 Water Sampling 82
4.4.1 Groundwater Sampling 82
4.4.1.1 Conventional Monitoring Wells 82
4.4.1.2 Multiple-Level Monitoring Well Sampling 83
4.4.1.3 Groundwater Sampling from Open boreholes . . . 84
4.4.2 Surface Water Sampling 84
4.4.2.1 Lake Worth and Meandering Road Creek Water Sampling 84
4.4.2.2 Meandering Road Creek Seep Sampling 84
4.5 Fluid-Level Measurements 84
4.5.1 Water- and Free Product-Level Measurements 84
4.5.2 Continuous Groundwater-Level Measurements 85
4.6 Aquifer Tests 85
4.6.1 Single-Well Aquifer Tests 85
4.6.2 Multiple-Level Well Aquifer Tests 86
4.7 Monitoring Well Installation 86
4.7.1 Conventional Monitoring Wells 86
4.7.2 Multiple-Level Monitoring Well Installation 90
4.7.3 Monitoring Well Design Criteria 90
4.7.3.1 Conventional Nested Monitoring Wells 90
4.7.3.2 Multiple-Level Monitoring Wells 92
4.7.3.3 Well Materials 92
4.7.4 Monitoring Well Development 92

CONTENTS (Continued)

Page

4.8 Well-Location Survey 93
4.9 Decontamination Procedures 93
4.9.1 Soil Sampling Equipment 93
4.9.2 Drilling Equipment 93
4.9.3 Groundwater Sampling Equipment 94
4.9.4 Soil Gas Sampling Equipment 94
4.10 Paluxy Core Sampling 94
4.11 Air Sampling 94

5.0 ANALYTICAL PROCEDURES AND PROTOCOLS 95

5.1 Introduction 95
5.2 Sample Identification 95
5.3 Sample Requirements 95
5.4 Sample Handling, Packaging, and Shipping. 95
5.5 Laboratory Procedures 98
5.5.1 Analytical Methods 98
5.5.1.1 Volatile Organic Compounds (TCL) 98
5.5.1.2 Semi-Volatile Organic Compounds (TCL) 98
5.5.1.3 Priority Pollutant List Metals (total and dissolved) 99
5.5.1.4 Cyanide 99
5.5.1.5 Inorganics (F, Cl, CrO_4, SO_4, PO_4, NO_2, NO_3) in water 99
5.5.1.6 Inorganics (Cyanide) in water 99
5.5.1.7 Inorganics (Ca, Fe, Mg, K, Si, Na) in water . . 99
5.5.1.8 Total Petroleum Hydrocarbons 99
5.5.1.9 Oil and Grease 99
5.5.1.10 TCLP 99
5.5.1.11 Radioisotopes 100
5.5.1.12 Waterborne Petroleum Oils (LNAPLs) 100
5.5.2 Paluxy Core Methods 100

6.0 FIELD QUALITY ASSURANCE AND QUALITY CONTROL. 101

6.1 Introduction 101
6.2 Sampling Procedures 101
6.3 Sampling Control 101
6.3.1 Sample Identity 101
6.3.2 Sample Custody 101
6.3.3 Transportation/Shipment of Samples 101
6.4 Document Control 103
6.4.1 Introduction 103
6.4.2 Field Logbooks 103
6.4.3 Daily Drilling Log 103
6.4.4 Well Completion Log 105
6.4.5 Instrument Calibration Log 105
6.4.6 Soil Sampling Log 105
6.4.7 Groundwater Sample Collection Form 105
6.4.8 Chain-of-Custody Forms 105
6.4.9 Evidentiary File 105
6.5 Laboratory Quality Control 110

CONTENTS (Continued)

Page

6.5.1 Internal Quality Control checks 110
6.5.2 Duplicates 112
6.5.3 Trip and Field Blanks (water) 112
6.5.4 Equipment Blanks (water) 112
6.5.5 Reporting Limits 112

7.0 DATA MANAGEMENT 117

8.0 LOGISTICS AND SCHEDULE 118
8.1 Logistics 118
8.1.1 Communication and Coordination 118
8.1.2 Equipment, Supplies, and Transportation 118
8.1.3 Field Personnel 119
8.1.4 Laboratory Assignments 119
8.1.5 Sample Shipments 119
8.2 Schedule of Field Activities 119

9.0 HEALTH AND SAFETY 121

10.0 REFERENCES 123

11.0 ACRONYMS 125

APPENDICES

APPENDIX A FIELD INVESTIGATION PROCEDURES A-1
(See Appendix A -- Table of Contents)

FIGURES

Figure 2-1 General Location of AFP 4 3
Figure 2-2 Generalized Stratigraphic Column of the AFP 4 area 4
Figure 2-3 Phase 1 IRP Sites 7
Figure 3-1 Assembly Building/Parts Plant Location Map 9
Figure 3-2 Location of USTs (removed) containing soil contamination . . 10
Figure 3-3 Landfill 1 sampling area 27
Figure 3-4 Landfill 3 sampling area 29
Figure 3-5 Landfill 4 sampling area 32
Figure 3-6 FDTA No. 2 sampling area 34
Figure 3-7 FDTA No. 5 sampling area 35
Figure 3-8 FDTA No. 6 sampling area 38
Figure 3-9 Chrome Pit No. 3 sampling area 39
Figure 3-10 December, 1989 Chrome Pit No. 3 sampling locations 41
Figure 3-11 Die Yard Chemical Pits sampling area 43
Figure 3-12 FSA No. 1 sampling area 44
Figure 3-13 FSA No. 2 sampling area 47
Figure 3-14 FSA No. 3 sampling area 49
Figure 3-15 Former Fuel Storage Area sampling area 52
Figure 3-16 Jet Engine Test Stand sampling area 53
Figure 3-17 Wastewater Collection Basins sampling area 56

FIGURES (Continued)

Page

Figure 3-18 East Parking Lot/Flight Line Area 57
Figure 3-19 Meandering Road Creek / Lake Worth Sampling Locations 60
Figure 4-1 Initial Drawdown Versus Time for Bail-Test Data 87
Figure 4-2 Modified Drawdown Versus Time for Bail-Test Data 88
Figure 4-3 Well Completion Data and Hydraulic Conductivity Input Sample. 89
Figure 6-1 Chain of Sample Custody Form 102
Figure 6-2 Daily Drilling Report Log Form 104
Figure 6-3 Well Completion Log Form 106
Figure 6-4 Soil Sample Log Form 107
Figure 6-5 Groundwater Sample Collection Form 108

TABLES

Table 3-1 Summary of Data Quality Objectives for PA/SI and RI/FS Activities AFP 4 13
Table 4-1 Summary of Sampling Activities at AFP 4 68
Table 4-2 Definition of Analytical Parameters 73
Table 4-3 Field and Laboratory Quality Assurance Sample Types and Quantities 77
Table 4-4 New Monitoring Well Design 91
Table 5-1 Sample Containers, Preservation, Holding Times, and Analytical Procedures 96
Table 6-1 Reporting Limits for Laboratory Analyses 113

PLATE
(in pocket back)

Plate 1 Detailed Map of AFP4 showing study areas and well locations

1.0 INTRODUCTION

The purpose of this document is to outline a plan for the field sampling and laboratory analysis to be performed in support of Remedial Investigation/ Feasibility Studies (RI/FS) at Air Force Plant No. 4 (AFP 4) located near Fort Worth, Texas. Included in this plan are activities to be performed as Preliminary Assessment/ Site Inspection (PA/SI). This sampling and analysis plan is intended to be a guide that incorporates specific rationale and objectives for each sampling and analysis activity, sampling protocols and procedures, analytical protocols and procedures, data and document management, and data interpretation and evaluation. Also included are logistics and schedule for the RI/FS.

The sections that follow describe in detail the field investigation activities for areas at AFP 4, known or suspected to contain hazardous waste contamination, that require additional information on the type(s) and extent of contaminants that may pose a threat to human health or the environment. These sites are identified in the Work Plan (Volume I) that accompanies this plan. This plan addressed the sampling objectives, designs and procedures for each area. Figures are included that show the proposed sampling locations and corresponding tables are included to identify sample number, type and required analyses. Sections describing general sample handling, data and document management, logistics, and schedule are project-wide and follow discussions of the individual sampling sites.

Results of the field investigation outlined in this document will be used in the evaluation of: (1) the presence or absence and relative concentrations of reported or suspected contaminants at the waste sites, (2) the vertical and lateral extent of contamination, and (3) the potential pathways for the migration of contaminants within the environment. Based on these results, remedial action alternatives can be evaluated and public health assessments and feasibility studies can be completed.

2.0 SITE BACKGROUND

2.1 GENERAL BACKGROUND INFORMATION

2.1.1 Location

The AFP 4 facility is located in Tarrant County Texas, seven miles northwest of the City of Fort Worth Texas (Figure 2-1). AFP 4 occupies 602 acres and is bounded on the north by Lake Worth, on the east by Carswell Air Force Base, and on the south and west by the City of White Settlement. A detailed map of AFP 4 (Plate 1) is provided in the back pocket of this document.

2.1.2 Geologic and Hydrologic Setting

The geology of the AFP 4 area is characterized by a thin veneer of Quaternary age detrital alluvial deposits and fluvial terrace deposits overlying a sequence of Cretaceous sedimentary formations which in turn overlies a thick sequence of undifferentiated Paleozoic rocks. Figure 2-2 is a generalized stratigraphic column of the AFP 4 area.

The surficial deposits at AFP 4 consist mainly of two soil types: clayey soils of the Sanger-Purves-Slidell association; and clayey soils of the Aledo-Bolar-Sanger associations. These soils range in thickness from approximately 8 to 80 inches and consist mainly of clay loam, clays and silty clays.

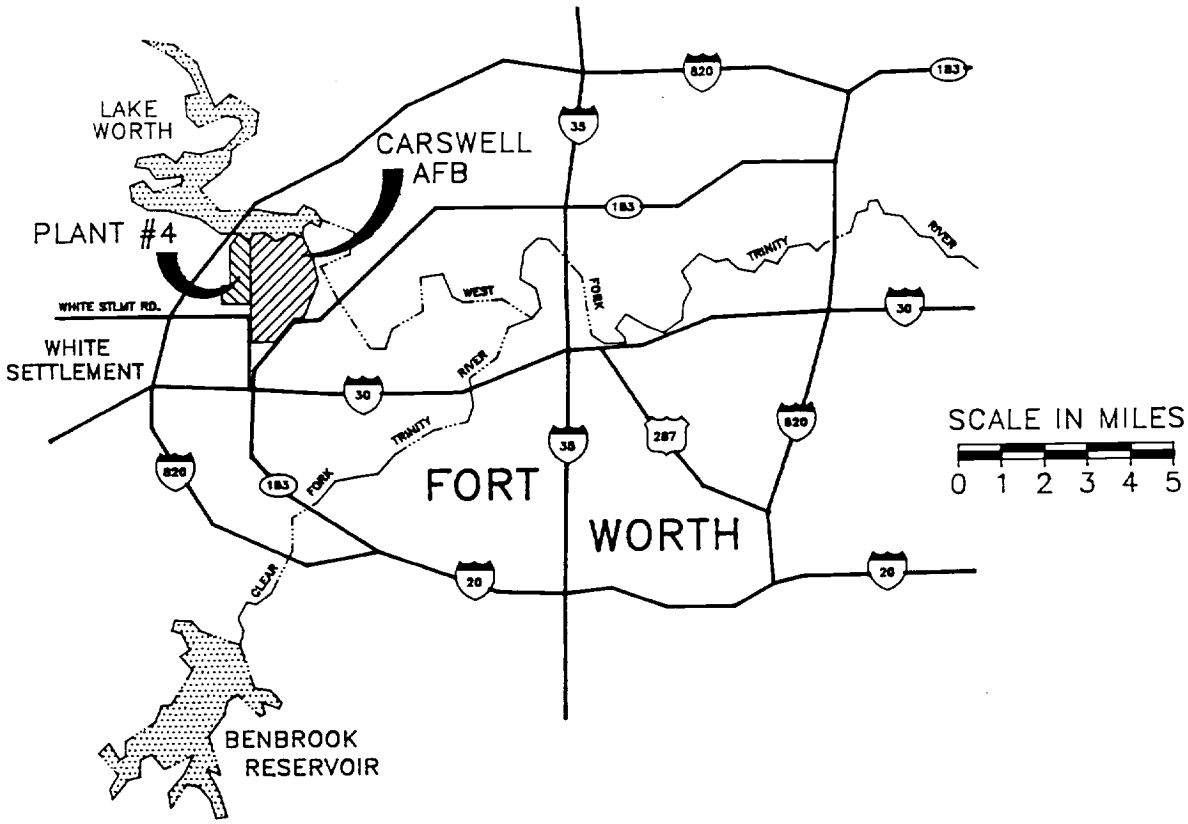
Below the soil layer are deposits of Quaternary alluvium which consist of sands,gravels, clay and silt representing detrital alluvial deposits and fluvial terrace deposits. These deposits form a thin veneer (0-40 ft.) overlying Cretaceous age rocks. The deposits are generally unconsolidated.

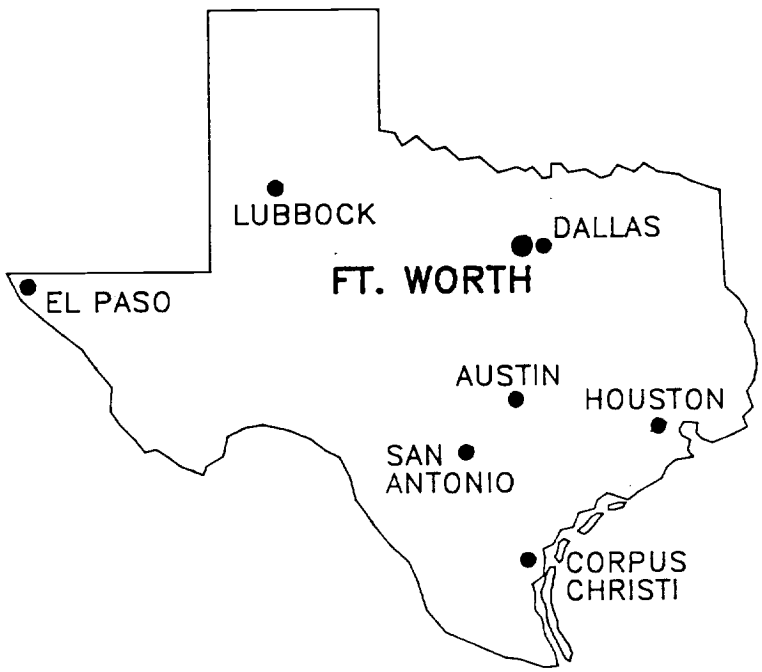
The Goodland Limestone underlies the Quaternary alluvium in most areas at AFP 4. This formation is a dense, thinly to massively bedded fossiliferous limestone which is reportedly extensively jointed and weathered in places. The Goodland Limestone has been completely removed in some areas of AFP 4. The formation ranges from 0-47 ft at AFP 4.

Below the Goodland Limestone are indurated fossiliferous limestones of the Walnut Formation. The Walnut Formation ranges in thickness from 0-46 ft at AFP 4. Although much of the Walnut Formation has been removed by erosion and is missing in one area of AFP 4, no faults or prominent fractures are known to occur in the Walnut at AFP 4.

Older Cretaceous rocks below the Walnut Formation include in descending order, the Paluxy Formation (Upper and Lower), the Glen Rose Formation, and the Twin Mountains Formation. The Paluxy Formation consists of an upper unit which is predominantly made up of fine-grained sandstone and a lower unit of coarser grained series of interbedded sand, clay, and shale. The Glen Rose Formation consists of fine-grained limestone, shale, marl and sandstone. The Twin Mountains Formation consists of coarse-to fine-grained sandstone, red shale, and red and yellow clay at the base.

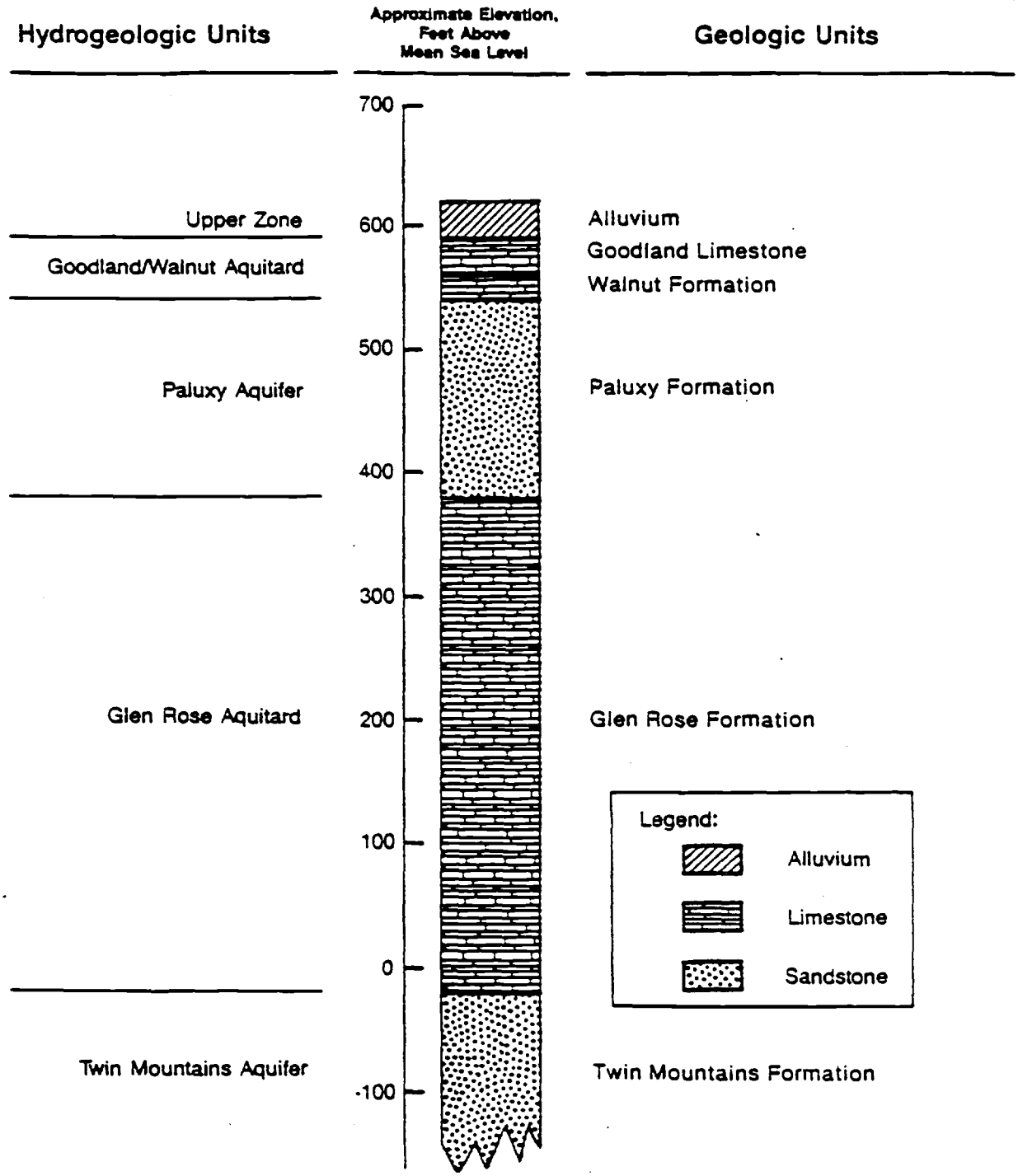
The aquifer systems of concern at AFP 4 are referred to as the upper zone and the Paluxy aquifers. The upper zone hydrogeologic unit is an unconfined aquifer contained mainly within the Quaternary alluvium and weathered Goodland





(After Radian, 1987)

Figure 2-1 General Location of AFP 4



(After Radian, 1987)

Figure 2-2 Generalized Stratigraphic Column of the AFP 4 area

Limestone. The groundwater in the upper zone occurs as a perched water table which is separated from underlying aquifers by the Walnut Formation which acts as an aquitard. Groundwater flow in the upper zone is influenced by the erosional surface of the Walnut Formation. Recharge of the upper zone at AFP 4 is from within AFP 4 and discharge occurs at seeps along the Meandering Road Creek adjacent to AFP 4. To the east, discharge is thought to occur into the Trinity River. There is no known use of the upper zone groundwater in the immediate area of AFP 4.

The Paluxy aquifer is an important source of potable groundwater in the Fort Worth area. Communities surrounding AFP 4 have developed municipal water supplies from the Paluxy aquifer. The Paluxy Formation contains at least two distinct sand units separated by clay and shale in the AFP 4 area. The upper sand unit of the Paluxy Formation is fine-grained and contains interbedded clay and cemented sandstone. This unit is dry in many areas of AFP 4. The sand is saturated to the East of the Assembly Building/ Parts Plant. Recharge of the upper sand is thought to be by leakage from the overlying upper zone especially in areas where the Walnut Formation is thin or absent.

The second sand unit occurs in the middle portion of the Paluxy Formation. This unit is thicker, more homogeneous, and more permeable than the upper sand unit. Below this unit, the lithology consists of interbedded sand, clay, and shale. The City of White Settlement pumps groundwater from wells completed in the middle Paluxy aquifer. Recharge to this aquifer in the area of AFP 4 is mainly from Lake Worth. Groundwater flow is to the southeast.

The Twin Mountains aquifer, which occurs below the Paluxy aquifers, is separated from the Paluxy Formation by the Glen Rose Formation which acts as an aquitard. The Twin Mountains aquifer is the principal water supply aquifer for the AFP 4 area. Recharge to this aquifer occurs west of AFP 4 and since the aquifer is approximately 600 ft below AFP 4 and no communication between the Paluxy aquifers and the Twin Mountains aquifer is suspected, contamination of the aquifer by activities at AFP 4 seems unlikely.

Surface water drainage at AFP 4 is mainly by storm drains and culverts which discharge to Lake Worth, Meandering Road Creek, or a tributary of Farmers Branch of the West Fork Trinity River. Meandering Road Creek also receives upper zone groundwater discharge from AFP 4 which in turn flows to Lake Worth.

2.1.3 Installation History

AFP 4 became operational in 1942 when Consolidated Aircraft began manufacturing the B-24 bomber for national defense during World War II. In 1953, General Dynamics took over operation of the manufacturing facility. Since 1953, AFP 4 has produced B-36, B-58, and F-111 aircraft and currently produces F-16 aircraft. In addition to F-16 aircraft, General Dynamics produces spare parts, radar units and missile components.

Manufacturing operations at AFP 4 have resulted in the generation of various hazardous wastes which include waste oils, fuels, spent solvents, paint residues, and spent process chemicals. Throughout most of the plants history, waste oil, solvents, and fuels were disposed of at on-site landfills or were burned in fire training exercises. Chemical wastes were initially discharged to the sanitary sewer system which went to the City of Fort Worth treatment

system. In the 1970s chemical process wastes were treated on-site at a newly constructed chemical waste treatment system prior to being discharged to the sanitary sewer system. Currently, waste oils and solvents are disposed of by a contractor and burning of these wastes has been discontinued. Chemical wastes continue to be treated on-site.

2.2 PREVIOUS WORK

Contamination studies and interim remedial action activities began in 1982 at AFP 4 and have continued until the present. Interim remedial action began with the installation of a french drain at Landfill 1 to intercept leachate flowing from the landfill area toward Meandering Road Creek.

Hargis and Montgomery, Inc. and Hargis and Associates, Inc. provided nearly continuous support to General Dynamics from 1982 to 1989 in various contaminant, hydrologic and geologic investigations at AFP 4. This included the installation and sampling of approximately 175 monitoring wells and the drilling of numerous soil borings.

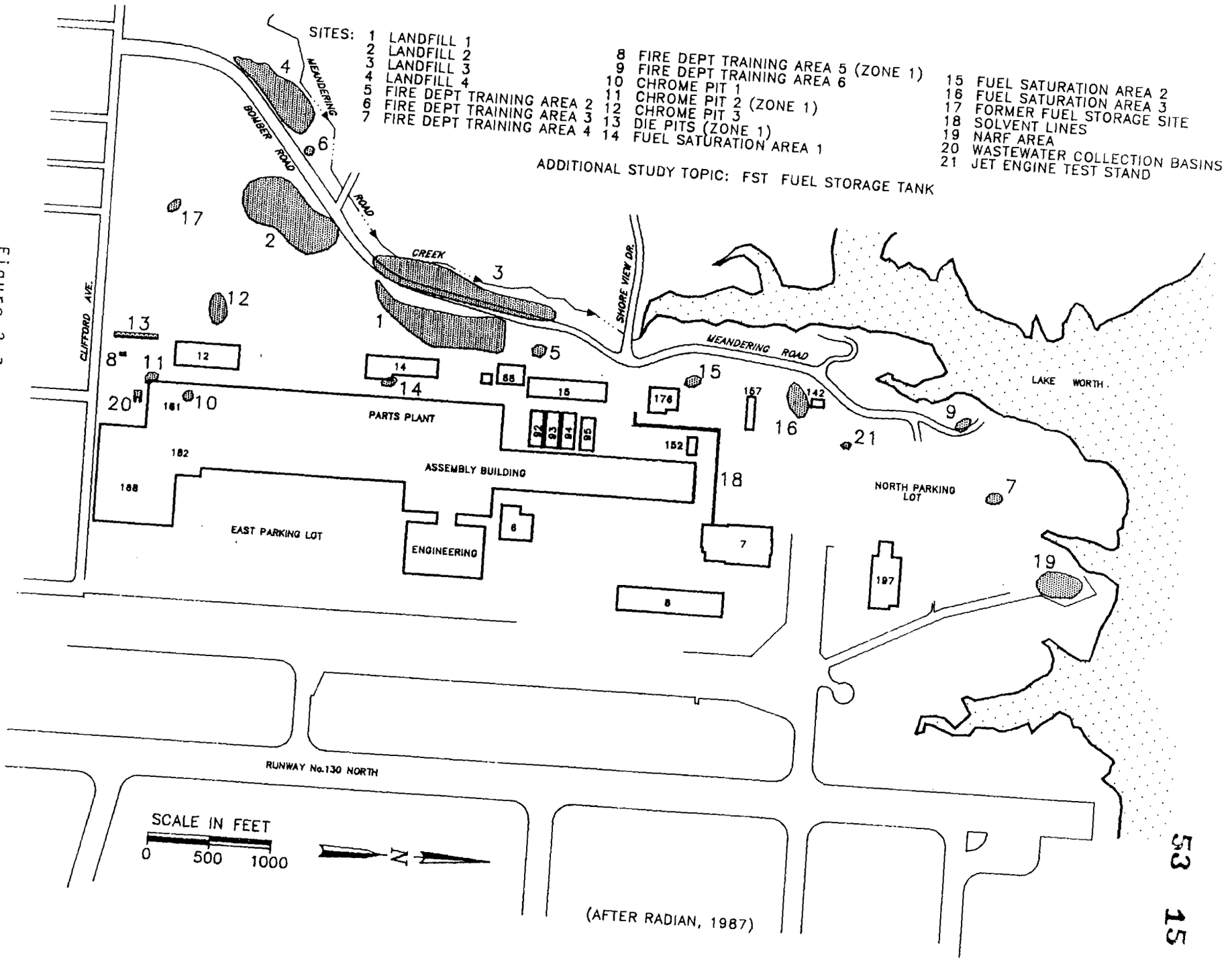
The IRP program at AFP 4 was initiated in 1984 when CH2M Hill conducted a Phase I Records Search and ranked 20 identified disposal sites (Figure 2-3) according to the USAF Hazard Assessment Rating Methodology (HARM).

The U.S. Army Corps of Engineers was retained in June of 1985 to further delineate groundwater conditions along the southern base boundary and the East Parking Lot area of AFP 4. The Corps drilled 28 soil borings and constructed 6 monitoring wells.

Radian Corporation was retained in September, 1985 to perform Stage I, Phase II, Confirmation/Quantification of the IRP. In support of this investigation, Radian drilled 11 soil borings and constructed 12 groundwater monitoring wells.

In December, 1985, Intellus Corporation was contracted to conduct an IRP Phase IV A Remedial Action Plan for ten potential disposal sites and Phase IV B Design and Construction for Fuel Saturation Areas Nos. 1 and 3. In support of this effort, Intellus drilled 12 soil borings and constructed 24 groundwater monitoring wells.

The activities proposed in this plan are essentially a continuation of the former IRP activities. All work, however, will be conducted according to guidance prepared by the EPA for conducting Remedial Investigation/Feasibility Studies (RI/FS) for CERCLA sites. A site-wide data base was established by General Dynamics which contains data from previous investigations. These data base will be updated as new information becomes available and RI/FS conclusions and recommendations will be based on all available information.



(AFTER RADIAN, 1987)

Figure 2-3 Phase I IRP Sites

3.0 SAMPLING OBJECTIVES

3.1 INTRODUCTION

The overall objectives of the PA/SI and RI/FS processes are to ensure that there is no risk to human health or safety and to ensure compliance with Federal and State laws. To this end, certain data gaps must be filled prior to making decisions on Remedial Action Alternatives. The following general objectives have been established for the PA/SI activities required for the Assembly Building/Parts Plant (Figure 3-1) and the Underground Storage Tanks (removed) Nos.19, 20, 24A, 24B, 25A, and 30 (Figure 3-2):

Assembly Building/Parts Plant

- Define specific target areas as potential source areas for subsurface soil and groundwater contamination.
- Provide preliminary information on the vertical distribution of contaminants.
- Better define groundwater flow directions and provide additional groundwater quality data.
- Make recommendations concerning the need for further investigations to be completed as part of the RI/FS for AFP 4.

The overall objectives of the PA/SI investigations of the locations of former underground storage tanks are to:

- Determine if the tanks have released contaminants which exceed regulatory standards into the environment.
- If contaminants have been released, provide preliminary data on the vertical and horizontal extent of the contamination.
- Determine if the groundwater quality has been affected by contaminant releases associated with the former tanks and provide preliminary groundwater flow information.
- Make recommendations for the need for further investigations to be conducted as part of the RI/FS for AFP 4.

The objectives established for the previously identified hazardous wastes sites vary according to the amount and type(s) of existing data available. Although RI/FS objectives are site-specific, several basic objectives will be addressed by RI field investigation activities:

- Determine lateral and vertical limits of contaminants.
- Identify and assess contaminant pathways or mechanisms which could affect the human or natural environment.
- Assess risk or harm to health, safety, public welfare, and the environment from current conditions at AFP 4.

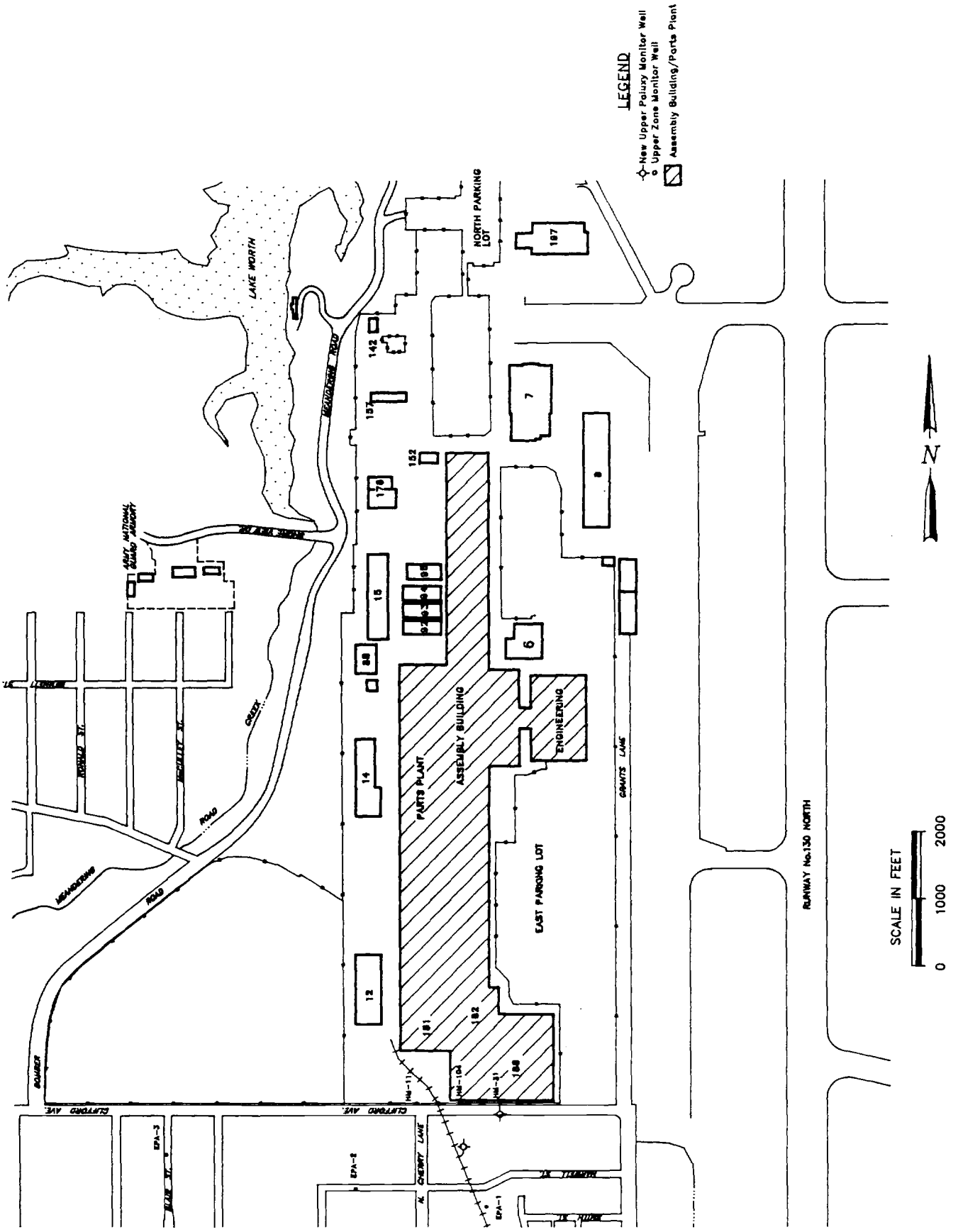


Figure 3-1 Assembly Building/Parts Plant Location Map

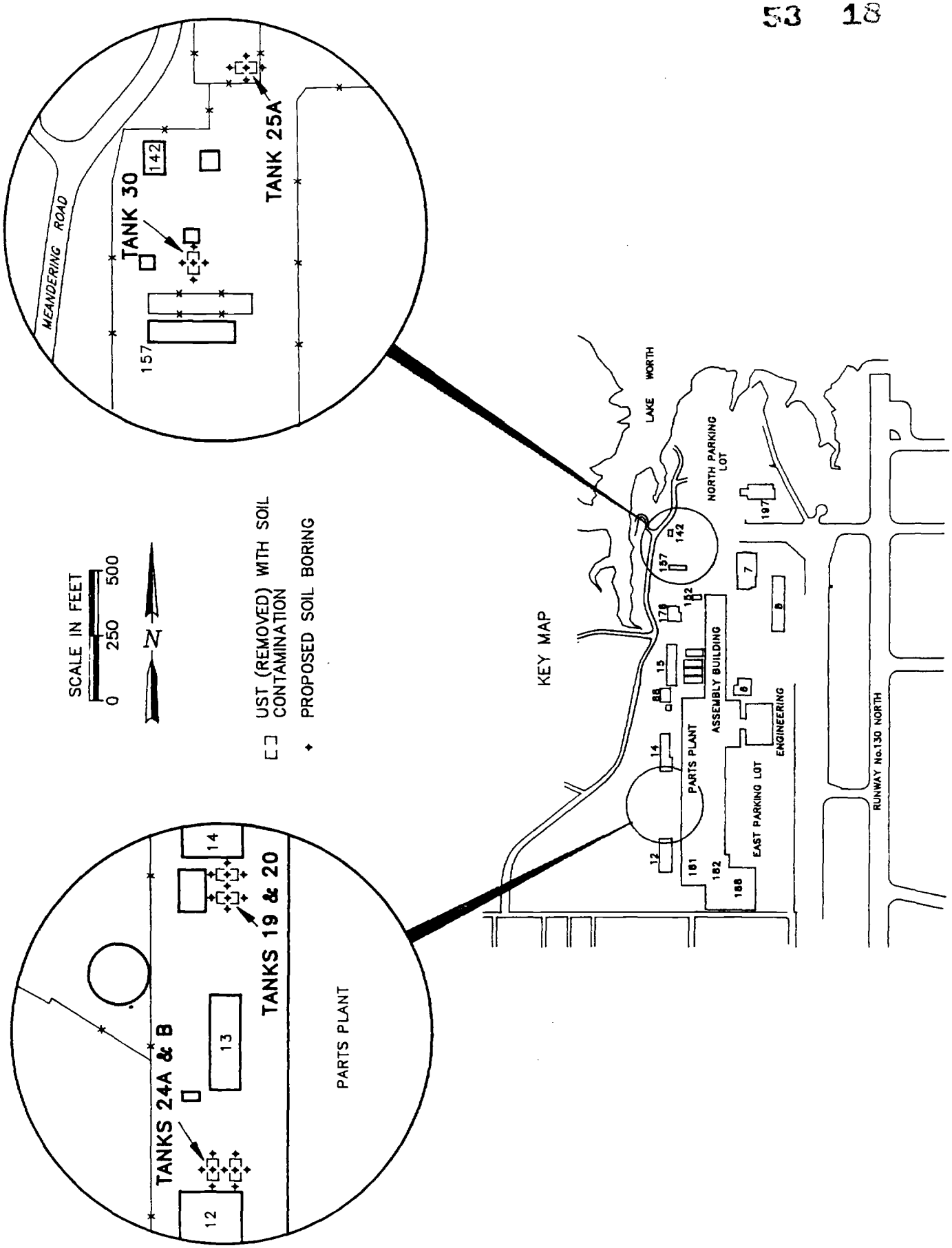


Figure 3-2 Location of USTs (removed) containing soil contamination and sample location map

- Provide data required to develop a range of remedial action alternatives designed to reduce or eliminate the possible adverse effects to the human or natural environment.

- Develop, screen, and analyze remedial action alternatives and present preferred alternatives for a Record of Decision (ROD).

- Perform an environmental assessment of the proposed remedial action(s) to determine the potential safety or health effects resulting from the remedial action activities.

- Provide recommendations for additional investigations if data gaps still exist.

3.2 DATA QUALITY OBJECTIVES

Due to the fact that AFP 4 is on the proposed federal Superfund National Priorities List (NPL), the ultimate objective is to obtain sufficient data and to perform necessary remedial action(s) on former waste and spill sites necessary to obtain "No Further Action" decisions resulting in removal of AFP 4 from the list. The data collection program proposed in this Sampling and Analysis Plan is designed to provide data which meet specified requirements for precision, accuracy, representativeness, completeness, and comparability to be used in making decisions on remedial action alternatives for AFP 4. The RI/FS for AFP 4 is not typical of other Superfund sites in that much of the scoping process and field investigation activities were completed as part of the IRP program. Therefore, the field investigation activities presented in this plan represent a mixture of PA/SI, RI/FS, remedial design and remedial action activities. Each activity will have specific data quality objectives. In many cases a phased approach in data collection will be used to meet a specific objective.

This plan uses the classification of appropriate analytical levels as specified in the EPA guidance document Data Quality Objectives for Remedial Response Activities Development Process (EPA, 1987), which allows data to be categorized according to the level of analytical support required to meet specific data usage objectives. The following is a brief description of the data levels used:

- Level I- field screening or analysis using portable instruments. Results are often not compound specific and not quantitative but results are available in real-time. It is the least costly of the analytical options.

- Level II- field analyses using more sophisticated portable analytical instruments: in some cases, the instruments may be set up in a mobile laboratory on site. There is a wide range in the quality of the data that can be generated. It depends on the use of suitable calibration standards, reference materials, and sample preparation equipment: and the training of the operator. Results are available in real-time or several hours.

- Level III- all analyses performed in an off-site analytical laboratory. Level III analyses may or may not use CLP procedures, but do not usually utilize the validation or documentation procedures required of CLP Level IV analysis. The laboratory may or may not be a CLP laboratory.

- Level IV- CLP routine analytical services (RAS). All analyses are performed in an off-site CLP analytical laboratory following CLP protocols. Level IV is characterized by rigorous QA/QC protocols and documentation.

- Level V- analysis by non-standard methods. All analyses are performed in an off-site analytical laboratory which may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits. CLP special analytical services (SAS) are Level V.

Table 3-1 is a summary of site-specific data quality objectives which lists the type of data to be collected, the objective for collecting the data, the proposed data usage, and the analytical level required.

3.3 SAMPLING RATIONALE AND DESIGN

The following section is designed to show the rationale behind the field investigation studies to be performed at AFP 4 and to present the sampling design selected to accomplish the work. This section is organized by site and presents site-specific findings based on previous work, current sampling and analysis objectives, and sampling and analysis design. Figures show the general sampling areas and where possible, the specific sampling points for each site.

3.3.1 Assembly Building/Parts Plant

3.3.1.1 Findings

Groundwater contamination is present downgradient of the Assembly Building/Parts Plant. Most investigations to date have concentrated on defining the extent of the contaminant plume and as a result, the source of the contamination has not been determined. The most widespread contaminant east of the building is TCE. Past spills of TCE have reportedly occurred within the chemical process building adjacent to the Parts Plant. Trenches, sumps, floor drains, and buried pipelines are also present throughout the manufacturing facility. These are all potential source areas for contamination resulting from spills and leaks.

3.3.1.2 Sampling and Analysis Objectives

The main objective of the PA/SI investigation of the Assembly Building/Parts Plant is to identify potential source areas for contamination present in groundwater downgradient of the buildings. Screening of the entire perimeter of the buildings will provide both upgradient and downgradient information on the type and extent of contamination in soils and groundwater. Specific areas of contamination will be further investigated to help define the contaminant

Table 3-1 Summary of Data Quality Objectives for PA/SI and RI/FS Activities AFP 4.

Site	Data Type	Objective	Data Use	Analytical Level[a]
Assembly Building/ Parts Plant	Soil Gas	Identify target source areas for contamination	Preliminary Assessment/ Site Inspection	Level II
	Soil Sample Analyses	Identify types of contaminants present in soil gas target areas	Preliminary Assessment/ Site Inspection	Level III
	Groundwater Analyses	Identify types of contaminants present in groundwater in soil gas target areas	Preliminary Assessment/ Site Inspection	Level III
	Groundwater-Level Measurements	Provide preliminary groundwater flow direction information for entire manufacturing building perimeter	Preliminary Assessment/ Site Inspection Site Characterization	Level I
Underground Storage Tanks	Soil Sample Analyses	Determine if contaminants are present in soils surrounding the location of former tanks	Preliminary Assessment/ Site Inspection	Level III
	Groundwater Analyses	Determine if contaminants from the former tank area have entered the groundwater system	Preliminary Assessment/ Site Inspection	Level III
	Organic Vapor Monitoring	Field screening for biased sample selection and health and safety breathing zone protection	Preliminary Assessment/ Site Inspection	Level I

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SI and RI/FS Activities AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
Landfill No. 1	Groundwater Analyses	Confirm concentrations of contaminants in groundwater, areal extent and distribution	Site Characterization Risk Assessment Evaluation of alternatives Engineering Design	Level IV
	Groundwater-level Measurements	Define groundwater flow directions and magnitude and direction of hydraulic gradients	Site Characterization Risk Assessment Evaluation of Alternatives Engineering design	Level I
	Aquifer Slug Tests	Determine hydraulic conductivity and flow velocity	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level I
	Soil Sample Analyses	Determine the concentrations, distribution, and areal extent of contamination	Site Characterization Risk Assessment Evaluation of Alternatives	Level IV
	Organic Vapor Monitoring	Screening for biased sampling and health and safety personnel breathing zone protection	Site Characterization	Level I, Level II
Landfill No. 3	Groundwater Analyses	Confirm concentrations of contaminants, distribution, and areal extent	Site Characterization Risk Assessment Evaluation of Alternatives	Level IV

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SA and RI/FS Activities at AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
Landfill No. 3 (continued)	Groundwater-Level Measurements	Determine the direction and magnitude of the hydraulic gradients at the site	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level I
	Aquifer Slug Tests	Determine hydraulic conductivity to aid in determining flow velocity	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level II
	Free Product Sample Analyses	Identify type of product present to aid in determining source	Site Characterization	Level III
	Surface Water Sample Analyses	Confirm the presence or absence of contaminants in surface water from Meandering Road Creek	Site Characterization Risk Assessment	Level III
	Sediment Sample Analyses	Confirm the presence or absence of contaminants in sediments from Meandering Road Creek	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
Landfill No. 4	Soil Sample Analyses	Determine presence, distribution, and extent of contaminants in soils of the Meandering Road Creek floodplain	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
FDTA No. 2	Soil Sample Analyses	Confirm presence or absence, distribution, and areal extent of contamination	Site Characterization Risk Assessment Evaluation of Alternatives	Level III

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SI and RI/FS Activities at AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
FDTA No. 2 (continued)	Groundwater Sample Analyses	Determine if contaminants from the FDTA No. 2 have affected groundwater quality and assess the need for additional monitoring wells	Site Characterization	Level III
FDTA No. 5	Soil Sample Analyses	Confirm contaminant concentrations, distribution, and areal extent	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
	Groundwater Sample Analyses	Determine if FDTA No. 5 is a source of groundwater contamination	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level IV
	Groundwater-Level Measurements	Define groundwater flow directions and magnitude and direction of hydraulic gradients	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
	Aquifer Slug Tests	Determine hydraulic conductivity and flow velocity	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level II
FDTA No.6	Soil Sample Analyses	Evaluate soil contamination around perimeter of excavated portion of FDTA No. 6 to determine if additional remedial action is necessary	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level IV

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SI and RI/FS Activities at AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
FDTA No. 6 (con't)	Groundwater Sample Analyses	If water is encountered in soil borings, determine groundwater quality	Site Characterization	Level III
Die Yard Chemical Pits	Soil Sample Analyses	Determine if MCLs are exceeded peripheral to and below the excavated area	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level IV
	Groundwater Sample Analyses	Determine if downgradient groundwater is affected by the Die Yard Chemical Pits when compared with upgradient water quality	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level IV
	Aquifer Slug Testing	Determine hydraulic parameters of the upper zone in the Die Yard Pit area.	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level II
FSA No. 1	Review Free Product Recovery System Design	Evaluate interim remedial action as means of source removal	Risk Assessment Evaluation of Alternatives Engineering Design	N/A
	Soil Gas Samples	Define the lateral extent of fuel contamination	Site Characterization	Level II
	Soil Sample Analyses	Determine contaminant levels, distribution, and areal extent	Site Characterization Risk Assessment Engineering Design	Level III

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SI and RI/FS Activities at AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
FSA No. 1 (con't)	Groundwater Sample Analyses	Define maximum extent of groundwater contamination	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level IV
	Aquifer Slug Tests	Define the hydraulic conductivity and flow velocity	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level II
FSA No. 2	Soil Gas Samples	Delineate the extent of fuel contamination surrounding FSA No.2	Site Characterization	Level II
	Soil Sample Analyses	Define concentrations, distribution and areal extent of contamination	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
FSA No. 3	Review Free Product Recovery System Design	Evaluate interim remedial action as a means of source control	Evaluation of Alternatives Engineering Design	N/A
	Soil Gas Samples	Delineate lateral extent of fuel contamination	Site Characterization	Level II
	Soil Sample Analyses	Define levels, distribution, and areal extent of contamination	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
	Groundwater Sample Analyses	Determine levels and extent of groundwater contamination	Site Characterization Risk Assessment Engineering Design	Level IV

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SI and RI/FS Activities at AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
FSA No.3 (con't)	Aquifer Slug Tests	Determine hydraulic conductivity and flow velocity	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level II
Former Fuel Storage Area	Soil Sample Analyses	Determine vertical and lateral extent of contamination	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
	Groundwater Sample Analyses	Confirm previous results	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
Jet Engine Test Stand	Soil Sample Analyses	Define lateral and vertical extent of contamination	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level III
	Groundwater Sample Analyses	Evaluate downgradient extent of contamination and determine if source area is same as FSA No. 3	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level IV
Wastewater Collection Basins	Soil Sample Analyses	Determine if leakage has occurred from the basins into surrounding soils	Site Characterization	Level III
	Groundwater Sample Analyses	Compare downgradient with upgradient groundwater quality to assess whether basins are a source of contaminants	Site Characterization	Level III

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SI and RI/FS Activities at AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
Wastewater Collection Basins (con't)	Aquifer Slug Tests	Determine hydraulic conductivity and flow velocities	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level II
East Parking Lot/Flightline	Obtain Carswell data	Combine Carswell and AFP 4 data for contaminant fate and transport modeling	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	N/A
	Groundwater Sample Analyses	Define maximum extent of TCE plume and relative concentrations	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level IV
Meandering Road Creek	Sediment Sample Analyses	Determine extent of contamination and define potential source areas	Site Characterization Risk Assessment	Level III
	Surface Water Sample Analyses	Determine water quality of water upstream and downstream of AFP 4 to determine if the facility is contributing contaminants to the surface water pathway	Site Characterization Risk Assessment	Level III
	Seep Sample Analyses	Identify and characterize upper zone discharge from AFP 4 to Meandering Road Creek to determine if contaminants are entering the surface water pathway	Site Characterization Risk Assessment Evaluation of Alternatives	Level III

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SI and RI/FS Activities at AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
Lake Worth	Surface Water Sample Analyses	Establish water quality of Lake Worth adjacent to AFP 4 to determine if contaminants from the facility are entering the surface water pathway	Site Characterization Risk Assessment	Level III
	Sediment Sample Analyses	Determine if contamination is present adjacent to AFP 4 and if present, identify the potential source(s) of the contaminants	Site Characterization Risk Assessment	Level III
Off-Site Background Samples	Soil Sample and Soil Gas Sample Analyses	Determine background concentrations of analytes in soils in non-contaminated areas for comparison with analytes in soil at AFP 4	Site Characterization Risk Assessment	Level III
Ecological Sampling	Plant, Animal, and Fish Sample Analyses	Determine the potential effect of contaminants from AFP on the environment	Risk Assessment	Level III
Air Quality Site-Wide	Carbon Tubes and Hi-Vol Filter Samples	Establish baseline air quality upwind and downwind of contaminated areas of AFP 4	Site Characterization Risk Assessment Evaluation of Alternatives Engineering Design	Level II, Level III
General Measurement Activities	Groundwater Quality Parameter measurements	Document basic water quality, indicate changes over time and distance, provide information on geochemistry of the hydrologic system including oxidation/reduction.	Site Characterization	Level II

Table 3-1 (continued). Summary of Data Quality Objectives for PA/SI and RI/FS Activities at AFP 4

Site	Data Type	Objective	Data Use	Analytical Level[a]
General Measurement Activities (con't)	Organic Vapor Monitoring	Screening of soil cores and cuttings for biased sampling of anomalous zones and health and safety monitoring of breathing zone	Site Characterization	Level I, Level II
Paluxy Aquifer	Paluxy Core Analyses	Define hydraulic parameters of Paluxy aquifer	Site Characterization Risk Assessment	Level V

[a]Level I = Field Screening; Level II = Field Analysis; Level III = Laboratory Analysis without CLP/RAS data package Level IV = Laboratory analysis with CLP/RAS data package; Level V = Physical property analysis by non-standard methods.

source. On the basis of the results of the perimeter survey, select sites within the buildings will be drilled and sampled as part of the source investigations.

In addition to determining potential source areas for contamination, it appears the upper zone contamination may be migrating off-site near the southeast corner of the facility. Off-site monitoring wells are needed to help define the extent of off-site contamination (Figure 3-1).

3.3.1.3 Sampling and Analytical Design

A soil gas survey will be conducted around the entire perimeter of the buildings with locations spaced every 200 feet. Samples will be collected at a depth of four feet using a hollow stainless steel drive rod and drive points. Soil gas measurements will be made initially using a calibrated Photovac TIP. A low volume sampling pump will then be attached to the rods and a sorbent tube will be used to collect a sample for laboratory VOC analysis. In areas having positive results for VOCs, additional closer spaced soil gas sample locations may be required to better define the lateral extent of contamination.

On the basis of the soil gas survey, perimeter locations containing elevated VOCs will be further investigated by soil borings and soil samples. The borings will be drilled from the surface to the top of the water table. Soil samples will be collected in 5 foot intervals with samples for VOCs being grab samples and the remaining samples being a composite of each five foot interval. The estimated number of soil borings is 25 with approximately 100 samples being collected. Composite soil samples will be analyzed for semi-VOCs, total petroleum hydrocarbons, and metals.

From the soil gas and soil boring survey results, selected boring locations will be identified to be drilled within the Assembly Building/Parts Plant to help define the location and extent of soil contamination beneath the buildings. Locations will be selected on the basis of meeting the data objectives while having a minimal impact on daily plant operations. The borings may be completed as monitoring wells to provide groundwater flow and quality data beneath the facility. These wells will be flush mounted in low traffic areas. Groundwater samples will be collected after completion and development and then collected in a month for an additional sampling round. Samples will be analyzed for VOCs, semi-VOCs, total petroleum hydrocarbons, and total metals. All monitoring wells will be drilled and screened to allow sampling of discrete intervals potentially containing LNAPLs, DNAPLs, and soluble phase contaminants.

Since possible sources of contaminants are underground pipes within the facility, pressure or hydrostatic testing may be performed to determine if they leak and if so, the rate and volume of leakage.

On the basis of hydrologic data from both new and existing monitoring wells in the southeastern portion of the facility, two to four off-site monitoring wells will be installed southeast of Clifford Avenue. Groundwater samples will be collected after monitoring well completion and development and then again after one month. The samples will be analyzed for VOCs, semi-VOCs, total metals, total petroleum hydrocarbons, and oil and grease.

3.3.2 Underground Storage Tanks (Removed)

3.3.2.1 Findings

Fourteen USTs were removed at AFP 4 prior to December 22, 1988 which was the effective date of federal Subtitle I regulations. Twelve of the tanks contained petroleum products and two contained hazardous substances. Following removal of the tanks, soil samples collected from the excavations indicated that six of the tank locations contained contaminants in soils.

The six tanks (Tank Nos. 19, 20, 24A, 24B, 25A, and 30) contained methyl ethyl ketone, xylene, gasoline, gasoline, JP-4 and JP-4 respectively. Analytical results of the soil samples from the tank excavations generally indicated that the contaminants in the soil corresponded to the former contents of the tanks. There were, however, several compounds present that were not reported as being stored in the tanks.

3.3.2.2 Sampling and Analysis Objectives

Previous sampling of the former tank locations was insufficient to determine the potential levels and extent of contamination associated with leaks and spills from the tanks. These tank areas need to be evaluated as potential source areas for groundwater contamination of the upper zone. The initial investigation will be a PA/SI screening to determine if additional investigations are warranted as part of the RI/FS for AFP 4. Although preliminary sampling has shown that contamination exists at the six locations, no attempt was made to characterize the extent of contamination prior to backfilling, grading and paving. These sites may have been a significant source of contamination to the soils and groundwater over the years.

3.3.2.3 Sampling and Analytical Design

Soil borings will be placed around the perimeter of each of the six former underground storage tank locations where contamination was reported to be present. A total of four borings, one on each side of the former excavated area, will be initially drilled from the surface to the top of the water table. In addition, one boring will be drilled in the approximate center of the formerly excavated area to determine if any contamination remains at depth. Soil samples will be collected at five foot intervals with samples for VOCs being grab samples and the remaining samples being composites of the entire 5 foot interval. Composite soil samples will be analyzed for semi-VOCs, and total petroleum hydrocarbons. A minimum of ten percent of the composite samples or one per borehole will also be analyzed for metals with an emphasis placed on those samples which appear visually contaminated. If contamination exceeding established thresholds is encountered in any of the borings, additional soil borings will be made outward (approximately 50 feet) from the contaminated boring to help define the lateral and vertical extent of contamination. A maximum of 48 borings are estimated for the six locations (8 per site).

If contamination is found to extend to the water table at any of the former tank locations, one downgradient monitoring well will be installed to monitor upper zone groundwater quality. If no upgradient wells exist in the area of the former tanks, an upgradient well will be installed to compare groundwater

quality both upgradient and downgradient of the site to determine if the former tank sites are source areas for groundwater contamination. A maximum of six downgradient wells will be installed and sampled. Samples will be analyzed for VOCs, semi-VOCs, and total petroleum hydrocarbons.

If no contamination above federal MCLs is found during the sampling of the former tank areas, a "No Further Action" decision paper will be prepared and submitted for regulatory review and concurrence. If contamination is present, the data will be evaluated to determine if additional RI investigations are required prior to conducting feasibility studies for remedial action.

3.3.3 Landfill No. 1

3.3.3.1 Findings

Although the majority of the waste disposed of at Landfill No. 1 consisted of general refuse, rubble, plaster, lumber, and fill dirt, unspecified amounts of potentially hazardous wastes were also disposed of in the landfill. These included drums of liquid wastes, solvents, thinners and paint wastes from tank trucks dumped in shallow pits. Oils and fuels were also dumped in pits and burned. At least five separate pits were used as shown by aerial photographs of the landfill taken when the landfill was active.

Several contaminants have been identified in the Landfill which exceed federal MCLs. These include arsenic, cadmium, chromium, lead, acenaphthene, benzene, ethylbenzene, fluoranthene, tetrachloroethylene, toluene, 1,1,1-trichloroethane, trichloroethylene, and vinyl chloride. The landfill appears to still contain oil and grease, waste solvents and process chemicals as evidenced by the contaminants detected in soils and groundwater in the landfill area.

Some interim remedial action has been performed to remove sources of contaminants such as the removal of contaminated soil associated with former oil pits. Two french drains have been installed to collect leachate from the landfill prior to discharging into Meandering Road Creek. A large portion of the landfill still remains to be characterized prior to making remedial action alternative decisions.

3.3.3.2 Sampling and Analysis Objectives

Previous investigations at Landfill No.1 have identified a variety of contaminants both in the groundwater and the soils, many of which exceed federal standards. Much of the original contamination has been removed, but the overall extent of contamination has not been adequately assessed by previous investigations. Additional data must be collected to assess the potential for contaminant migration that might pose a threat to human health or the environment and to provide sufficient data to evaluate various remedial action alternatives in terms of effectiveness in reducing risk and in terms of being cost-effective. The additional data collection will mainly be designed to better define the overall extent (both vertical and horizontal) of contaminants that may require remediation depending upon the results of the baseline risk assessment.

3.3.3.3 Sampling and Analytical Design

Previous investigations have provided a significant amount of data concerning the distribution of contaminants in specific areas within the landfill. A focused sampling approach will be used to confirm previous results while providing data needed to fill in data gaps. Intrusive sampling of both subsurface soils and groundwater will be used to obtain a minimum of Level III data to be used for site characterization, risk assessment, and alternative evaluations and decisions. Previous investigations did not define the overall lateral extent of contamination and did not adequately characterize the hydrologic flow system at Landfill No. 1. The following describes the sampling determined as being required to meet the data quality objectives for Landfill No. 1 (see Table 3-1).

A grid will be established across an area of approximately 1000 x 500 feet which encompasses the entire Landfill No. 1 site. Grid locations in the parking lot area will be marked with paint on the asphalt surface using a grid spacing of 100 feet. At 50 percent of the grid points, a soil boring will be drilled and composite soil samples will be collected at 5 foot intervals from the surface to the top of the water table with the exception of samples for volatile organics which will be grab samples taken from each five foot interval. Composite samples will be analyzed for semi-VOCs, oil and grease, and metals. This will result in approximately 25 borings and 75 soil samples.

On the basis of the results of the initial sampling, the remaining grid points may be drilled as needed to better define specific areas of contamination using the same sampling and analytical design.

Aquifer testing will be performed on those existing wells in Landfill No. 1 that were properly completed and not previously tested and on previously tested wells where aquifer test data appeared inconsistent with other test results. Previously tested wells are HM-10, HM-19, F-216, and F217 (see Figure 3-3). The test will be a standard slug-withdrawal method. The results of new tests will be combined with previous results to characterize the hydraulic parameters of the upper zone at Landfill No. 1.

Contaminant transport modeling will be performed using new and existing hydrologic data and water quality data to determine if the present french drain system is adequate to intercept contaminants flowing from the landfill towards Meandering Road Creek.

3.3.4 Landfill No. 3

3.3.4.1 Findings

Landfill No. 3 was used for a variety of wastes including hazardous wastes consisting of mixed oils and solvents. Small pits within the landfill were used for the burning of some of these wastes. After use of the landfill was discontinued, fill dirt and rubble were used to fill and grade the surface of the landfill.

Results of soil sampling and groundwater sampling during previous investigations indicate that both media are contaminated with fuel-and

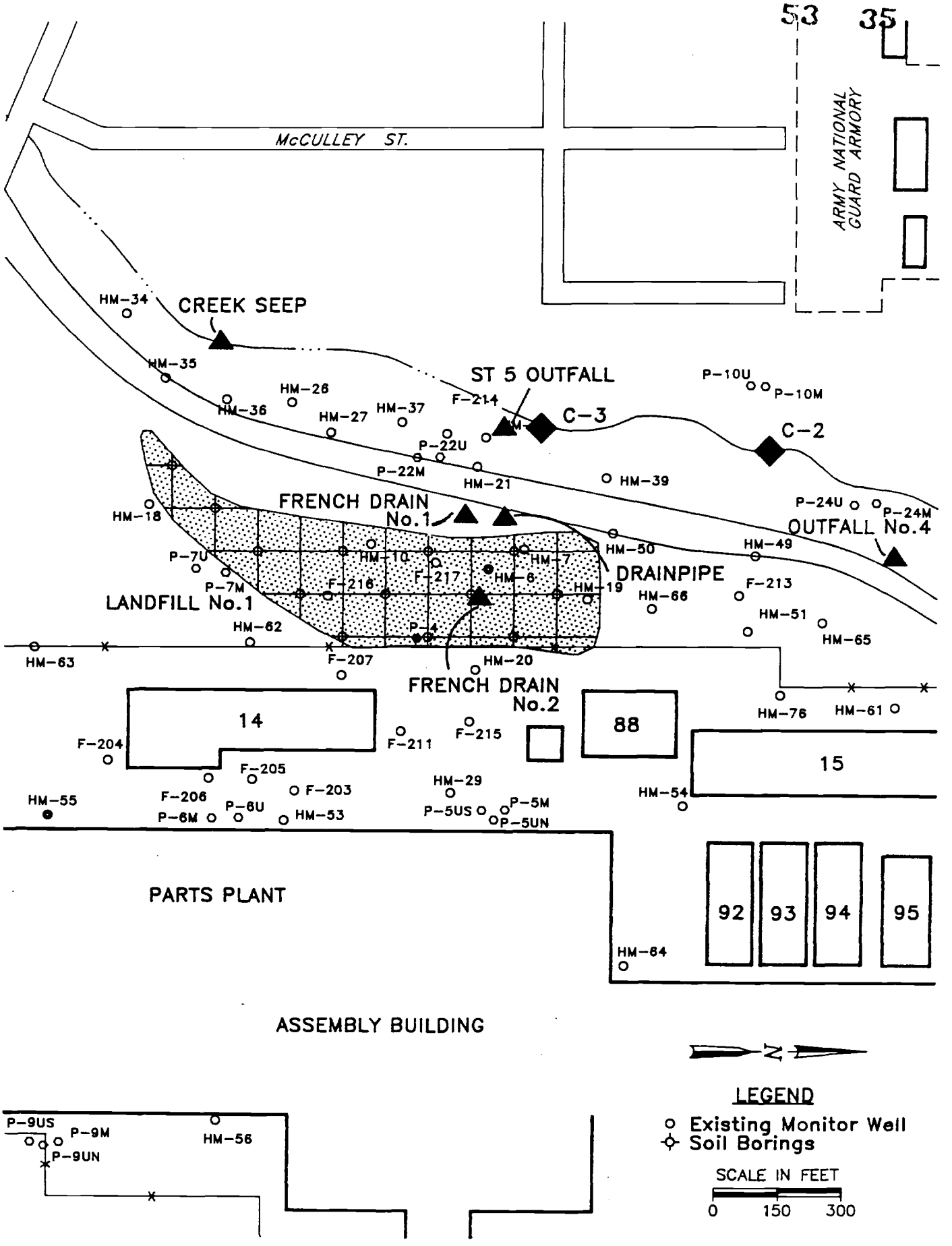


Figure 3-3 Landfill 1 sampling area and sample location map

solvent-related contamination. In two monitoring wells at the site, floating fuel-related, and solvent-related products were observed. Several contaminants were found to exceed federal MCLs. These include arsenic, chromium, lead, vinyl chloride, methylene chloride, trans-1,2-dichloroethylene, trichloroethylene, tetrachloroethylene, toluene, 1,4-dichlorobenzene, 1,2-dichlorobenzene, acenaphthene, naphthalene, fluorene, and phenanthrene.

Due to the presence of a significant amount of floating product observed in two wells at the landfill, a localized source of fuel-related and solvent-related contaminants is indicated within the landfill and major contaminants appear to be confined to a relatively small area.

3.3.4.2 Sampling and Analysis Objectives

The main objectives for the field investigations proposed for Landfill No. 3 are to: 1) define the lateral extent of contamination, delineate extent of contaminants exceeding federal MCLs, 2) determine the location(s) and amount of contaminants discharging from the upper zone into the Meandering Road Creek, and 3) characterize the hydrologic flow system at Landfill No. 3.

Previous investigations have roughly defined the extent of contamination. Additional soil borings are necessary, however to better define the lateral extent. Previous investigations also did not adequately define the flow characteristics of the groundwater at Landfill No. 3. This flow information is necessary to determine contaminant fate and transport as well as risk to human health and the environment. More information is needed on the amount of contaminants being discharged and received by the Meandering Road Creek drainage; this information is needed for risk assessment and evaluation of remedial action alternatives.

3.3.4.3 Sampling and Analytical Design

A sampling grid will be established on 100 foot centers across Landfill 3 (Figure 3-4). Soil borings will be drilled and sampled at grid points to help define the lateral and vertical extent of contamination. The borings will be drilled from the surface to the top of the Walnut Formation. Grab samples for VOCs and composite samples for semi-VOCs, total metals, and oil and grease will be collected for each two foot interval to the top of the water table.

Selected soil borings (4-6) will be used as temporary monitoring wells for water level measurements and two rounds of groundwater sampling. The groundwater will be analyzed for VOCs, semi-VOCs, total petroleum hydrocarbons, and total metals. The data from the temporary wells will provide groundwater flow and quality data to be used in contaminant transport modeling.

Aquifer tests will be performed on monitoring wells that were properly completed and not previously tested to determine hydraulic conductivity and groundwater flow velocity of the upper zone at Landfill No. 3. The tests will be performed using the slug withdrawal method.

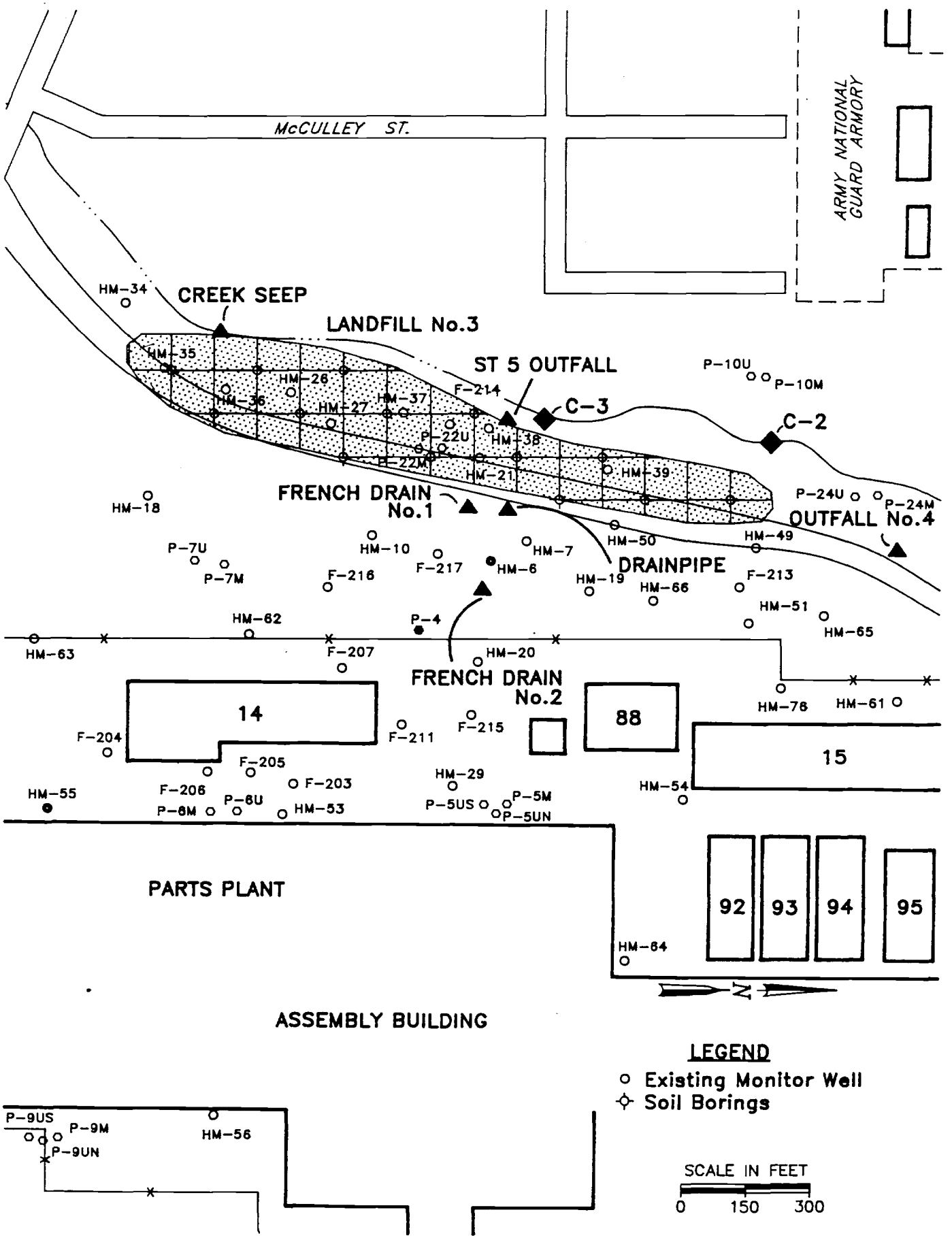


Figure 3-4 Landfill 3 sampling area and sample location map

Groundwater from seeps downgradient of the landfill along Meandering Road Creek will be sampled to estimate the amount and relative concentrations of contaminants discharging from the upper zone into the Meandering Road Creek drainage. The seep samples will be analyzed for VOCs, semi-VOCs, total petroleum hydrocarbons, and total metals.

To determine if contaminants from upper zone discharge are migrating to the Paluxy aquifer, one upper Paluxy monitoring well will be installed which is hydraulically downgradient of Landfill No. 3. A groundwater sample will be collected after well completion and development and again after one month. If the results of the two samples differ significantly, a third sample will be collected one month after the second round. Each sample will be analyzed for VOCs, semi-VOCs, total petroleum hydrocarbons, and total metals.

Channel soil and sediment sampling will be conducted across the Meandering Road Creek drainage to determine contaminant distribution from the point of upper zone discharge (seeps) to the present stream channel. Approximately 10 samples spaced 10 feet apart will be collected from the surface to a depth of two feet from a point adjacent to the seep extending to the creek in an area west of monitoring well F-214 (Figure 3-4). The soil and sediment samples will be analyzed for VOCs, semi-VOCs, oil and grease, and metals. Results of this study will be compared with results of the detailed study of the Meandering Road Creek (see Section 3.3.18.6, this Plan).

Prior to sampling new or existing monitoring wells, fluid levels in each well will be measured using an interface probe to determine the presence or absence of free-floating product. Free floating product from monitoring wells, where present, will be sampled using a Teflon™ bailer and analyzed using ASTM method D 3328-78 (reapproved 1982) to identify the type(s) of product present. Product chromatograms resulting from the scan will be evaluated based on alkane content and their aromatic profiles to identify the type(s) of contamination present. The chromatograms will be compared with chromatograms of known samples of various fuel products (i.e., JP-4, Avgas, Jet A, fuel oil, gasoline, etc.). The results will also be evaluated to determine if the product spill appears to be relatively recent or old based on ratios of light and heavy volatile fractions compared with ratios derived from new product.

3.3.5 Landfill No. 4

3.3.5.1 Findings

Landfill 4, located adjacent to Meandering Road near the southwest boundary of the AFP 4 facility, utilized a low area of the Meandering Road Creek floodplain for the disposal of construction rubble. Some evidence exists that suggests that other types of waste may have been disposed of at the landfill. These may have included small quantities of solvents, oils, fuels, and thinners.

VOCs and other organic compounds were reported in early investigations but were not confirmed during the IRP Phase II investigations. A "No Further Action" remedial action alternative was previously recommended. Soil samples, however have not been collected at this site. On the basis of a review of aerial photographs of the landfill when it was still in use, it appears that materials other than construction rubble were deposited in the landfill.

Because the landfill is located on the Meandering Road Creek floodplain, a potential exists for migration of contaminants into the surface waters of Meandering Road Creek.

3.3.5.2 Sampling and Analysis Objectives

Although this site has been recommended for "No Further Action", there are not sufficient data to support this decision. The decision is based solely on groundwater monitoring data from two monitoring wells with one (HM-5) being in the upper (upgradient) portion of the landfill and the other (HM-9) being downgradient of the landfill (Figure 3-5). The objective of the proposed sampling at Landfill No. 4 is to evaluate whether leachate is flowing from the base of the landfill into the adjacent soils on the floodplain of Meandering Road Creek.

3.3.5.3 Sampling and Analytical Design

Five soil borings along the base of the landfill will be drilled to a maximum depth of 10 feet and samples will be collected from two foot intervals (i.e.2-4, 4-6, 6-8, and 8-10 feet below the surface). With the exception of the samples for VOCs, each two foot interval will be composited and analyzed for semi-VOCs, oil and grease, and metals. Samples for VOCs will be grab samples from each two foot interval and will be collected immediately "as-is."

Analytical data for soil samples from Landfill No. 4 will be evaluated against background data to determine if contaminants above background concentrations are present. For those contaminants that are above background, a risk assessment will be performed. If the risk is within the acceptable range according to EPA Risk Assessment guidance, a "No Further Action" decision document will be prepared and submitted to regulatory agencies for concurrence. If contamination is found to exist, supplemental sampling may be recommended to better define the extent of contamination in support of Feasibility Studies.

3.3.6 FDTA No. 2

3.3.6.1 Findings

FDTA No. 2, currently located under the pavement of the West Parking Lot north of the Landfill No. 1 site, was used for fire training exercises for a period of two years. It was suspected that disposal of oils and fuels and uncontrolled burns may have also occurred while the FDTA No. 2 was in operation.

Both soil and groundwater results from previous investigations indicate that fuel-related contamination is present at FDTA No. 2. Groundwater collected from the approximate center of FDTA No. 2 was found to contain contaminants which indicate that solvent-related free product is present. The lateral and vertical extent of contamination has not been defined. Also, the hydraulic parameters of the upper zone in the area of FDTA No. 2 have not been adequately defined.

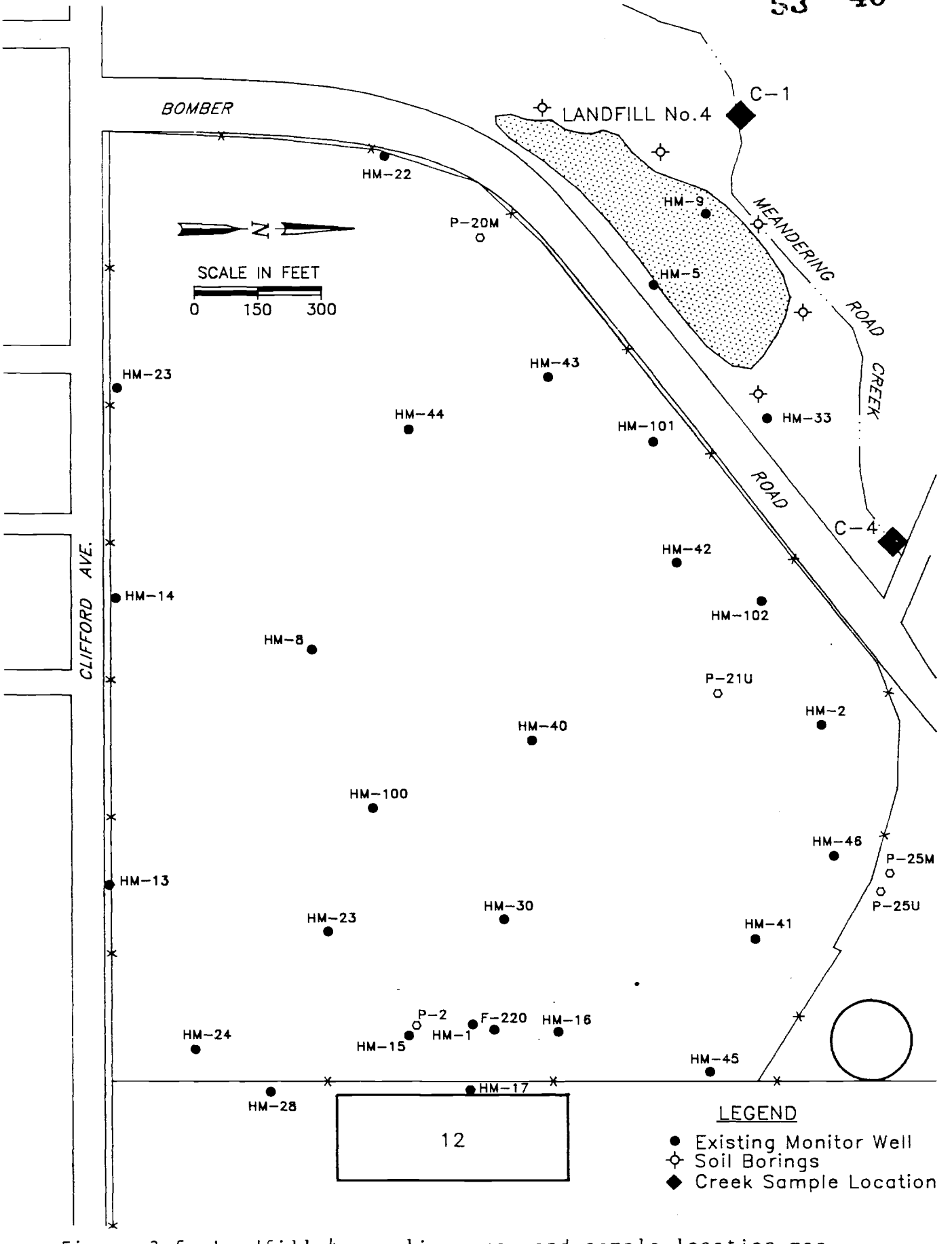


Figure 3-5 Landfill 4 sampling area and sample location map

3.3.6.2 Sampling and Analysis Objectives

The objectives of the proposed sampling activities at FDTA No. 2 are to: 1) determine the lateral and vertical extent of contamination in soils; 2) determine if the groundwater contains contaminants associated with FDTA No. 2; and 3) obtain information on the hydrologic system at FDTA No. 2 to allow contaminant transport modeling.

3.3.6.3 Sampling and Analytical Design

Four soil borings (Figure 3-6) will be drilled surrounding monitoring well HM-51 which is located near the approximate center of FDTA No. 2. The borings will be located 25 feet north, south, east, and west of existing well HM-51. Soil samples will be collected from the borings to determine the vertical extent and provide preliminary information on the horizontal extent of contamination. The soil samples will be collected from the surface to the top of the water table in two foot intervals (0-2, 2-4, 4-6). Grab samples for VOCs will be collected for each interval and the remaining material will be composited and analyzed for semi-VOCs, total petroleum hydrocarbons, and metals.

Up to four additional soil borings may be drilled outward from contaminated zones identified in the initial soil borings if contaminants above background concentrations are found. These additional borings will be drilled and sampled using the same sampling protocol as the initial borings.

The initial four soil borings will be deepened to the top of the Walnut Formation after soil has been sampled to the top of the water table. Groundwater will be bailed from the borings and analyzed for VOCs, semi-VOCs, and total petroleum hydrocarbons. If contaminants associated with FDTA No. 2 are detected in the groundwater, recommendations will be made for the installation of downgradient monitor well(s). If the boring upgradient of HM-51 is found to contain contaminants, recommendations will be made to evaluate other potential source areas.

3.3.7 FDTA No. 5

3.3.7.1 Findings

FDTA No. 5, which is located in the Die Yard area south of Facilities Building No. 12 (Figure 3-7) consisted of a shallow pit which received waste fuels, oils, and unspecified chemicals which were burned for fire extinguisher training exercises.

Analytical results from soil samples collected from two soil borings within the pit area indicate that the shallow soils do not contain significant concentrations of contaminants. Groundwater samples, however, contained anomalous concentrations of VOCs, semi-VOCs and fuel hydrocarbons. Fuel-related product was observed in a monitoring well in the vicinity of FDTA No. 5. Arsenic was also observed in monitoring wells at FDTA No. 5 in concentrations exceeding drinking water standards.

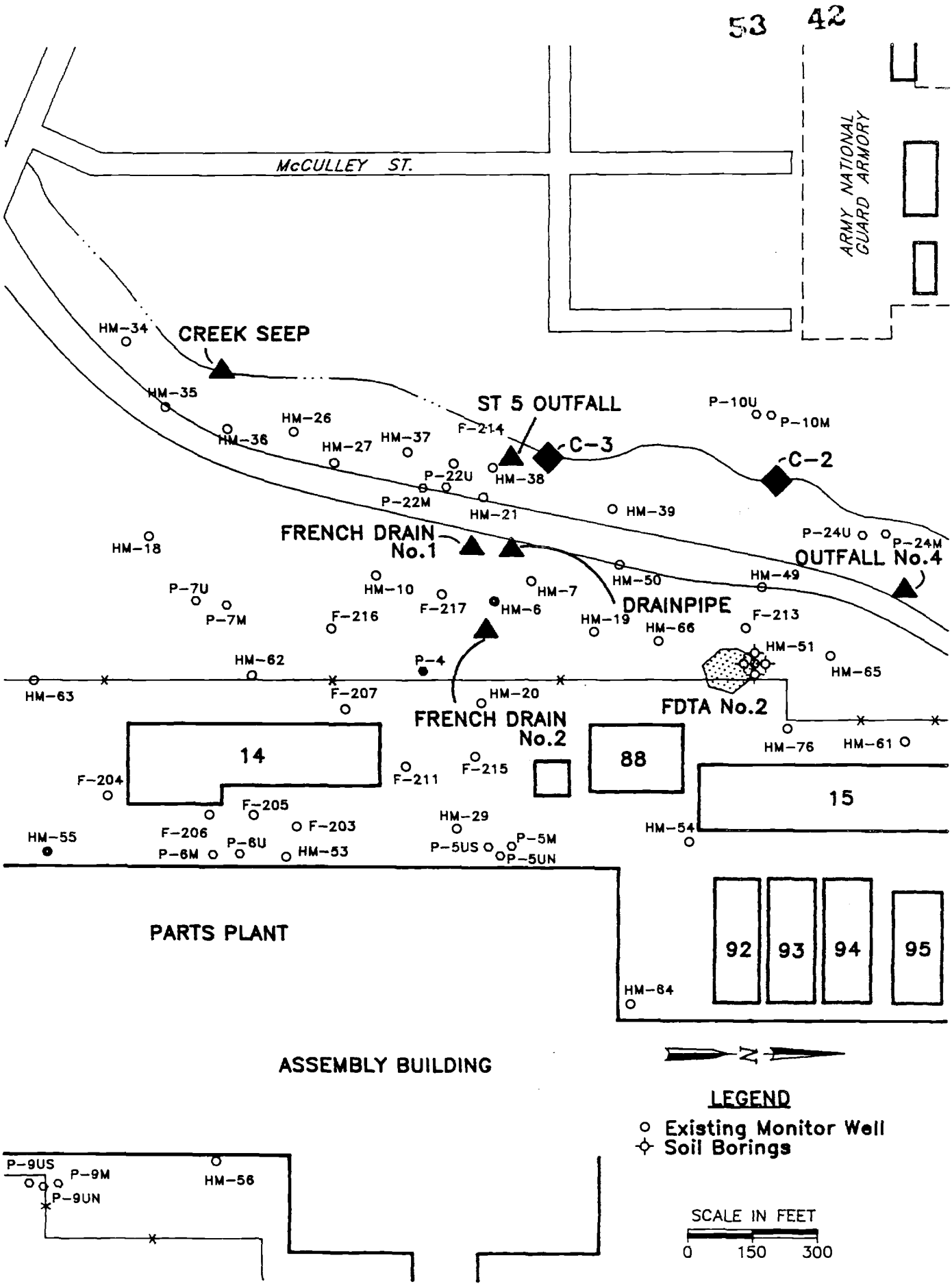


Figure 3-6 FDTA No. 2 sampling area and sample location map

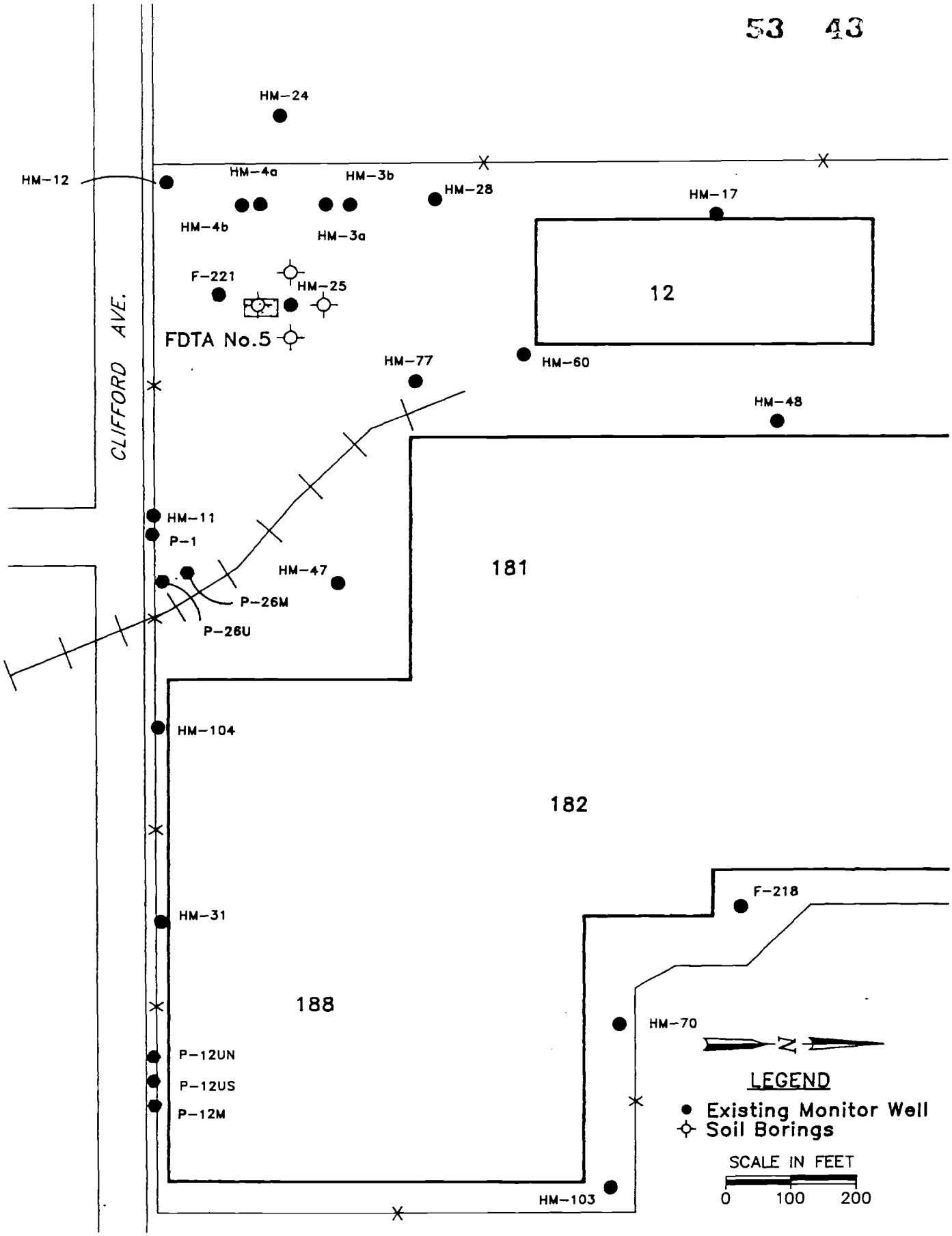


Figure 3-7 FDTA No. 5 sampling area and sample location map

3.3.7.2 Sampling and Analysis Objectives

Although previous investigations indicate that the soils at FDTA No. 5 are not contaminated, additional soil sample data are needed to confirm these initial findings. If the soils are not contaminated, the groundwater contamination found in the FDTA No. 5 area may be related to a different upgradient source of contamination. Additional groundwater data are needed from upgradient monitoring wells and downgradient monitoring wells to determine if the FDTA No. 5 is a source area for groundwater contamination. Aquifer testing is needed to characterize the hydraulic parameters of the upper zone in the FDTA No. 5 area to allow groundwater flow and contaminant transport modeling.

3.3.7.3 Sampling and Analytical Design

Four soil borings will be drilled at FDTA No. 5 to help define the lateral extent of soil contamination. The soil borings will be located 50 feet north, south, east, and west of monitoring well HM-25 which is located near the reported center of the training area. The borings will be drilled to the top of the water table and soil samples will be collected in five foot intervals. Samples for VOC analysis will be grab samples taken from each 5 foot interval. The remaining samples will be composite samples representing the entire 5 foot interval. The composite samples will be analyzed for semi-VOCs, oil and grease, and metals.

The east and west soil borings will be extended to the top of the Walnut Formation using the same method (hollow-stem auger drilling) used to reach the top of the water table. These two borings will be included as the DNAPL portion of the nested monitoring wells. Other boreholes will be drilled nearby to enable sampling of discrete intervals for LNAPLs and soluble organic compounds. Groundwater samples will be taken after completion and then one month later for one additional sampling round. The samples will be analyzed for VOCs, semi-VOCs, total metals, TPH, and oil and grease. The western nested well will be used to determine if upgradient sources are contributing to contamination found in monitoring well HM-25. The eastern nested well will be used to assess the contribution of FDTA No. 5 to downgradient groundwater contamination. If the results of the first two rounds of sampling are not consistent, a third round (one month after the second round) will be collected.

Water-level measurements and aquifer tests will be performed on the new monitoring wells to aid in the determination of flow directions and hydraulic parameters of the upper zone at FDTA No. 5. Aquifer tests will be completed using the slug-withdrawal method.

3.3.8 FDTA No. 6

3.3.8.1 Findings

FDTA No. 6 was the primary fire department training area at AFP 4. It is located on the northwestern side of AFP 4 adjacent to Meandering Road. The training area was used from the late 1950's to 1980 for periodic training exercises which used approximately 250 gallons of waste fuels and oils per exercise. The IRP Phase I investigation indicated that unknown quantities of fuels and oils were likely deposited in the FDTA No. 6 between training exercises.

Analytical results from previous investigations indicate that the soils at FDTA No. 6 are contaminated with VOCs, semi-VOCs, fuel hydrocarbons, and oil and grease. Although no groundwater samples have been collected in the immediate area of FDTA No. 6, it is suspected that no upper zone groundwater exists in the area.

3.3.8.2 Sampling and Analysis Objectives

Interim remedial action was performed at FDTA No. 6 in 1982 and 1983 when oil and fuel contaminated soils were removed and hauled to an approved hazardous waste landfill. Although most of the contamination may have been removed, there are insufficient data to verify that remaining contaminants no longer exceed federal MCLs. To confirm that the FDTA No. 6 does not pose a threat to human health or the environment, additional information is needed to define the overall extent of contamination.

3.3.8.3 Sampling and Analytical Design

On the basis of a review of information concerning the interim remedial action, 4 to 6 soil borings will be drilled around the perimeter of the excavated portion of FDTA No. 6 (Figure 3-8). The borings will be drilled to the top of the Walnut Formation and a single sample will be collected with VOCs being sampled immediately as grab samples and the remaining sample material being composited over the entire length of the boring. The composited soils will be analyzed for semi-VOCs, oil and grease, and metals. In addition, a single boring will be drilled in the approximate center of the excavated portion of the FDTA and samples will be collected and analyzed using the same protocol specified for the other borings at FDTA No. 6 to determine if contamination exists below the excavated zone.

Although it is suspected that no upper zone groundwater is present at this location, if water is encountered in any of the soil borings, the water will be bailed from the boring and analyzed for VOCs, semi-VOCs, and total petroleum hydrocarbons. If groundwater is present, the boring(s) will be completed as groundwater monitoring wells. The monitoring well, since it would most likely be shallow, will be fully screened to allow detection of LNAPLs, DNAPLs, and soluble organic compounds.

3.3.9 Chrome Pit No. 3

3.3.9.1 Findings

Chrome Pit No. 3, located on the Radar Range west of Facilities Building No. 12 (Figure 3-9), was used for the disposal of chromate, barium-chromate sludge, dilute metal solutions, and drums of unidentified liquids.

In 1983 and 1984, approximately 8,900 cubic yards of contaminated soil was excavated and removed from the pit as an interim remedial action.

3.3.9.2 Sampling and Analysis Objectives

Although remedial action has been performed at Chrome Pit No. 3, the amount of samples collected within the excavated area were not sufficient to determine that the site no longer poses a threat to human health or the environment.

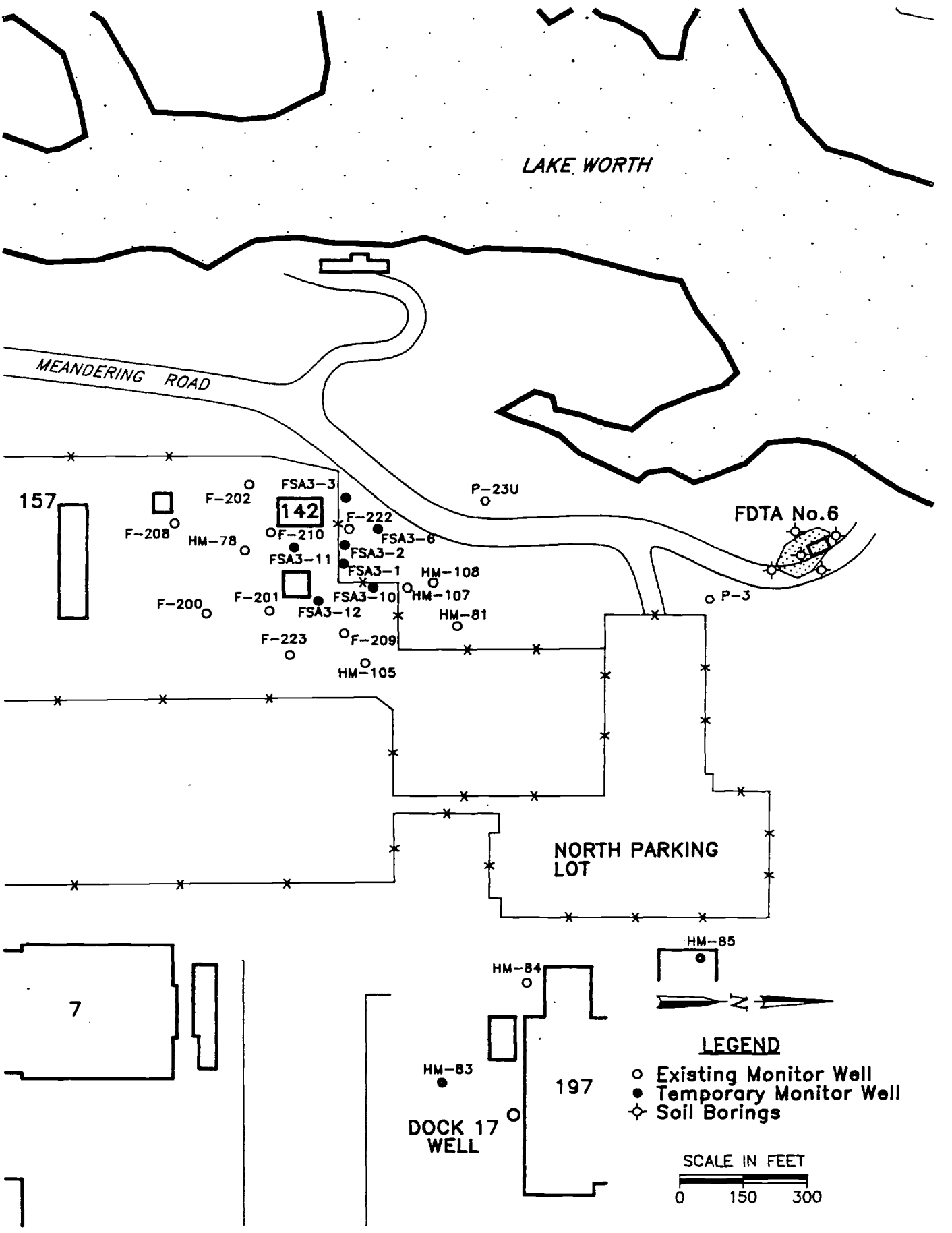


Figure 3-8 FDTA No. 6 sampling area and sample location map

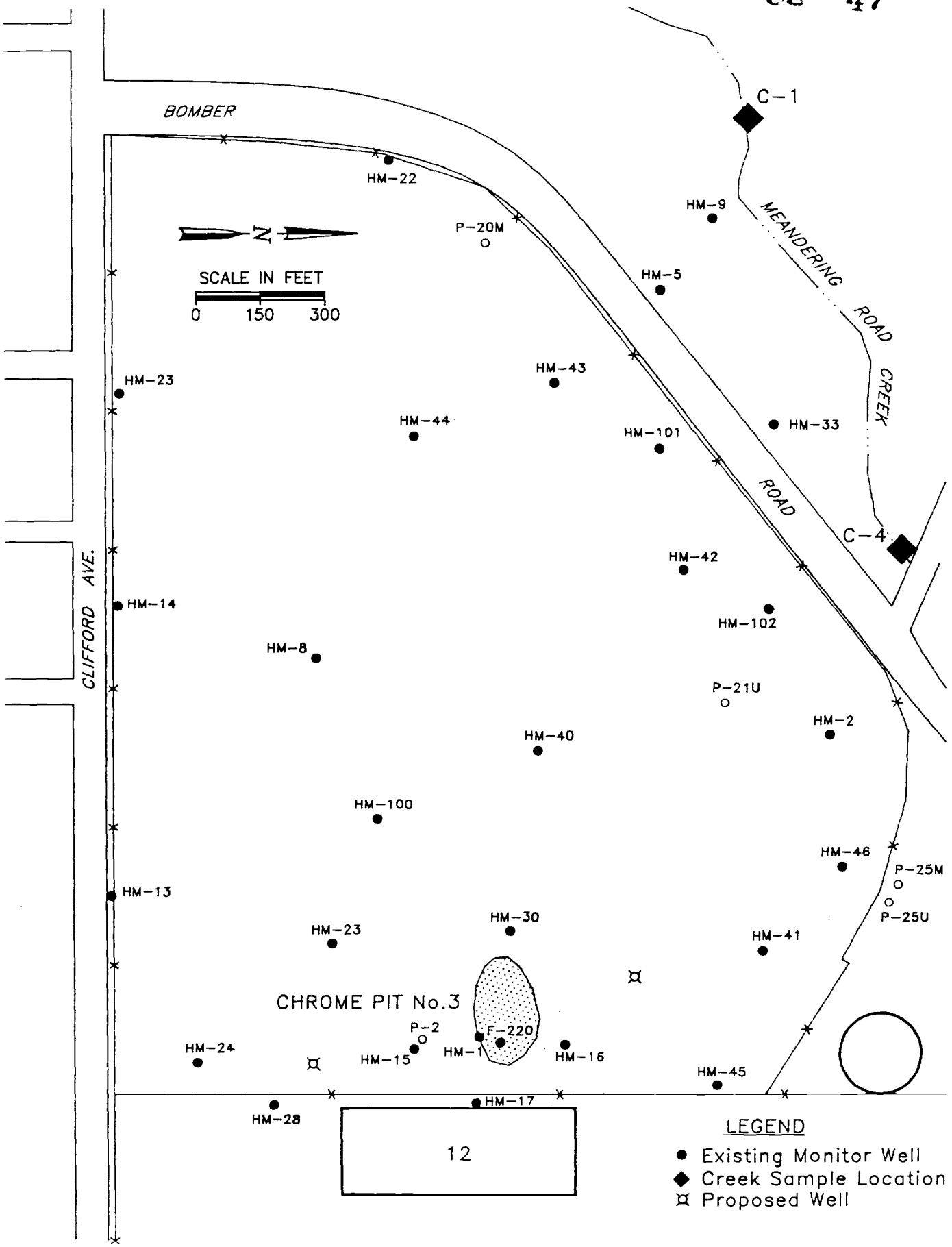


Figure 3-9 Chrome Pit No. 3 sampling area and sample location map

Soil samples are needed around the perimeter of the excavated portion of the area to determine if contaminants exceeding federal MCLs are still present.

Future plans for the Chrome Pit No. 3 site include the building of a new chemical processing building over the site. Additional sampling of the shallow subsurface was conducted in December, 1989 to provide information needed to clear the area for laying the foundation for the new building. The results from this sampling will be combined with the results of sampling proposed in this plan to make a final remedial action alternative decision.

The December, 1989 soil sampling was concentrated around the perimeter of the former excavation and the additional area to be occupied by the proposed chemical waste treatment process building (Figure 3-10). Borings were drilled to a nominal depth of 10 feet with samples being collected over 2 foot intervals. Samples for VOCs were grab samples whereas the remainder of the samples represented composites of each 2 foot interval. The samples were analyzed for VOCs, semi-VOCs, and metals (including hexavalent chromium). Analytical results indicated that no contaminants above background concentrations were present in Chrome Pit No. 3 soils.

3.3.9.3 Sampling and Analytical Design

No further soil investigations appear to be required based on the results of the December, 1989 soil sampling. Since contamination was previously identified in groundwater at Chrome Pit No. 3, however, one upgradient and one downgradient monitoring well will be installed to help determine the source of contaminants to the groundwater in the Chrome Pit No. 3 area. The monitoring wells will be completed to allow sampling of discrete intervals for LNAPLs, DNAPLs, and soluble organic compounds.

Groundwater samples will be collected after well completion and development and again after one month. The samples will be analyzed for VOCs, semi-VOCs, and total metals. If the results of the two rounds differ significantly, a third sample will be collected one month after the second round.

Groundwater samples will also be collected from existing wells and will be analyzed for VOCs, semi-VOCs, and total metals. All samples from wells that previously contained detectable cyanide will be analyzed again for cyanide.

Water-level measurements and aquifer tests will be performed on existing wells that were properly completed and not previously tested and on all new monitoring wells in the Chrome Pit No. 3 area to determine flow directions and hydraulic parameters for groundwater flow and contaminant transport modeling. Aquifer tests will be conducted using the slug-withdrawal method.

3.3.10 Die Yard Chemical Pits

3.3.10.1 Findings

The die yard chemical pits, located east of the Radar Range and south of Facilities Building No. 12, were used for the disposal of chromate sludges, metal solutions, and other chemical wastes. In 1962, the site was graded and the entire die yard was paved. On the basis of the IRP Phase I investigation, it is suspected that contaminated soils from the pits may have been spread

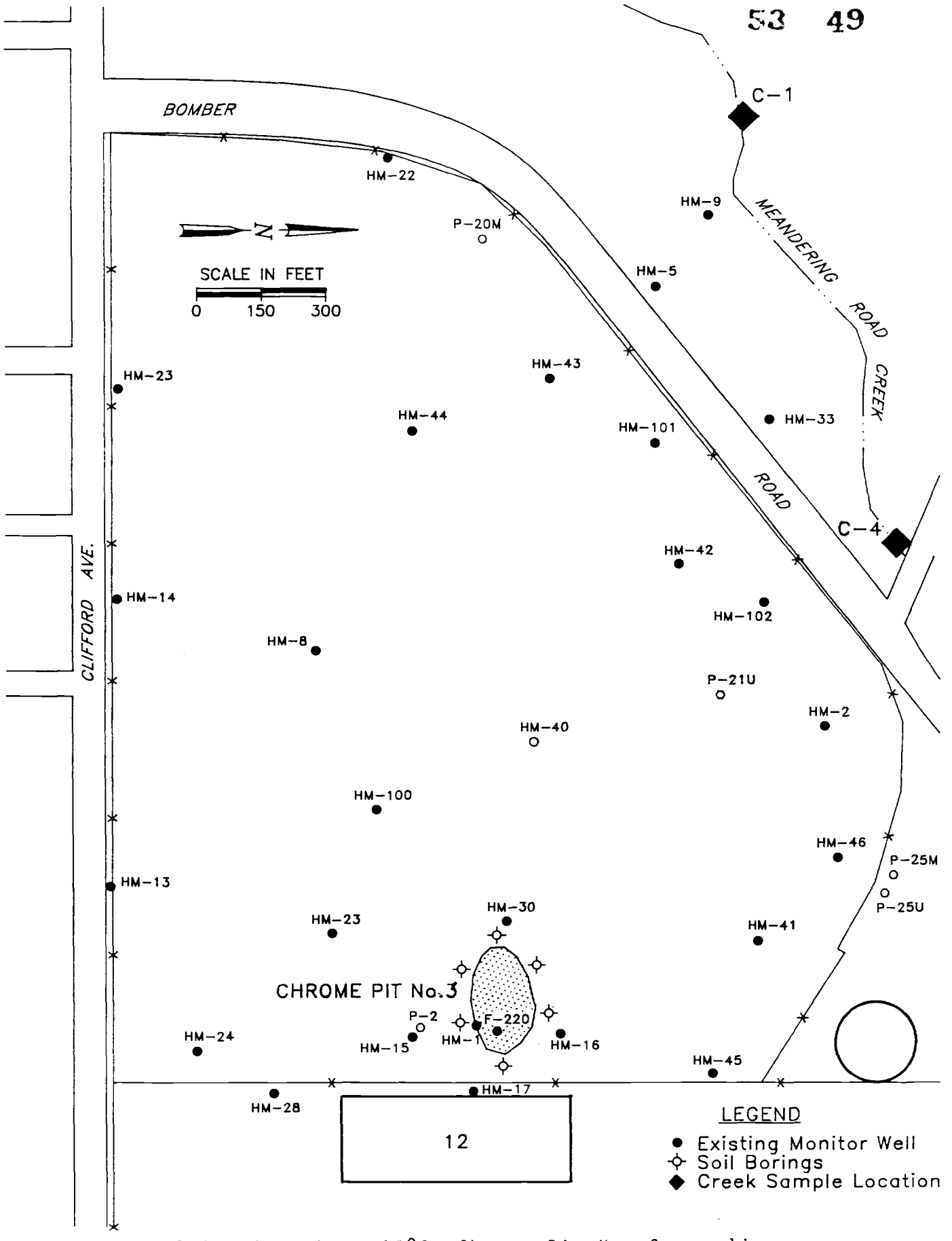


Figure 3-10 December, 1989, Chrome Pit No. 3 sampling area and sample location map

around the die yard area during the grading activities. The site of the original pits was excavated and 1,100 cubic yards of contaminated soil were removed and transported to an approved hazardous waste landfill for disposal. Confirmation sampling was not conducted to verify that the area was adequately remediated.

3.3.10.2 Sampling and Analysis Objectives

Sampling and analysis of the soils in the entire die yard pit area is needed to determine if contaminants exceeding background concentrations are present and if they are present, their lateral and vertical extent. Results of previous investigations indicate that contaminants were still present following the interim remedial action of the pits.

Groundwater contamination has not been adequately characterized during previous investigations and the hydrologic flow system at the site has also not been characterized. Additional monitoring wells are needed to assist in determining whether groundwater contamination in the die yard pit area can be attributed to the former pits or whether it is a result of other upgradient sources.

3.3.10.3 Sampling and Analytical Design

Eight soil borings will be drilled around the periphery of the excavated pit(s) area to determine the lateral and vertical extent of contamination. In addition, two soil borings will be drilled in the central portion of the excavated area to determine the effectiveness of the interim remedial action (Figure 3-11). The borings will be drilled to the top of the water table and soil samples will be collected from five foot intervals (0-5, 5-10, 10-15, etc.). Samples collected for VOCs will be grab samples collected "as is" from each interval whereas, the remaining samples will be collected from composites from each five-foot interval. The composite samples will be analyzed for metals, cyanide, and semi-VOCs. The soil borings in the central portion will only have samples collected from the 15-20 and 20-25 foot intervals.

One of the soil borings on the east side of the die yard pits will be completed as an upper zone monitoring well to evaluate the groundwater quality immediately downgradient of the former pits. The monitor well will be completed to allow sampling of discrete intervals for LNAPLs, DNAPLs, and soluble organic compounds. A groundwater sample will also be collected from existing well HM-24 which is located upgradient of the site. Samples will be analyzed for VOCs, semi-VOCs, total metals, and cyanide.

Slug-withdrawal tests will be performed on the new well to determine the hydraulic parameters of the upper zone in the die yard area.

3.3.11 <u>FSA No. 1</u>

3.3.11.1 Findings

FSA No. 1, which is located west of the Parts Plant and east of Facilities Building No. 14 (Figure 3-12), is the site of an area where the ground reportedly became saturated by fuels leaking from fuel lines over

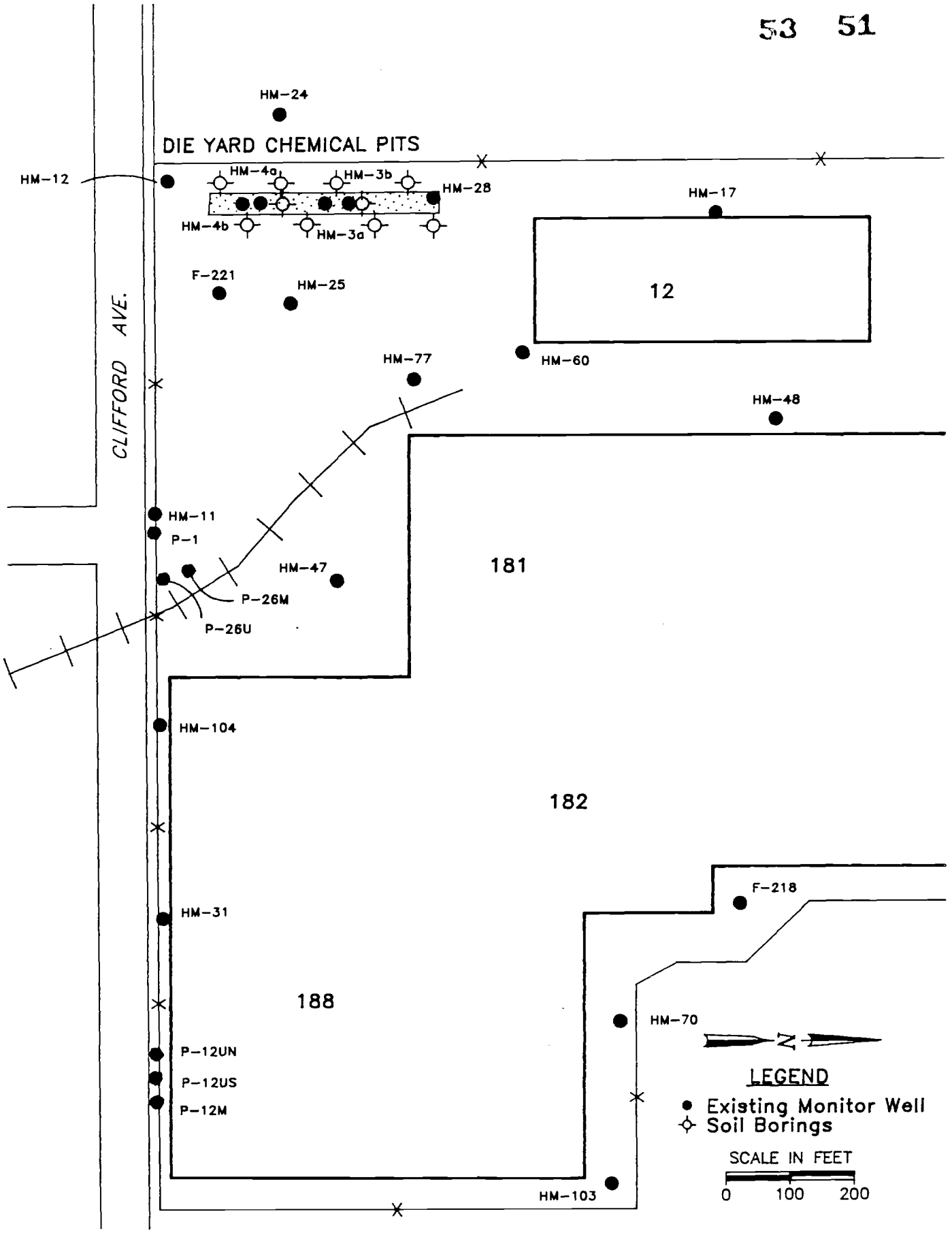


Figure 3-11 Die yard chemical pits sampling area and sample location map

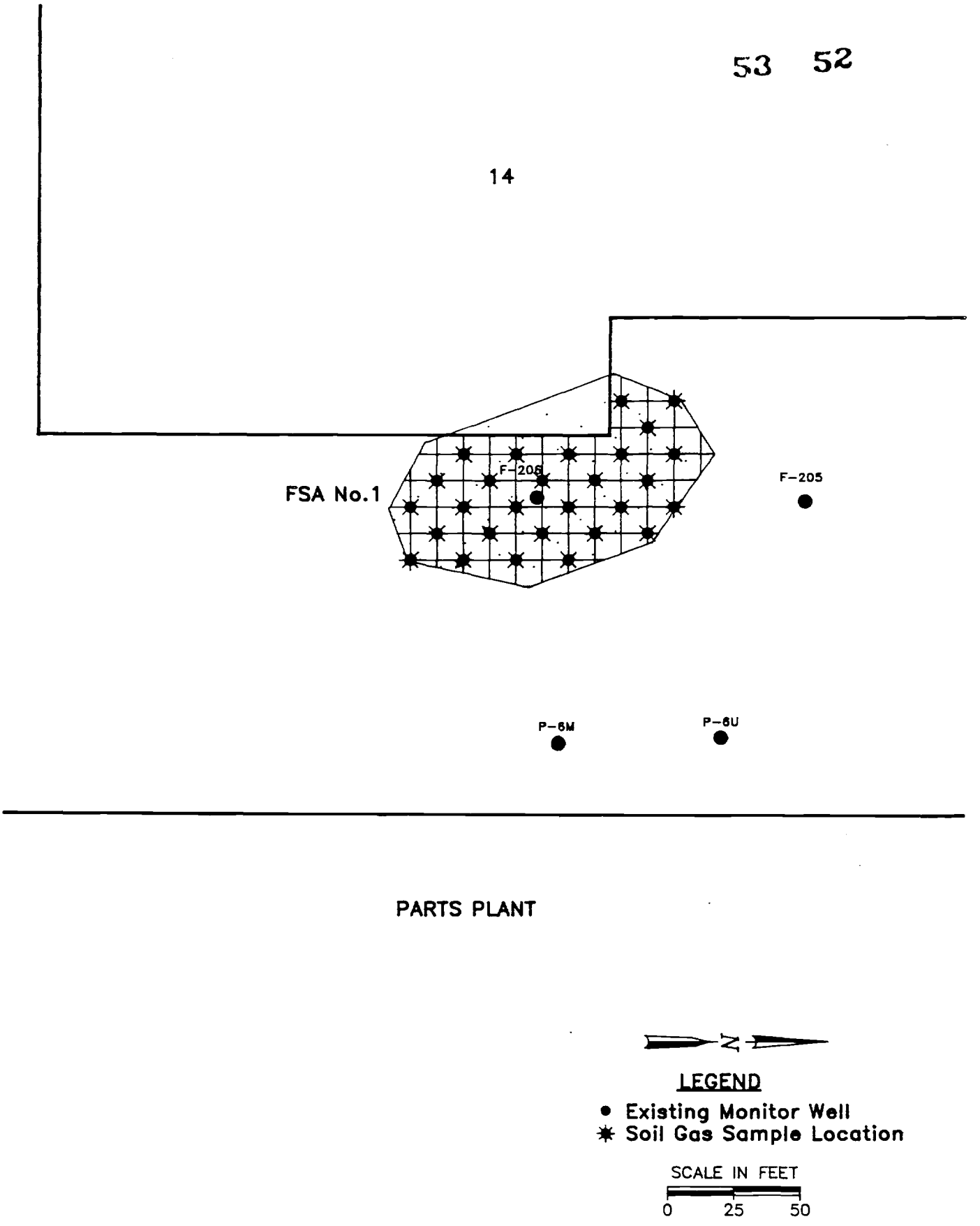


Figure 3-12 FSA No. 1 sampling area and sample location map

approximately a ten year period. The saturated area is immediately north of underground fuel tanks and a fuel pumping station.

Analytical results from previous investigations indicate that the soils (from one boring) are contaminated with fuel hydrocarbons. Groundwater collected from monitoring wells in the FSA No. 1 area also contain anomalous concentrations of VOCs, semi-VOCs, fuel hydrocarbons and metals. Three of the monitoring wells were reported to contain significant amounts of fuel-related floating product.

Engineering designs have been developed by General Dynamics for an interim remedial action groundwater treatment system designed to recover floating product and treat the groundwater.

3.3.11.2 Sampling and Analysis Objectives

Due to the presence of significant amounts of floating product in wells at FSA No. 1, interim remedial action is necessary to reduce the potential risk to human health and the environment. Implementation of a product recovery system will occur concurrently with additional RI/FS field investigation activities.

The overall extent of soils contamination needs to be defined as well as the extent of floating product and groundwater contamination. The sampling approach will be designed to identify the extent of potential source contaminants upgradient and the extent of contamination already in the groundwater flow system downgradient. This information must be obtained to evaluate remedial action alternatives design for source control (i.e. removal of contaminated soils and removal of floating product) and alternatives designed to treat contaminated pathways (i.e. groundwater treatment facilities, French Drains).

3.3.11.3 Sampling and Analytical Design

As an interim remedial action, a free product removal system will be installed and free product will be removed and disposed of concurrently with RI/FS studies. This system will be installed by the operating contractor, General Dynamics. UNC Geotech will monitor the effectiveness of this interim remedial action when developing remedial action alternatives for the site.

A soil gas survey will be conducted in the FSA No. 1 area to better define the overall lateral extent of fuel-related contamination. The soil gas survey will be conducted on a grid using a 10 foot spacing. Soil gas measurements will initially be made at half of the grid points at a depth of four feet using a Photovac TIP. A Dräger tube (or equivalent) sample for petroleum hydrocarbons will be collected at each location. At ten percent of the locations, a sorbent tube will also be used to collect a sample to be sent to an analytical laboratory for VOC analysis. Where better definition is needed in specific areas, the remaining grid locations will be used.

Background soil gas samples will be collected outside of the area of suspected contamination. The results of the survey at FSA No. 1 will be compared with the background data. On the basis of this comparison, up to 10 soil borings will be selected at grid points in areas where contaminants exceed background concentrations. The borings will be drilled to the top of the water table and

soil samples will be collected from five-foot intervals. Samples to be analyzed for VOCs will be grab samples whereas the remaining samples will be taken from composites of each five foot interval. The composite samples will be analyzed for semi-VOCs, total petroleum hydrocarbons, and metals.

Five of the ten borings will be completed as upper zone groundwater monitoring wells. The locations of these wells will generally correspond to the estimated maximum extent of the zone of contamination. The wells will be completed in a way that allows sampling of discrete intervals for LNAPLs, DNAPLs, and soluble organic compounds. The wells will be sampled after completion and development and resampled a month later for one additional sampling round. The groundwater will be analyzed for VOCs, semi-VOCs, total metals, and total petroleum hydrocarbons. If floating product is observed in any of the new wells, the wells may be added to the product recovery system. This will require the installation of four-inch wells.

Slug-withdrawal tests will be performed on all new monitoring wells. The results will be compared with aquifer test data from existing wells to define the hydraulic parameters of the upper zone at the FSA No. 1 area. Water-level measurements will be taken prior to each sampling from all wells in the FSA No. 1 area to determine groundwater flow directions and flow velocity. Water-level measurements will also be made prior to, during, and after remedial action so that the natural and modified groundwater flow directions can be determined.

3.3.12 FSA No. 2

3.3.12.1 Findings

FSA No. 2, located northwest of Facilities Building No. 176 (Figure 3-13), is a site which reportedly was saturated by fuels leaking from a buried fuel pipeline in the 1970s and early 1980s.

From five soil borings that were drilled and sampled during previous investigations, only one shallow soil sample was reported to contain anomalous concentrations of VOCs and fuel hydrocarbons. Samples for one of two groundwater monitoring wells in the FSA No. 2 area also contained only trace amounts of fuel hydrocarbons.

3.3.12.2 Sampling and Analysis Objectives

Although soil and groundwater contamination at the FSA No. 2 does not appear to be extensive, additional information is needed on the lateral and vertical extent of contamination. The location of the borings required to assess the extent of contamination will be based on the location of the boring and monitoring well containing contaminants in previous investigations.

The hydrologic flow system also needs to be better defined in the FSA No. 2 area. Aquifer testing is needed to characterize the hydraulic parameters of the upper zone to be used in groundwater and contaminant transport modeling.

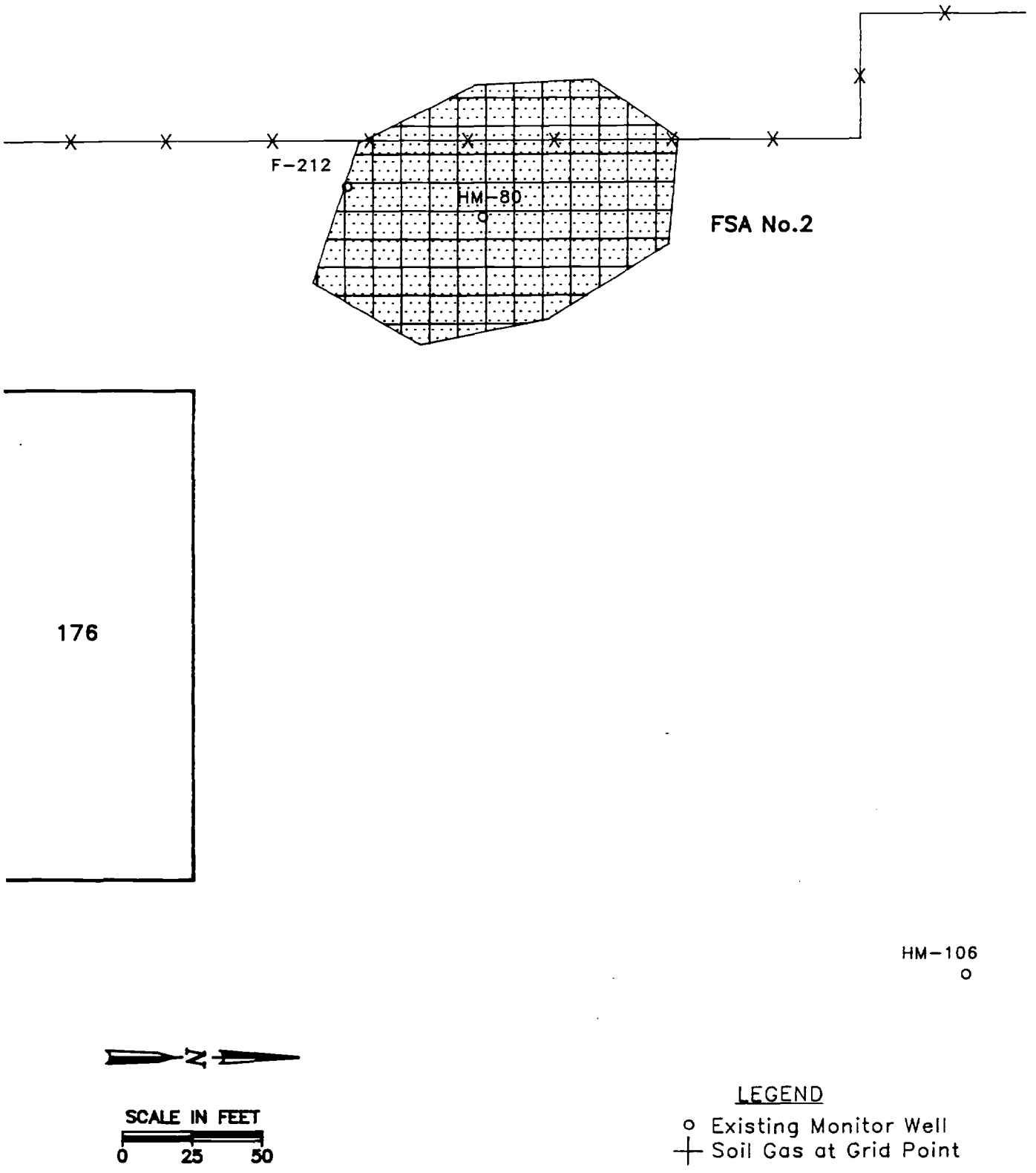


Figure 3-13 FSA No. 2 sampling area and sample location map

3.3.12.3 Sampling and Analytical Design

A soil gas survey will be conducted as a screening tool over the FSA No. 2 area. The survey will be conducted using a 20 foot grid spacing. Soil gas measurements will be initially made at a depth of four feet using a calibrated Photovac TIP. In addition, Dräger tube (or equivalent) samples for petroleum hydrocarbons will be used at each location. At 10 percent of the locations, a sorbent tube will be used to collect a sample for laboratory VOC analysis.

Results of the soil gas survey will be used to guide the placement of soil borings. Five soil boring locations will be selected at grid locations where soil gas measurements indicated anomalous amounts of fuel-related contamination when compared to background concentrations for the area. Locations for soil borings will be submitted to EPA Region VI for review and concurrence. These borings will be drilled from the surface to the top of the water table (estimated 15 feet) and samples will be collected in three foot intervals. Samples for VOCs will be grab samples from each three foot interval. The remaining samples will be composites of each three foot interval and will be analyzed for semi-VOCs and total petroleum hydrocarbons. These borings will be used to better define the lateral and vertical extent of contamination.

One additional conventional monitoring well (see Table 4-4) will be installed upgradient and one will be installed downgradient of FSA No. 2 to help define the lateral extent of the contaminant plume at FSA No. 2. Where possible, a soil boring will be completed as a monitoring well. Monitoring zones in separate boreholes will be placed to detect LNAPLs, solubles, and DNAPLs. Groundwater samples will be collected after completion and development and again after one month. A third round will be collected only if the results of the first two are in disagreement. Groundwater samples will be analyzed for VOCs, semi-VOCs, total petroleum hydrocarbons, and total metals.

3.3.13 FSA No. 3

3.3.13.1 Findings

FSA No. 3, which is located immediately east of Meandering Road between Facilities Building Nos. 157 and 142 (Figure 3-14), is a site contaminated by fuels from leaking buried fuel pipelines during the 1970s and early 1980s.

Fuel-related floating product has been observed in seven of thirteen wells in the area of FSA No. 3. Analytical results of groundwater samples show that the groundwater at FSA No.3 contains anomalous concentrations of VOCs, semi-VOCs and fuel hydrocarbons.

General Dynamics currently is in the process of providing engineering design of a system for the removal of floating product and the treatment of contaminated groundwater.

3.3.13.2 Sampling and Analysis Objectives

Installation and implementation of a system designed for the removal of floating product will take place concurrently with RI/FS activities as an interim remedial action at FSA No. 3.

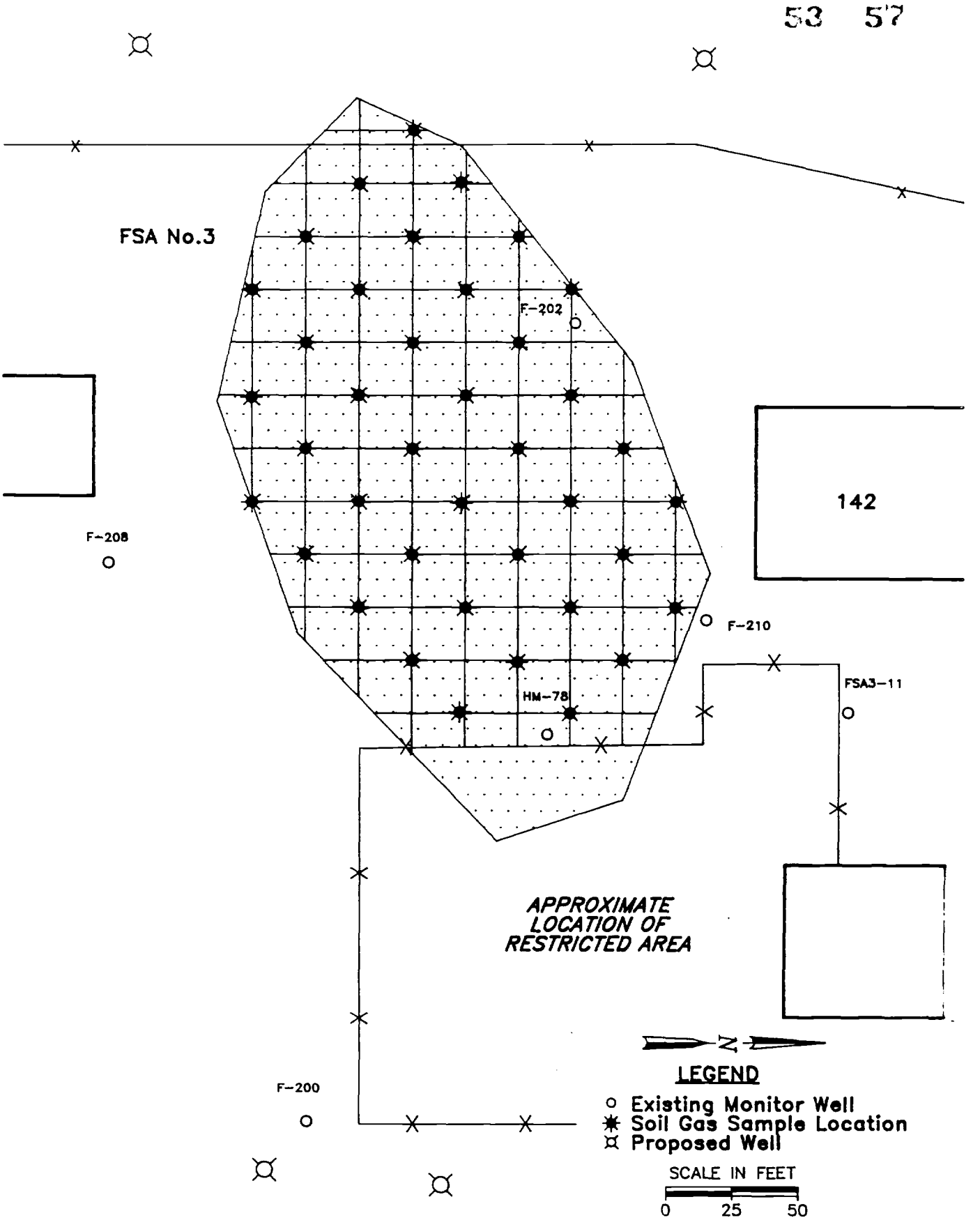


Figure 3-14 FSA No. 3 sampling area and sample location map

Additional hydrologic data are required to complete the RI/FS. Hydraulic parameters of the upper zone at FSA No. 3 are needed to conduct groundwater and contaminant transport modeling. This will require additional aquifer testing of both new and existing monitoring wells. Water-level measurements are needed to help determine flow directions at FSA No. 3. Water quality data are also needed to help define the extent of contamination. This will include installation and sampling of new wells as well as sampling of existing wells.

Additional soil sample data are required around the perimeter of FSA No. 3 to better define the lateral and vertical extent of contamination.

3.3.13.3 Sampling and Analytical Design

A free product recovery system will be installed by General Dynamics, Inc. and product recovery will begin concurrently with RI/FS activities.

A soil gas survey will be conducted using a grid spacing of 20 feet as a screening tool across the FSA No. 3 area to help define the lateral extent of soils contamination. Soil gas measurements will be made at a depth of four feet using a Photovac TIP at each location. A Dräger tube (or equivalent) for petroleum hydrocarbons will also be used for sampling at each location. At 10 percent of the locations, a sorbent tube will be used to collect a sample for laboratory VOC analysis.

Background soil gas measurements will be collected outside of the FSA No. 3 area and the results of the soil gas survey will be compared with the background data to determine areas that exceed background concentrations. On the basis of previous data, and the approximate extent of contamination outlined by the soil gas survey, from 5 to 10 soil borings will be drilled at grid point locations on the outer margin of the contaminated area to help define the lateral and vertical extent of contamination. Soil samples will be collected at 3 foot intervals from the surface to the top of the water table. The samples for VOCs will be grab samples from each three foot interval. The remaining samples will be composite of each interval. Composite samples will be analyzed for semi-VOCs and total petroleum hydrocarbons.

Four additional sets of nested monitoring wells will be installed -- two will be to the east and two to the west of FSA No.3 (Figure 3-14). Where possible, soil borings drilled for soil contamination data will be completed as monitoring wells. Monitoring zones will be placed in separate boreholes to detect LNAPLs, solubles, and DNAPLs. Groundwater samples will be collected from the new wells following completion and development and again after one month. A third round will be collected only if the results of the first two are in disagreement. Groundwater samples will be analyzed for VOCs, semi-VOCs, total metals, and total petrolem hydrocarbons. If floating product is observed in new monitoring wells, the wells will be added to the product recovery system as needed.

Aquifer tests using the slug withdrawal method will be performed on new monitoring wells and the results will be compared to and combined with previously obtained data from existing wells. These data will be used to determine the hydraulic parameters of the upper zone at FSA No. 3. Water-level measurements will be taken prior to each round of sampling from new monitoring wells and from existing wells to establish groundwater-flow

direction data. All of the hydrologic data will be used in groundwater and contaminant transport modeling.

3.3.14 Former Fuel Storage Area

3.3.14.1 Findings

A 100,000 gallon above-ground JP-4 storage tank which was located near the center of the Radar Range from the early 1940s to 1962 was suspected to have leaked.

Previous investigations have indicated that soils at the Former Fuel Storage Area are contaminated with semi-VOCs and oil and grease. In addition, anomalous concentrations of nickel were present in a monitoring well located south of the area.

3.3.14.2 Sampling and Analysis Objectives

Although the site was recommended for "No Further Action", additional soil and groundwater sampling are needed to confirm previous results and to provide additional data on the extent of contamination at the site.

3.3.14.3 Sampling and Analytical Design

Four soil borings will be drilled (one 25 feet north, south, east and west respectively of monitoring well HM-8 (Figure 3-15) where contamination was previously detected to determine the lateral and vertical extent of contamination. The borings will be drilled from the surface to the top of the water table with samples collected in five foot intervals. Samples for VOCs will be grab samples from each five foot interval. Other samples will be composites of each five foot interval. The composite samples will be analyzed for total petroleum hydrocarbons, semi-VOCs, and oil and grease.

An additional groundwater sample will be collected from monitoring well HM-14 and analyzed for nickel to confirm results of previous sampling.

3.3.15 Jet Engine Test Stand

3.3.15.1 Findings

The jet engine test stand site, located northeast of Facilities Building No. 142 and east of Meandering Road (Figure 3-16), was identified during IRP Phase II investigations as a site containing fuel-related contamination in soils and groundwater. The site is located north of a fuels test area and a known area of fuel contamination (FSA No. 3). Facilities Building No. 21 near the site has a sump which collects water for cooling, noise suppression, and building cleanup and pumps it to an industrial waste line. Just south of the site and Building No. 21 are two underground tanks once used for fuel storage. There appear to be several possible sources for contamination present at the jet engine test stand site.

3.3.15.2 Sampling and Analysis Objectives

Although the site was formerly recommended for "No Further Action", previous data indicate that significant concentrations of contaminants may be present

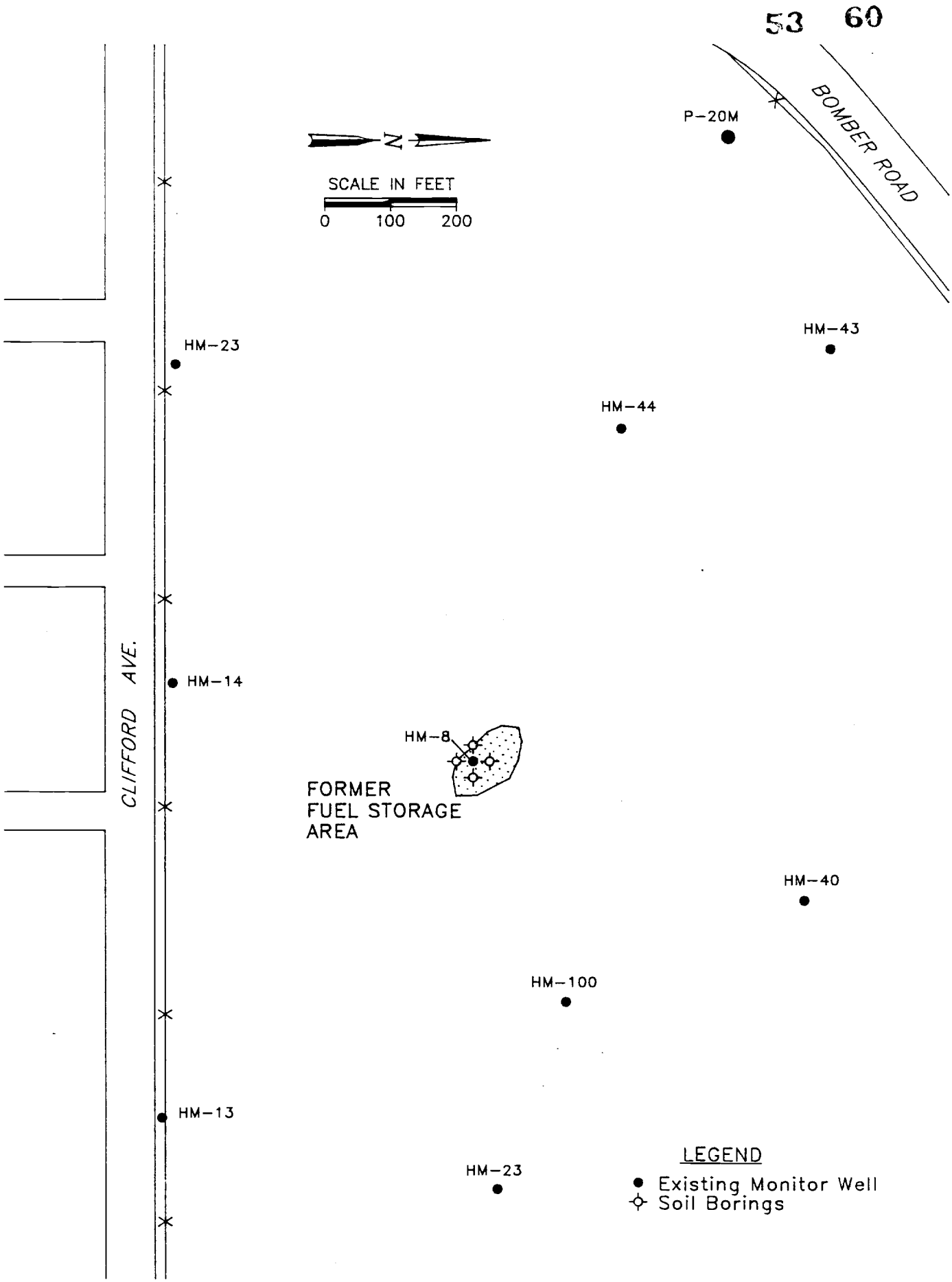


Figure 3-15 Former fuel storage area sampling area and sample location map

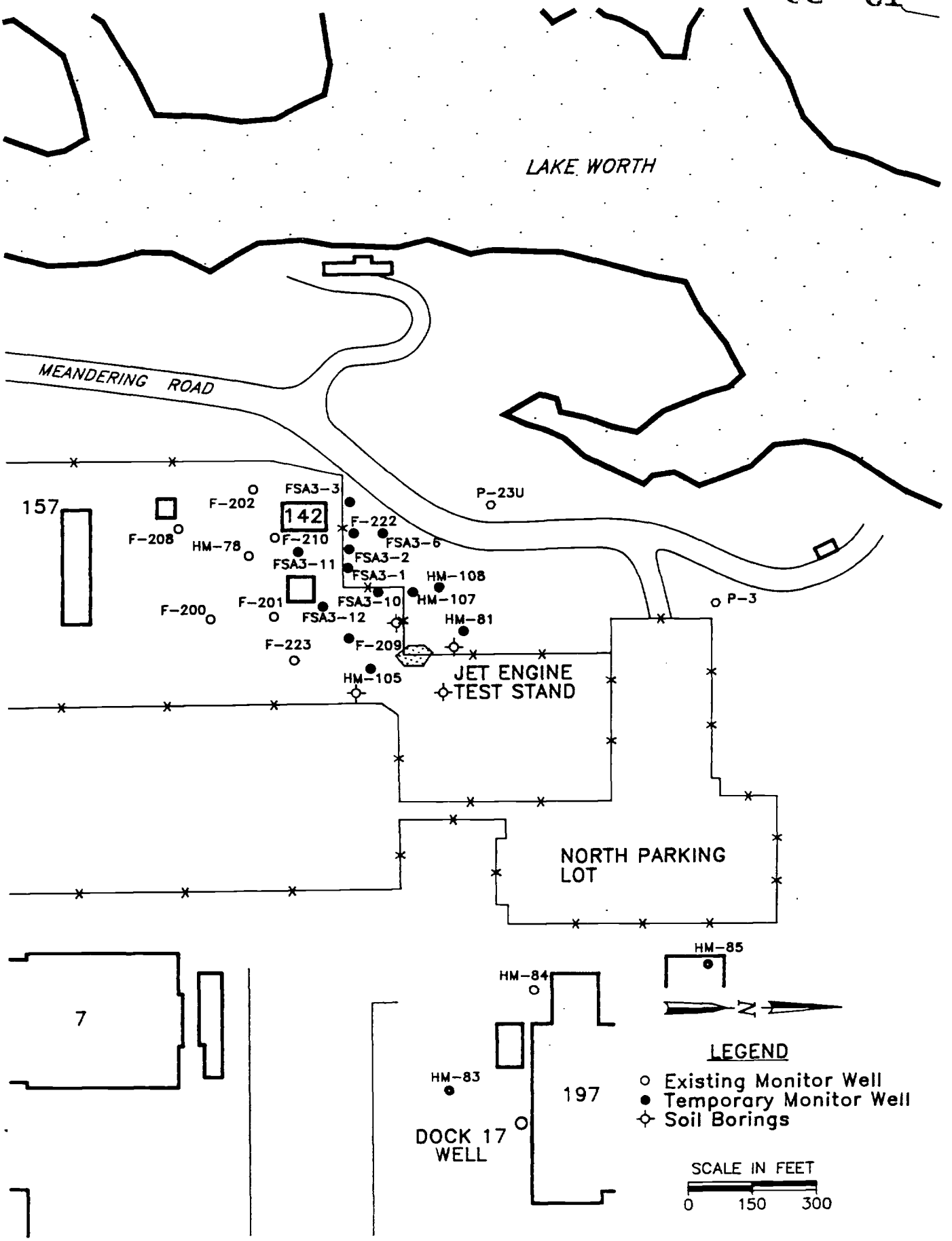


Figure 3-16 Jet engine test stand sampling area

at the site. Additional soil borings and soil samples are warranted at the site to better define the extent of contamination at the site.

Additional groundwater quality data are needed from existing wells located downgradient of the site and a new monitoring well and groundwater samples are needed upgradient of the site to determine if the site is contributing contaminants to the hydrologic system.

Aquifer testing using the slug withdrawal method is needed for existing monitoring wells and the new monitoring well to determine the hydraulic parameters of the upper zone in the jet engine test stand area. Water-level measurements will be taken from existing wells and the new well prior to sampling to better define groundwater flow direction at the site. These data will be used in groundwater flow and contaminant transport modeling.

3.3.15.3 Sampling and Analytical Design

Four soil borings will be drilled and sampled around the perimeter of the Jet Engine Test Stand. The borings will be sampled in five-foot intervals from the surface to the top of the water table. A grab sample for VOCs will be taken from each interval. The remaining sample will be a composite of each five-foot interval. Composite soil samples will be analyzed for semi-VOCs, total petroleum hydrocarbons, and oil and grease.

The upgradient soil boring will be completed as one of the separate wells in a conventional nested well. Groundwater samples will be collected from the new well and existing temporary wells located downgradient of the Jet Engine Test Stand (Figure 3-16) to determine if the test stand area is contributing contaminants to the groundwater. Groundwater samples will be analyzed for VOCs, semi-VOCs, total metals, and total petroleum hydrocarbons.

Slug withdrawal tests will be performed on the new well and existing wells that were properly completed.

3.3.16 Waste Water Collection Basins

3.3.16.1 Findings

The waste water collection basins, located south of the Process Building (Facilities Building No. 181), consist of two concrete-lined waste basins with an approximate capacity of 85,000 gallons that are designed to collect and settle suspended solids from plant waste water. These basins, which have been in use since 1966, have received several spills of vapor degreaser and other chemical spills from the Process Building over the years. The integrity of the concrete lining the basins has not been evaluated. It is suspected that a crack in the basin floor or wall may have allowed contaminants to leak to the surrounding soils.

Groundwater samples were collected from one monitoring well southeast of the basins and analytical results indicate that the groundwater is contaminated with VOCs. It is uncertain whether the VOCs in the groundwater can be attributed to the basins. A sanitary sewer line runs on an east-west line

through the site and a storm drain runs northwest-southeast approximately 75 feet south of the basins. These potential sources plus Chrome Pit No. 2 may account for some of the contamination present in the groundwater southeast of the basins. The presence of TCE in the groundwater indicates that the source is related to the Process Building (vapor degreaser spills).

3.3.16.2 Sampling and Analysis Objectives

Floor drains from the Process Building empty into the wastewater collection basins. Solvent and other chemical spills may potentially enter the basins and through leakage, enter soils and the groundwater pathway. Groundwater downgradient of the basins has been shown to contain TCE which is used extensively in the Process Building. To evaluate whether the basins have been a source of TCE and other contaminants, additional subsurface soil sampling and upper zone groundwater sampling is needed both upgradient and downgradient of the basins. Aquifer tests and water-level measurements are also needed to characterize the hydrologic flow conditions in the area of the basins. The initial objective of the data collection in the basins area is to determine if the basins are a source of contamination or if the source exists upgradient of the basins. Once the source area is determined, additional data may be required to characterize the extent of contamination related to the identified source. In addition, a visual inspection of the integrity of the basin walls and floor is needed to determine if significant leakage may be occurring from these basins.

3.3.16.3 Sampling and Analytical Design

One soil boring will be drilled immediately downgradient (east) of the wastewater collection basins and 25 feet north of monitoring well HM-47 (Figure 3-17). The boring will be drilled to the top of the water table and soil samples will be collected from five foot intervals. The samples for VOCs will be grab samples from each five foot interval; the remaining samples will be composites of each interval. The composite samples will be analyzed for semi-VOCs, and metals.

The soil boring will be deepened following soil sampling and completed as an upper zone monitoring well. Groundwater samples will be collected following completion and development and again in a month. The groundwater samples will be analyzed for VOCs, semi-VOCs, and total metals. The results of groundwater sampling of the new monitoring well will be compared with results from upgradient wells (HM-77, F-221, new well east of HM-25) and with HM-47 (downgradient) to determine if the basins are contributing to existing groundwater contamination to the east.

Slug-withdrawal tests will be performed on the new monitoring well and well HM-47 to determine the hydraulic parameters of the upper zone in the wastewater basins area. Water-level measurements will also be taken prior to each sampling to determine groundwater flow directions at the site.

3.3.17 <u>East Parking Lot/Flight Line TCE Plume</u>

3.3.17.1 Findings

The East Parking Lot and the flight line area are located east of the Assembly Building/Parts Plant (Figure 3-18). Monitoring wells installed previously in

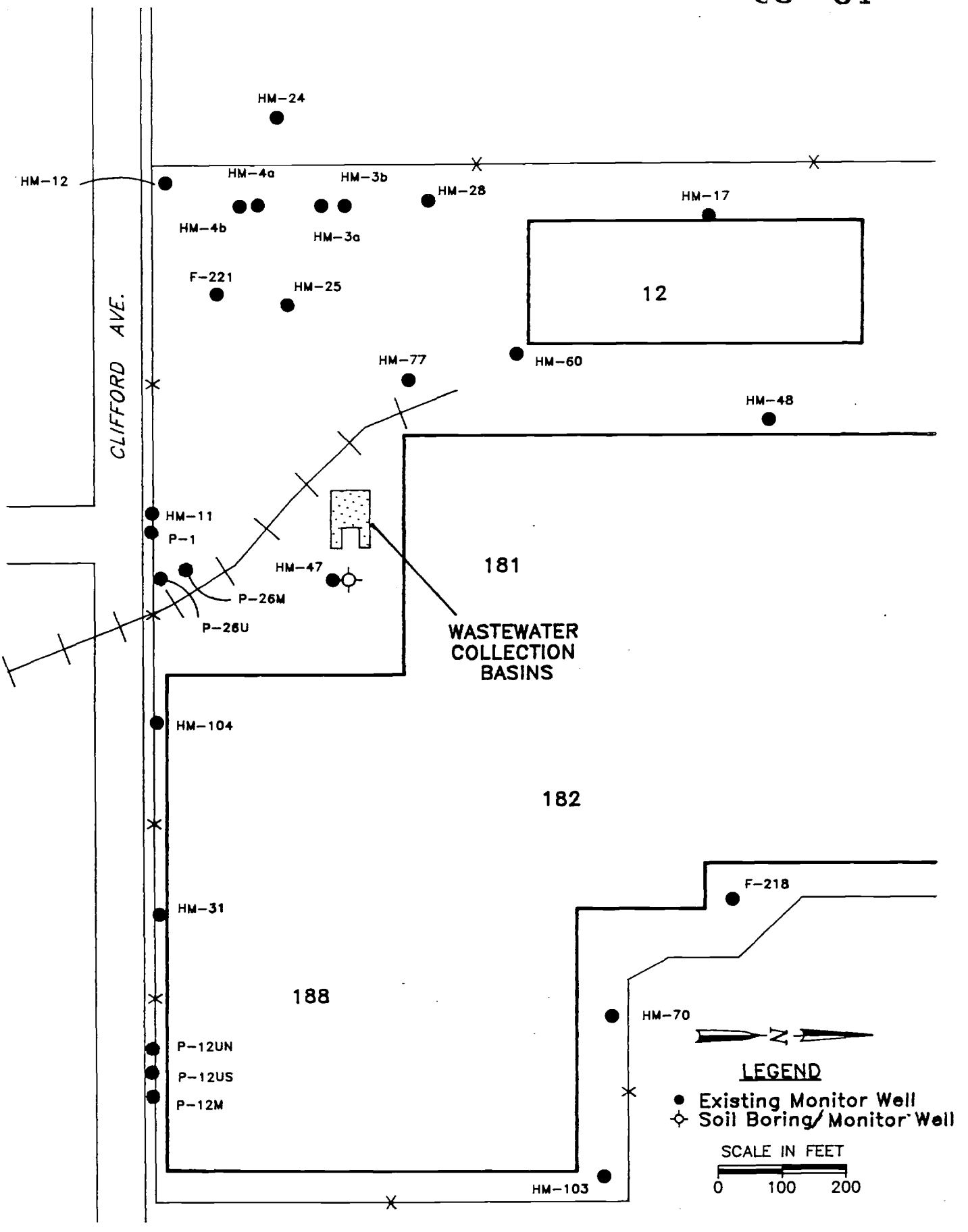


Figure 3-17 Wastewater collection basins sampling area and sample location map

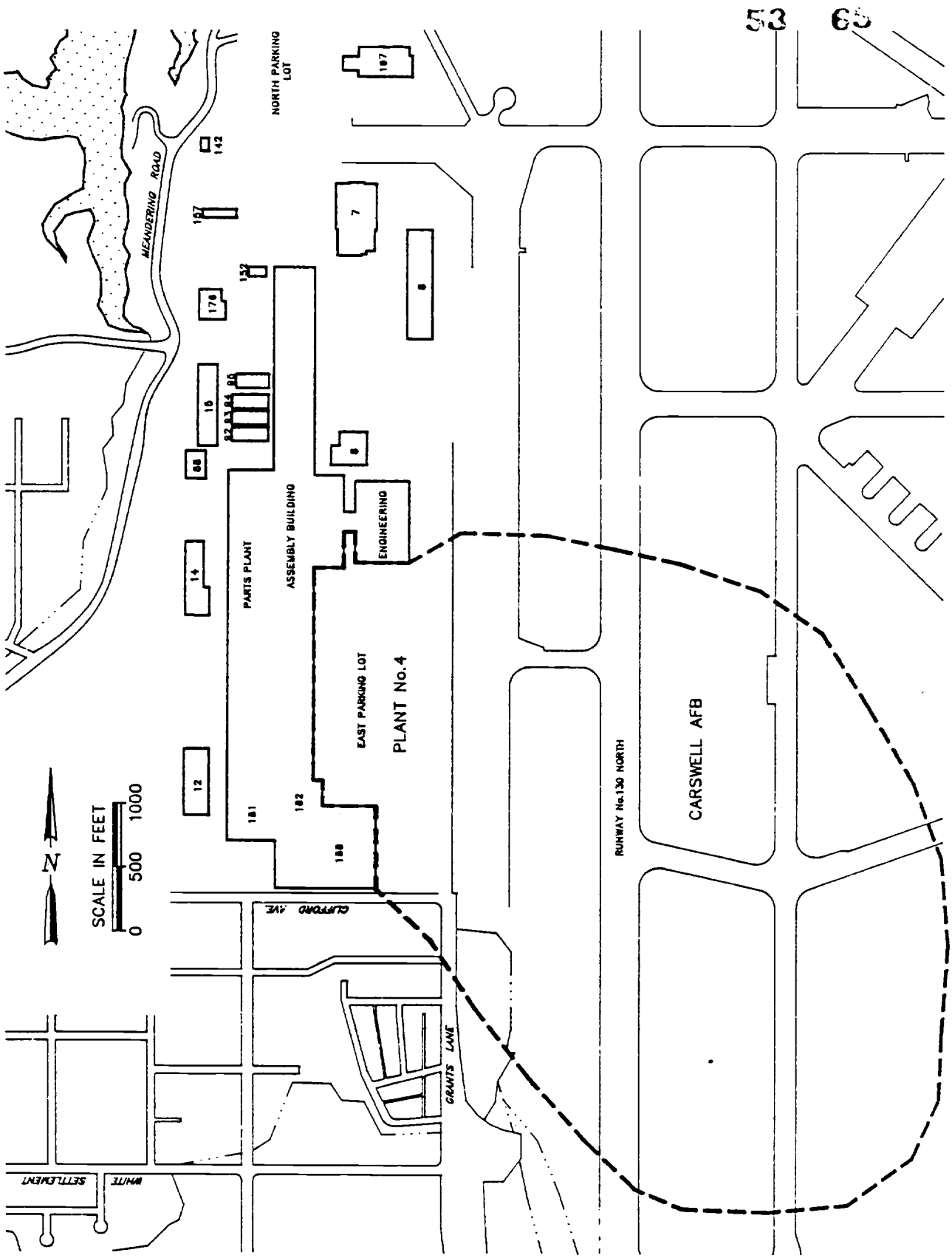


Figure 3-18 East parking Lot/Flightline area sampling area

the East Parking Lot area were found to contain high concentrations of dichloroethylene (DCE), trichloroethylene (TCE), and chromium. Through several investigations, 22 upper zone monitoring wells have been installed to characterize the plume. Neither the source or the total extent of the plume have been determined. Included in this discussion is tetrachloroethylene (PCE) contamination identified by the cafeteria near the northern end of the Parts Plant. A groundwater divide exists that is reported to bisect the Assembly Building/Parts Plant. The groundwater in the East Parking Lot flows to the east whereas the groundwater in the cafeteria area is said to flow to the west.

3.3.17.2 Sampling and Analysis Objectives

The Assembly Building/Parts Plant perimeter survey (see Section 3.3.1) is being conducted to determine potential source areas for contamination found in the East Parking Lot/Flight Line area. A large amount of information currently exists for the area but the maximum extent (downgradient) of contamination has not been defined. Evidence exists that shows that the contaminant plume is moving east-southeast from AFP 4 onto Carswell AFB. In turn, there is also evidence that contaminants originating from Carswell AFB are mixing with AFP 4 contaminants as the plume migrates eastward. The objective of the East Parking Lot/ Flight Line area sampling is to define, in conjunction with Carswell AFB, the overall extent of contamination and potential risks to human health or the environment.

3.3.17.3 Sampling and Analytical Design

Results of previous IRP investigations will be obtained from Carswell AFB and data will be incorporated into the AFP 4 data base. These will include boring and monitoring well location coordinates, analytical results, water-level measurements, aquifer tests, or any other pertinent data. These results will be used to develop a groundwater flow and contaminant transport model using modeling software such as SUTRA, MODFLOW, MOC, or FEMWATER/FEMWASTE.

On the basis of flow modeling, locations for additional groundwater monitoring wells (upper zone) will be identified and submitted to EPA Region VI for review and concurrence. These wells will generally be located downgradient from existing Carswell AFB monitoring wells. Samples collected from each new monitoring well will be analyzed for VOCs, semi-VOCs, total metals, and total petroleum hydrocarbons for two monthly rounds of sampling (one month apart). Well locations, drilling permits, and site access will be coordinated with Carswell AFB. These monitoring wells will be completed to allow sampling of discrete intervals for LNAPLs, DNAPLs, and soluble organic compounds.

3.3.18 Site-Wide Investigations

3.3.18.1 Lake Worth

3.3.18.1.1 Findings

Contaminants from AFP 4 may be entering Lake Worth via surface water drainage and upper zone groundwater discharge. Because Lake Worth is used as a source of public water supply and is also a source of recharge to the Paluxy aquifer, additional data are needed to evaluate the potential risk

to human health and the environment from contaminants in surface water and sediment of Lake Worth.

3.3.18.1.2 Sampling and Analysis Objectives

Water samples will be collected to obtain surface water quality data from Lake Worth adjacent to AFP 4. These data will be used to evaluate if contaminants are present in the waters of Lake Worth and, if present, the likely source of the contaminants and potential receptors and risk associated with those contaminants. Background samples will be collected from Lake Worth in two separate areas along the northern shore of Lake Worth to determine if changes in water quality occur as a result of activities at AFP 4.

Sediment samples will be collected from the shore of Lake Worth to determine if past contaminant spills or releases have reached Lake Worth. The data from the sediments will be used to assess potential risk associated with contaminated sediments (if present).

3.3.18.1.3 Sampling and Analytical Design

Approximately 25 surface water samples will be collected from Lake Worth. Surface water samples will be collected from points 10 feet from the shore and every 400 feet along the shore of Lake Worth beginning at a point 400 feet west of Meandering Road Creek and moving in an easterly direction to the AFP 4/Carswell property boundary (Figure 3-19). Samples will be grab samples obtained using the container immersion method. Samples will be analyzed for VOCs, semi-VOCs, oil and grease, total petroleum hydrocarbons, and metals.

Approximately 25 sediment samples will be collected at the same locations following water sampling activities. The sediments will be collected to a depth of two feet below the lake bottom surface. Grab samples from 1-foot intervals will be collected immediately for VOC analysis. The remainder of the sample material for each 1-foot interval will be composited and analyzed for semi-VOCs, oil and grease, total petroleum hydrocarbons, and metals. Any sample collected in the vicinity of the former NARF area (see Figure 2-3) will also be analyzed for radionuclides by gamma spectroscopy and alpha spectrometry. The sample collected northwest of the mouth of Meandering Road Creek will be used to assess background levels of radionuclides.

3.3.18.2 Air Quality Monitoring

3.3.18.2.1 Findings

Previous investigations have not adequately addressed potential contamination of the air pathway as a result of activities at AFP 4. Several areas are known to contain soils and groundwater contaminated with VOCs which have the potential for entering the air pathway through volatilization. Other areas such as the fire training areas may contain surface contamination available to the air pathway through windblown particles.

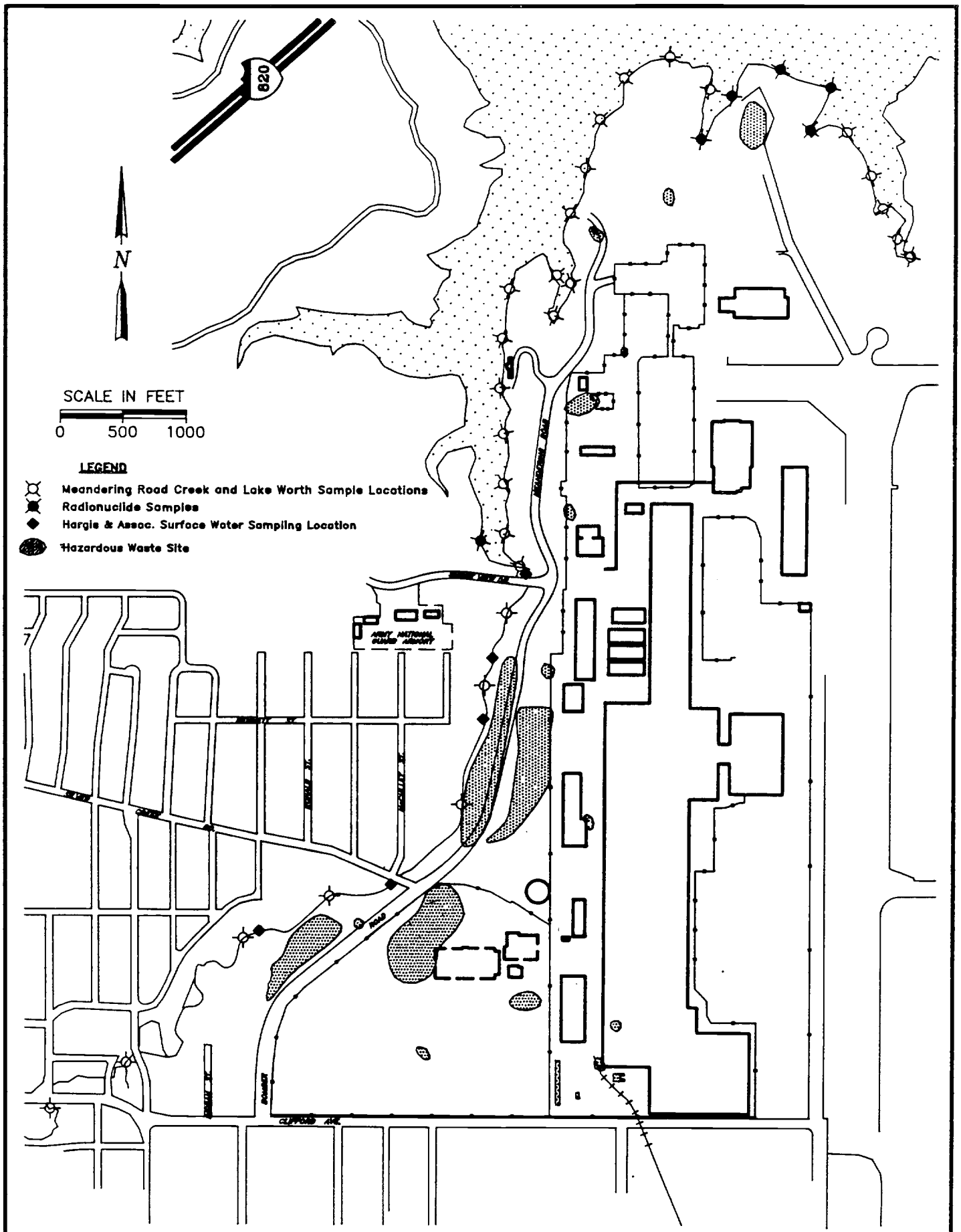


Figure 3–19. Meandering Road Creek and Lake Worth sample locations.

3.3.18.2.2 Sampling and Analysis Objectives

Baseline air quality data are needed in several areas at AFP 4 to evaluate the potential for contaminant transport in the air pathway and to assess risk to potential on-site and off-site receptors. Background air quality data are also needed both upwind and downwind of AFP 4 to allow comparisons of area air quality versus air quality at AFP 4.

3.3.18.2.3 Sampling and Analytical Design

Off-site air monitoring will be conducted concurrently with on-site RI/FS field activities at AFP 4 with one station located upwind of the facility and one station located downwind. Meteorological data will be reviewed to determine the predominant wind direction at AFP 4. The station locations will be selected based on these data. The sampling stations will consist of a low volume sampling pump and activated charcoal tube for collecting organic compound vapors and a Hi-Vol sampler for the collection of airborne particulate matter. Sample collection will be performed according to ASTM procedures D3686-84 and D4096-82, respectively.

3.3.18.3 Continuous Groundwater Elevation Monitoring

3.3.18.3.1 Findings

Review of data from previous studies indicate that the hydrologic regime is poorly understood. In particular, more data are needed on the interconnectedness between the aquifers and their responses to external stresses. Although some wells have been continuously monitored, these data are insufficient to adequately characterize the entire system of aquifers.

3.3.18.3.2 Sampling and Analysis Objectives

Additional information is needed for both the upper zone and Paluxy aquifer systems to determine how each aquifer responds to external stresses over time. This information will be used in groundwater flow and contaminant transport modeling to account for changes in the aquifer due to such variables as lake fluctuations, variations in precipitation, and aquifer pumping.

3.3.18.3.3 Sampling and Analytical Design

At two distinct locations at the plant, "continuous" data loggers and electronic pressure transducers will be installed in upper zone and Paluxy aquifer monitoring wells. One location will be selected near Lake Worth and the other location will be distant from Lake Worth. Data collected will be evaluated to determine:

- hydraulic communication between the two aquifer systems
- hydraulic response to external stresses
- hydraulic properties.

3.3.18.4 Paluxy Aquifer System Characterization

3.3.18.4.1 Findings

Insufficient data are available to characterize the hydraulic parameters of the Upper Paluxy aquifer in several areas of AFP 4. Because the Paluxy aquifer system is an important water supply resource in the Fort Worth area, parameter data are needed to allow contaminant transport modeling for AFP 4 and adjacent properties.

3.3.18.4.2 Sampling and Analysis Objectives

Aquifer pumping tests are needed to provide hydraulic parameters for use in groundwater flow and contaminant transport modeling and remediation evaluation. In addition, these tests are needed to evaluate the hydraulic properties of the important aquitards that are part of the Paluxy system. Subsurface borings, logging, and monitoring well construction will be conducted to provide additional hydrogeologic control in areas that are currently lacking this information in the area of AFP 4. Core analyses will be conducted to provide hydraulic and contaminant transport parameters for use in transport modeling.

Groundwater quality data are needed to provide information on site-wide water quality of the Paluxy aquifer system. This information will be used to assess the impacts of individual contamination sites on the overall water quality of the Paluxy aquifer system downgradient of AFP 4.

3.3.18.4.3 Sampling and Analytical Design

Subsurface boring, logging, and monitoring well construction will be completed for 4-6 additional Upper Paluxy multiple-level wells in areas where data are lacking. Cores will be collected and submitted to an engineering laboratory for core analysis to determine vertical hydraulic conductivity, total organic carbon content, and organic partition and distribution coefficients (see section 5.5.2 for specific analytical methods). Two monitoring zones will be completed in each well -- a DNAPL zone and a dissolved phase zone.

Following well drilling and completion, aquifer pumping tests will be conducted on the new wells and some existing wells in the Paluxy aquifer system. Hydraulic response will be monitored in other formations during the tests to determine the degree of interconnectedness. Groundwater samples will be collected from the new wells and analyzed for VOCs, semi-VOCs, and total metals.

3.3.18.5 Ecological Sampling

3.3.18.5.1 Findings

Data are lacking on the ecological system at AFP 4. Several potential sources of contaminants exist at AFP 4 that could adversely affect the natural environment.

3.3.18.5.2 Sampling and Analysis Objectives

Representative samples of vegetation, small animals (i.e., rodents), and aquatic life will be collected in areas known or suspected to be contaminated with hazardous waste to provide data necessary to complete a baseline risk assessment and to complete an environmental assessment of remedial action alternatives.

3.3.18.5.3 Sampling and Analytical Design

An ecological survey will be conducted for specific areas adjacent to AFP 4. An inventory of flora and fauna will be prepared and observations will be made to determine if there is any evidence of environmental damage or stress in the area of AFP 4.

If evidence of stressed vegetation is observed, samples of the affected vegetation will be collected and analyzed for trace contaminants. Selection will be based on visual observations such as discoloration, stunted growth, or dead vegetation.

If burrowing animals are found to inhabit areas of known contamination exceeding background concentrations, a representative specimen will be collected and analyzed for trace contaminants.

Representative samples of bottom dwelling aquatic life such as fish or crayfish will be collected from Meandering Road Creek, Farmers Branch of the Trinity River, and Lake Worth and analyzed for trace contaminants.

3.3.18.6 Meandering Road Creek

3.3.18.6.1 Findings

Upper zone groundwater is known to discharge from AFP 4 along the Meandering Road Creek drainage by way of seeps. Much of the upper zone groundwater upgradient of the seeps is known to be contaminated with fuels, solvents, oil and grease, and metals. A potential exists for contamination of surface waters and sediments as a result of upper zone discharge into Meandering Road Creek. It is also suspected that the creek is providing recharge to the Paluxy aquifer. A potential exists for contaminant migration into the Paluxy aquifer which is used for domestic water supplies in surrounding communities.

3.3.18.6.2 Sampling and Analysis Objectives

The objective of the Meandering Road Creek study is to determine the extent of surface water contamination originating from AFP 4. Upstream surface water and sediment samples are needed to determine potential contamination to the surface water pathway from upstream sources before the creek enters the AFP 4 facility boundary. Samples along the facility boundary are needed to better define the source areas for contamination entering Meandering Road Creek from AFP 4. Additional seeps need to be identified and sampled to characterize upper zone discharge.

3.3.18.6.3 Sampling and Analytical Design

Existing surface water sampling locations, previously sampled by Hargis + Associates, Inc. on a routine basis, will not be resampled because sufficient data exist from these locations. New locations will be established both upstream and between previously established sampling locations to better define the distribution of contaminants (see Figure 3-19). Exact locations will be determined in the field and approved by the onsite EPA representative. These samples will be collected using the container immersion method (see Appendix A, A6.11g) and will be analyzed for volatile organics, semi-volatile organics, total metals, total petroleum hydrocarbons, and oil and grease. Water quality parameters (pH, conductivity, temperature) will be monitored in the field at the time of sampling.

Sediment samples will be collected at all new and existing creek sampling locations (Figure 3-19) and will be analyzed for volatile organics, semi-volatile organics, metals, total petroleum hydrocarbons, and oil and grease.

Seep samples will be collected at all existing seep sampling locations (see Figure 3-19) and at any additional seeps present along the drainage at the time of sampling (location and frequency of seeps may be dependent upon time of year and climatic conditions at time of sampling). It is estimated that up to 10 seep samples will be collected along the Meandering Road Creek drainage. These samples will be collected using a stainless steel scoop and will be analyzed for volatile organics, semi-volatile organics, total metals, total petroleum hydrocarbons, and oil and grease (see Appendix A6.13).

3.3.18.7 Background Sampling

3.3.18.7.1 Findings

Insufficient data exist for background concentrations of analytes in soils and soil gas for the area of AFP 4 to allow comparisons of background versus anomalous concentrations of specific contaminants in soils and soil gas.

3.3.18.7.2 Sampling and Analysis Objectives

Two off-site locations having the same lithologic materials as found at AFP 4 will be identified for use as locations for determining background concentrations of specific analytes. The locations will be chosen not only according to lithology but will also be chosen on the basis of being in a non-contaminated area (i.e., no nearby industrial activity). Soil and soil gas samples collected at each location will be analyzed and the resulting analyses will be used for comparing analyte concentrations found at AFP 4 with background concentrations. These data will aid in determining areas which contain anomalous concentrations of specific analytes. "Anomalous concentrations" will later be determined using statistical techniques (i.e., mean and standard deviation using a student "t" test).

3.3.18.7.3 Sampling and Analytical Design

Two soil samples will be collected at each background location. A soil boring will be completed to a depth of two feet using a stainless steel hand barrel auger to obtain two samples. One from the surface to a depth of one foot and a second sample from the one foot to two foot depth. Each one foot interval will be composited after a grab sample is collected for volatile organics. The composited sample will be analyzed for semi-volatiles, metals, total petroleum hydrocarbons, and oil and grease.

Near the soil boring, a soil gas sample will be collected from a depth of four feet and a sample tube will be sent to the analytical laboratory for Gas Chromatograph/Mass Spectrometer (GC/MS) analysis. In addition, field screening measurements will also be taken for comparison with the laboratory data (see Appendix A, A7.1, and A9.3 for a description of the sampling and field screening techniques that will be used).

3.3.18.8 Leachability Testing

3.3.18.8.1 Findings

Leachability tests on contaminated soils are needed at AFP 4 to provide data on potential groundwater contamination that could result from leaching. The data are also needed when evaluating the types and effectiveness of various remedial action alternatives for cleanup of contaminated soils.

3.3.18.8.2 Sampling and Analysis Objectives

Zones of contamination at each type of hazardous waste site at AFP 4 will be sampled for TCLP analysis. Samples will be biased toward the most highly contaminated soils based on visual evidence and/or field screening techniques (i.e. photoionization detector). Samples will be split with one split being analyzed by standard analytical methods and the other split being analyzed by TCLP. The resulting data will be compared and the amount of contaminants available to environmental pathways through leaching processes will be evaluated. The data will also be evaluated to determine the effects of leaching on various remedial action technologies.

3.3.18.8.3 Sampling and Analytical Design

A biased sample of contaminated soil will be collected from each type of contaminated area present at AFP 4. These will include:

- A representative FDTA site
- A representative FSA site
- Landfill 1
- Landfill 3
- Die Yard Chemical Pits
- Other zones of contamination encountered during RI/FS characterization as required.

Splits will be taken at each sample location; one split will be analyzed for VOCs, semi-VOCs, and metals by standard analytical methods and the

second split will be for TCLP analysis. The TCLP split will be immediately extracted and analyzed for VOCs and semi-VOCs. A portion of the extract will be reserved for metals analysis. The TCLP sample will be analyzed for metals only if metals concentrations from the standard analysis exceed 20 times the TCLP regulatory levels (40 CFR 261.24). All samples will be from the most highly contaminated zones based on visual and field screening techniques.

3.3.18.9 Common Ions

3.3.18.9.1 Findings

Common ion water quality data are needed for aquifer systems at AFP 4 to aid in determining sources of aquifer recharge, defining groundwater flow paths, and evaluating the effect of water quality on potential remedial action technologies used in groundwater remediation.

3.3.18.9.2 Sampling and Analysis Objectives

Data from common ion analyses will be used to characterizwe the geochemistry of the aquifer systems at AFP 4. Comparison of common ion data from monitoring wells distributed across the AFP 4 facility may be useful in determining the source and direction of groundwater flow. Stiff diagrams previously generated by Hargis and Associates, Inc. at AFP 4 appear useful in differentiating water originating from Lake Worth versus Meandering Road Creek, for example, in the Upper Paluxy Aquifer.

3.3.18.9.3 Sampling and Analytical Design

Representative samples from potential source areas of groundwater recharge (i.e. Lake Worth, Meandering Road Creek, and potable water mains) will be collected and analyzed for common ions to be used for comparison with groundwater obtained from the Upper Zone and Paluxy aquifers. Samples will be collected at 20 percent of the monitoring wells sampled and will be analyzed for chloride, fluoride, nitrate, nitrite, phosphate, sulfate, calcium, iron, magnesium, potassium, silica, and sodium.

4.0 GENERAL DESCRIPTION OF FIELD PROCEDURES

53 75

4.1 INTRODUCTION

This section is intended to provide guidance to the sampling team on the detailed procedures to be used for collecting samples and data in the field. The procedures described in the following section will be used to complete the tasks identified in Section 3.0. Procedure descriptions are presented by media (i.e. soils, sediments, groundwater, surface water). Appendix A of this plan presents step-by-step procedures whereas this section provides a more general description of the equipment, methods, and procedures.

Some specific procedures have been modified by a *Site Specific Procedure Change* or *Notice* in Appendix A. If a situation arises that is not addressed by the specific procedures or the change notice, the guidance in this section (4.0) should be followed.

Table 4-1 contains a summary of the sampling locations, tasks, and sampling procedures to be used for each site. Unusual field sampling conditions may require departures from the procedures described in this section. Such occurrences will be fully documented in the field logbooks for the affected site(s). Table 4-2 defines the analytical parameters to be used for AFP 4. Table 4-3 specifies the quality assurance/quality control (QA/QC) sample types and quantities for both the field and laboratory activities. For sample container size and type, sample preservation requirements, and holding times, see Table 5-1 of Section 5.0.

4.2 SOIL AND SEDIMENT SAMPLING

4.2.1 Surface Soil Sampling (or shallow subsurface)

4.2.1.1 Barrel Auger

Prior to sampling, the immediate area to be sampled will be cleaned of debris or litter. A barrel auger (hand operated) will be used to penetrate surface and near-surface soil to the desired depth to obtain a sample for analysis. Depths will generally be from 0 to 6 inches or 0 to 12 inches. The sampling equipment will consist of a stainless steel auger bit attached to a stainless steel rod and a "T" handle. The auger bit will be used to bore a hole to the desired depth and then will be withdrawn. The barrel portion of the auger bit holds the soil cuttings and eliminates contact with the sidewall of the borehole, which will minimize the potential of contaminating the soil from other parts of the hole.

Using a stainless steel spoon and/or knife, the sample will be removed from the auger barrel and will be placed in a stainless steel or aluminum tray for thorough mixing prior to bottling. Sample material to be analyzed for volatile organics, however, will be bottled as-is immediately upon removal from the auger barrel to avoid loss of volatiles. The sample material removed will be scanned with a photoionization detector. Where radioactive materials are suspected, the sample will be scanned with a beta-gamma detector and an alpha-particle detector. These measurements will aid in decisions to be made concerning sample packaging, handling, shipping, and personnel-protection requirements. Following sample collection, the sampling equipment will be cleaned using decontamination procedures described in Section 4.9.

Table 4-1. Summary of Sampling Activities at AFP 4

Site	Location	Sample Type	Sample ID	Sampling Technique	Analytes
Assembly Building/ Parts Plant	Building perimeter	Soil gas	AFP4-SG-001 thru 100	Drive rod to 4 feet, sorbent tube	VOCs- BTEX
		Subsurface Soils	AFP4-SS-001 thru 100	Split-Barrel Sampler	VOCs, semi-VOCs, total petroleum hydrocarbons metals
	New monitoring wells (AB-01 thru 05)	Groundwater	AFP4-GW-001 thru 075	Multiple-Level Sampler	VOCs, semi-VOCs, total petroleum hydrocarbons, metals
Underground Storage Tanks	Tank No. 19	Subsurface Soils	AFP4-SS-101 thru 150	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, and metals
	New Wells	Groundwater	AFP4-GW-076 thru 086	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, TPH
	Tank No. 20	Subsurface Soils	AFP4-SS-151 thru 200	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, and metals
	New Wells	Groundwater	AFP4-GW-087 thru 098	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, TPH
	Tank No. 24A	Subsurface Soils	AFP4-SS-251 thru 300	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, and metals
	New Wells	Groundwater	AFP4-GW-099 thru 110	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, TPH
	Tank No. 24B	Subsurface Soils	AFP4-SS-301 thru 350	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, and metals
	New Wells	Groundwater	AFP4-GW-111 thru 122	Bladder or Peristaltic Pump	VOCs, semi-VOCs, TPH
	Tank No. 25A	Subsurface Soils	AFP4-SS-351 thru 400	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, and metals
	New Wells	Groundwater	AFP4-GW-135 thru 146	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, total petroleum hydrocarbons

Table 4-1 (continued)

Site	Location	Sample Type	Sample ID	Sampling Technique	Analytes
USTs (cont)	Tank No. 30	Subsurface Soils	AFP4-SS-201 thru 250	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, and metals
	New Wells	Groundwater	AFP4-GW-123 thru 134	Pump and Bailer	VOCs, semi-VOCs, TPH
Landfill No. 1	Grid Locations	Subsurface Soils	AFP4-SS-401 thru 475	Split-Barrel Sampler	VOCs, semi-VOCs, oil and grease, metals
Landfill No. 3	Grid Locations	Subsurface Soils	AFP4-SS-476 thru 500	Split-Barrel Sampler	VOCs, semi-VOCs, oil and grease, metals
	Temporary wells	Groundwater	AFP4-GW-147 thru 166	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, total petroleum hydrocarbons, metals
	Seeps in Meandering Road Creek Drainage	Surface Water	AFP4-SW-001 thru 005	Submersion of sample bottles	VOCs, semi-VOCs, total petroleum hydrocarbons, metals
	Meandering Road Creek Channel	Surface soil and sediment	AFP4-S-001 thru 010	Barrel Auger (hand operated)	VOCs, semi-VOCs, oil and grease, metals, TPH
	Existing Wells	Floating Product	AFP4-FP-001 thru 005	Bailer	Organic compound scan
	New wells	Groundwater	AFP4-GW-167 thru 168	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, TPH, and metals
Landfill No. 4	Floodplain Borings	Subsurface Soils	AFP4-SS-501 thru 525	Barrel Auger (hand operated)	VOCs, semi-VOCs, oil and grease, metals
FDTA No. 2	Soil borings vicinity of existing well HM-51	Subsurface Soils	AFP4-SS-526 thru 575	Split-Barrel Sampler	VOCs, semi-VOCs, TPH and metals
		Groundwater (borings)	AFP4-GW-169 thru 173	Bailer	VOCs, semi-VOCs, total petroleum hydrocarbons

Table 4-1 (continued)

Site	Location	Sample Type	Sample ID	Sampling Technique	Analytes
FDTA No. 5	Soil borings vicinity of existing well HM-25	Subsurface Soils	AFP4-SS-576 thru 600	Split-Barrel Sampler	VOCs, semi-VOCs, oil and grease, metals
	New monitoring wells	Groundwater	AFP4-GW-174 thru 185	Bladder or Peristaltic Pump	VOCs, semi-VOCs, metals TPH, and oil & grease
FDTA No. 6	Soil borings perimeter of former excavation	Subsurface Soils	AFP4-SS-601 thru 625	Split-Barrel Sampler	VOCs, semi-VOCs, metals oil & grease
	New monitoring wells	Groundwater (if present)	AFP4-GW-186 thru 197	Bailer	VOCs, semi-VOCs, TPH
Chrome Pit No. 3	Soil Borings (if needed below 10 ft.)	Subsurface Soils	AFP4-SS-626 thru 635	Split-Barrel Sampler	VOCs, semi-VOCs, metals
	New and Existing Monitoring wells (if required)	Groundwater	AFP4-GW-198 thru 215	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, metals, cyanide also for some existing wells
Die Yard Chemical Pits	Soil Borings periphery of excavated area	Subsurface Soils	AFP4-SS-636 thru 675	Split-Barrel Sampler	VOCs, semi-VOCs, metals, cyanide
	New Monitoring Well	Groundwater	AFP4-GW-216 thru 227	Multiple-Level Sampler	VOCs, semi-VOCs, metals, cyanide
	Existing Well HM-24	Groundwater	AFP4-GW-228	Bailer	VOCs, semi-VOCs, metals, cyanide
FSA No. 1	Grid Locations	Soil Gas	AFP4-SG-101 thru 150	Drive rod to 4 feet, sorbent tube	BTEX
	Soil Borings at Grid Locations	Subsurface Soils	AFP4-SS-676 thru 725	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, and metals
	New Monitoring Wells	Groundwater	AFP4-GW-229 thru 275	Bladder or Peristaltic Pump and bailer	VOCs, semi-VOCs, TPH, and metals

Table 4-1 (continued)

Site	Location	Sample Type	Sample ID	Sampling Technique	Analytes
FSA No. 2	Grid Locations	Soil Gas	AFP4-SG-151 thru 200	Drive Rod to 4 feet, sorbent tube	BTEX
	Soil Borings at Grid Locations	Subsurface Soils	AFP4-SS-726 thru 775	Split-Barrel Sampler	VOCs, semi-VOCs, total petroleum hydrocarbons
	New Monitoring Wells	Groundwater	AFP4-GW-276 thru 293	Bladder or Peristaltic Pump and bailer	VOCs, semi-VOCs, TPH, and metals
FSA No. 3	Grid Locations	Soil Gas	AFP4-SG-201 thru 250	Drive Rod to 4 feet, sorbent tube	BTEX
	Soil Borings at Grid Locations	Subsurface Soils	AFP4-SS-776 thru 800	Split-Barrel Sampler	VOCs, semi-VOCs, total petroleum hydrocarbons
	New Monitoring Wells	Groundwater	AFP4-GW-294 thru 329	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, TPH, and metals
Former Fuel Storage Area	Soil borings vicinity of existing well HM-8	Subsurface Soils	AFP4-SS-801 thru 820	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, oil and grease
	Existing Well HM-8	Groundwater	AFP4-GW-330	Tri-Loc Pump and Bailer	nickel
Jet Engine Test Stand	Soil Borings around perimeter of test	Subsurface Soils	AFP4-SS-821 thru 840	Split-Barrel Sampler	VOCs, semi-VOCs, TPH, oil and grease
	New Monitoring wells	Groundwater	AFP4-GW-331 thru 335	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, TPH, and metals
	Existing "temporary" wells	Groundwater	AFP4-GW-111 thru 115	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, TPH, and metals
Wastewater Collection Basins	Soil boring north of monitoring well HM-47	Subsurface Soils	AFP4-SS-841 thru 845	Split-Barrel Sampler	VOCs, semi-VOCs, metals
	New Monitoring well	Groundwater	AFP4-GW-336 thru 338	Multiple-Level Sampler	VOCs, semi-VOCs, metals
East Parking Lot/ Flight Line	New Monitoring Wells	Groundwater	AFP4-GW-339 thru 380	Bladder or Peristaltic Pump and Bailer	VOCs, semi-VOCs, TPH, and metals
	New well borings	Subsurface Soils	AFP4-SS-846 thru 875	Split-Barrel Sampler	VOCS, semi-VOCs, metals

Table 4-1 (continued)

Site	Location	Sample Type	Sample ID	Sampling Technique	Analytes
Lake Worth	South Shoreline	Surface Water	AFP4-SW-010 thru 035	Container Immersion	VOCs, semi-VOCs, oil and grease, total petroleum hydrocarbons, metals
		Sediment	AFP4-S-011 thru 035	Hand corer with eggshell catcher	VOCs, semi-VOCs, oil and grease, total petroleum hydrocarbons, metals
		Sediment	AFP4-SR-001 thru 05	Hand corer with eggshell catcher	Radionuclides (NARF area only)
Meandering Road Creek	White Settlement to Lake Worth	Surface Water and Seeps	AFP4-SW-036 thru 050	Container immersion	VOCs, semi-VOCs, oil and grease, total petroleum hydrocarbons, metals
		Sediment	AFP4-S-036 thru 045	Hand Corer	VOCs, semi-VOCs, oil and grease, total petroleum hydrocarbons, metals
Ecological Sampling (site-wide)		Biota Samples	AFP4-B-001 thru 020	Hand Collection	Trace Elements (to be determined)
Air Quality Sampling	Upwind/Downwind Locations	Air	AFP4-A-001 thru 050	Sampling pump with carbon tubes and hi-vol sampler	VOCs, metals (particulates)
Background Locations	Off-Site	Soil	AFP4-SS-900 thru 902	Barrel Auger (hand operated)	VOCs, semi-VOCs, oil and grease, total petroleum hydrocarbons, metals
		Soil gas	AFP4-SG-251 thru 252	Sorbent Tube	VOCs
Paluxy	Site wide	Core	AFP4-PC-001-010	Core	Vertical hydraulic conductivity, Kd, TOC, partition coefficient
	Site wide	Groundwater	AFP4-GW-381-386	Multiple-Level Sampler	VOCs, semi-VOCs, metals

Table 4-2. Definition of Analytical Parameters

Acronym in text	Laboratory Parameters	Analytical Method
	Target Compound List (TCL)	EPA Method 624/8240 or 8260[b] (GC/MS purge and trap) except as noted
VOCs	1) Volatile Organic Compounds	
	acetone	
	benzene[a]	
	bromodichloromethane	
	bromoform	
	bromomethane	
	2-butanone	
	carbon disulfide	
	carbon tetrachloride[a]	
	chlorobenzene	
	chloroethane	
	chloroform	
	chloromethane	
	dibromochloromethane	
	1,1-dichloroethane	
	1,2-dichloroethane[a]	
	1,1-dichloroethene	
	1,2-dichloroethene (total)	
	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 (TCE)[a]	
	vinyl acetate	
	vinyl chloride[a]	
	xylenes (total)	
Semi-VOCs	2) Semi-Volatile Organic Compounds	EPA Method 625/8270 (GC/MS extraction)
	acenaphthene	
	acenaphthylene	
	anthracene	
	benzo(a)anthracene	
	benzo(b)fluoranthene	
	benzo(k)fluoranthene	
	benzoic acid	
	benzo(g,h,i,)perylene	
	benzo(a)pyrene	
	benzyl alcohol	
	bromophenyl phenyl ether	
	4-chloroaniline	

Table 4-2 (continued). Definition of Analytical Parameters

Acronym in text	Laboratory Parameters	Analytical Method
	2) Semi-Volatile Organics (con't)	
	bis(2-chloroethyl)ether	
	bis(2-chloroethoxy)methane	
	bis(2-chloroisopropyl) ether	
	butyl benzyl phthalate	
	4-chloro-3-methylphenol	
	2-chloronaphthalene	
	2-chlorophenol	
	4-chlorophenyl phenyl ether	
	chrysene	
	dibenz(a,h)anthracene	
	dibenzofuran	
	1,2-dichlorobenzene	
	1,3-dichlorobenzene	
	1,4-dichlorobenzene	
	3,3-dichlorobenzidine	
	2,4-dichlorophenol	
	diethylphthalate	
	2,4-dimethylphenol	
	dimethyl phthalate	
	di-n-butyl phthalate	
	di-n-octyl phthalate	
	2,4-dinitrophenol	
	4,6-dinitro-2-methylphenol	
	2,4-dinitrotoluene	
	2,6-dinitrotoluene	
	bis(2-ethylhexyl)phthalate	
	fluoranthene	
	fluorene	
	hexachlorobenzene	
	hexachlorobutadiene	
	hexachlorocyclopentadiene	
	hexachloroethane	
	indeno(1,2,3-c,d)pyrene	
	isophorone	
	2-methylnaphthalene	
	2-methylphenol	
	4-methylphenol	
	naphthalene	
	2-nitroanaline	
	3-nitroanaline	
	4-nitroanaline	
	nitrobenzene	
	2-nitrophenol	
	4-nitrophenol	
	n-nitroso-di-n-dipropylamine	
	n-nitrosodiphenylamine	
	pentachlorophenol	
	phenanthrene	
	phenol	

Table 4-2 (continued). Definition of Analytical Parameters

Acronym in text	Laboratory Parameters	Analytical Method
	2) Semi-Volatile Organics (Con't) pyrene 1,2,4-trichlorobenzene 2,4,5-trichlorophenol 2,4,6-trichlorophenol	EPA Method 625/8270
	Priority Pollutant List	
Metals	1) Metals antimony lead arsenic nickel beryllium selenium cadmium silver chromium thallium copper zinc	Digested by EPA Method 3005, 3010, and 3020. Analysis by EPA 7000 series and EPA 6010.
Metals	TCLP arsenic barium cadmium chromium lead selenium silver	Extracted by EPA Method 1311 Digested by EPA Method 3010, 3020 Analysis by EPA 7000 series and 6010
	TCLP (VOCs and semi-VOCs) benzene bis(2-chloroethyl)ether carbon disulfide carbon tetrachloride chlorobenzene chloroform 1,2-dichlorobenzene 1,4-dichlorobenzene 1,2-dichloroethane 1,1-dichloroethylene 2,4-dinitrotoluene hexachlorobenzene hexachloro-1,3-butadiene hexachloroethane methyl ethyl ketone methylene chloride nitrobenzene pentachlorophenol phenol pyridine 1,1,2,2 tetrachloroethane tetrachloroethylene toluene 1,1,1-trichloroethane 1,1,2-trichloroethane	Extracted by EPA Method 1311 followed by EPA Method 8240/8260 for VOCs, 8270 for semi-VOCs

Table 4-2 (continued). Definition of Analytical Parameters

Acronym in text	Laboratory Parameters	Analytical Method
Metals	TCLP (VOCs and semi-VOCs) continued	
	trichloroethylene	
	2,4,5 trichlorophenol	
	2,4,6 trichlorophenol	
	vinyl chloride	
	Inorganics	
	chloride	EPA Method 300.0
	chromate (hexavalent chromium)	
	fluoride	
	nitrate	
	nitrite	
	phosphate	
	sulfate	
	cyanide	EPA Method 335.2
	calcium	EPA Method 6010
	iron	
	magnesium	
	potassium	
	silica	
	sodium	
TPH	Total Petroleum Hydrocarbons	EPA Method 418.1 (infrared spectroscopy)
O&G	Oil and Grease in Water	EPA Method 3550/413.2
	Oil and Grease in Soil	UNC Method K-7
	Radioisotopes	
	total uranium	EPA Method 6010
	thorium-230	UNC Method C-10 (alpha spectrometry)
	radium-226	UNC gamma spectroscopy
	cobalt-60	UNC gamma spectroscopy
	cesium-137	UNC gamma spectroscopy
LNAPL	Waterborne petroleum oil	
	qualitative scan	ASTM Method D 3328-78

[a] EPA Method 524.2, or EPA Method 8260 with a 25 mL purge, will be used for samples collected from Paluxy monitoring wells located on the plant perimeter where the Paluxy groundwater flow is in an off-site direction.

[b] EPA Method 8260 meets or exceeds EPA Method 8240 in precision and accuracy.

Table 4-3. Field and Laboratory Quality Assurance Sample Types and Quantities

Sample Type	Analyte	Minimum Field Quality Assurance: Duplicates	Equipment Blanks	Trip Blanks	Field Blanks	Minimum Laboratory Quality Assurance[1]: Checks	Duplicates	Blanks	Spikes
Groundwater	TCL Semi-Volatile Organics	10%	10%			5% or 1/Batch	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch
	TCL Volatile Organics	10%	10%	2/Trip	2/Trip	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch
	Priority Pollutant Dissolved Metals	10%	10%			5% or 1/Batch	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch
	Priority Pollutant Total Metals	10%	10%			5% or 1/Batch	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch
	Inorganics	10%	10%			5% or 1/Batch	5% or 1/Batch	N/A	5% or 1/Batch
	Total Petroleum Hydrocarbons	10%	10%			N/A	5% or 1/Batch	5% or 1/Batch	N/A
	Oil and Grease	10%	10%			N/A	5% or 1/Batch	5% or 1/Batch	N/A
LNAPL	Organic compounds in free-floating oil	10%	10%			N/A	5% or 1/Batch	N/A	N/A

Table 4-3 (continued). Field and Laboratory Quality Assurance Sample Types and Quantities

Sample Type	Analyte	Minimum Field Quality Assurance: Duplicates	Equipment Blanks	Trip Blanks	Field Blanks	Minimum Laboratory Quality Assurance[1]: Checks	Duplicates	Blanks	Spikes
Soil	TCL Semi-Volatile Organics	10%	10%			5% or 1/Batch	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch
	TCL Volatile Organics	10%	10%			5% or 1/Batch	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch
	Priority Pollutant Metals (total)	10%	10%			5% or 1/Batch	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch
	TCLP	10%	10%			5% or 1/Batch	5% or 1/Batch	5% or 1/Batch	5% or 1/Batch
	Total Petroleum Hydrocarbons	10%	10%			N/A	5% or 1/Batch	5% or 1/Batch	N/A
	Radioisotopes	10%	10%			5% or 1/Batch	5% or 1/Batch	N/A	N/A
	Oil and Grease	10%	10%			N/A	5% or 1/Batch	5% or 1/Batch	N/A

[1] A batch consists of 20 or fewer samples.

Equipment and supplies used for sampling with a barrel auger include the following:

- Barrel Auger
- Stainless Steel Spoon
- Stainless Steel Knife
- Disposable Latex Surgical Gloves
- Leather Gloves
- Stainless Steel Trays (or aluminum if Al is not being analyzed)
- Tape Measure
- Chain of Sample Custody Forms (form UNC 1512)
- Cooler With Ice (Blue Ice® or equivalent)
- Sample Containers
- Decontamination Solutions and Supplies (see Section 4.9)
- Waste Containers
- Photoionization Detector
- Alpha and Gamma-Ray Scintillometers (if applicable)

4.2.2 Subsurface Soil Sampling

4.2.2.1 Split-Barrel Sampler

A truck-mounted hollow-stem auger rig will be employed at the AFP 4 to complete the subsurface soil sampling in conjunction with the drilling of groundwater monitoring wells. Drilling procedures as related to sample collection are described in more detail in Appendix A, Section A2.0 and A3.0.

The hollow-stem auger will be used to auger to the sampling depth. A 3-inch O.D. by 24-inch-long split-barrel sampler will be lowered inside the hollow stem to the top of the interval to be sampled. Using a 140-pound drop hammer or equivalent hydraulic driver with a 30-inch drop, the sampler will be driven for the length of the sampler or until no further penetration is achieved after 50 blows for each 6 inches of penetration.

Once the sampler is full or no further penetration is possible, the sampler will be carefully removed from the borehole and separated from the drive-rod assembly. The sampler will be laid flat on an uncontaminated surface and the head and drive shoe removed. One-half of the split-barrel will be removed exposing the sample. The uppermost portion of the sample (slough) will be discarded. The sample will be screened with a photoionization detector while in the split-barrel sampler. Sample material to be analyzed for volatile

organic compounds will be removed immediately from the core. The remaining sample material will be placed in a stainless steel or aluminum pan and will be thoroughly mixed prior to bottling. If a discrete section of the core shows evidence of significant contamination, this section(s) will be sampled without mixing the entire sample core. These samples should be considered for TCLP analyses as specified in Section 3.3.18.8.

Following each sample collection, the split-barrel will be cleaned or replaced with a pre-cleaned barrel to avoid cross-contamination of the samples, as specified in Section 4.9 of this plan.

Equipment and supplies to be used in sample collecting with a split-barrel sampler include the following:

- Split-Barrel Sampler (stainless steel)
- Disposable Latex Surgical Gloves
- Stainless Steel Spoon
- Stainless Steel or Aluminum Pan
- Tape Measure
- Sample Containers
- Chain of Sample Custody Forms (form UNC 1512)
- Waste Containers
- Coolers and Ice (Blue Ice or equivalent)
- Photoionization Detector
- Alpha and Beta/Gamma Detectors (if applicable)

4.2.3 Barreled Drill Cuttings

A stainless steel barrel auger will be used to collect a grab sample for VOCs and a composite soil sample representative of the contents of the barrel. The auger will be forced into the media to the full length of the auger barrel. The core will be removed using a stainless steel knife or spoon. The composite sample will be placed in a stainless steel pan and thoroughly mixed prior to bottling.

4.2.4 Lake Worth and Meandering Road Creek Sediment Sampling

Sediment samples will be collected to a depth of two feet at each water sample location along the shore of Lake Worth. All sediment sampling in this area will be collected with a hand corer and an eggshell core catcher. Samples collected near the NARF area will be scanned for radioactivity with alpha, beta, and gamma detection equipment. These potentially radioactive samples will have a unique identification number (see section 5.2) and special handling, packaging, and shipping requirements that depend on the radiation levels (see section 5.4).

From Lake Worth and Meandering Road Creek, a grab sample will be collected from each 1-foot interval to a depth of 2 feet and immediately contained for VOC analysis. The remainder of the sample material from each 1-foot interval will be composited. A hand corer will also be used to collect sediment samples from Meandering Road Creek. The hand corer will be forced into the sediment in a smooth continuous motion, twisted, and then removed from the water. The nosepiece will be removed and the sample placed into a stainless steel or aluminum tray. The sample will be transferred into a labeled sample container with a stainless steel lab spoon or equivalent and preserved as required. Detailed procedures are provided in Appendix A5.1.

4.3 SOIL GAS SAMPLING

Soil-gas surveys will be performed using a systematic grid. At grid locations, a six foot long hollow 3/4-inch steel rod with an expendable drive point will be driven to a depth of 4 feet. In areas of easy access, a hydraulic hammer-drill mounted in the rear of a cargo van will be used to drive the rods. In areas of limited access, the rods will be driven manually using a three pound slide hammer. After driving to 4 feet, the rod will be raised 4 inches to release an expendable drive point and to ensure a cavity exists from which to draw the sample.

Using a battery-operated, low volume, sampling pump attached to the sampling tube, the air within the rod will be purged to ensure the sample is being obtained from the 4-foot zone. For the Fuel Saturation Areas, a calibrated Photovac TIP will be connected to the sample probe and a measurement will be taken and recorded. Following the TIP measurement, a specific indicating detector (Dräger tube) for petroleum hydrocarbons and a hand operated vacuum pump will be attached. Following these measurements, at approximately ten percent of the locations, a sorbent tube and battery operated sampling pump will be attached to the sample probe. A measured volume of soil gas will be pulled through the sorbent tube using the calibrated sampling pump. After sample collection the sorbent tube will be stored in a cooler at 4 °C to prevent thermal desorption. The sorbent tubes will be sent to an analytical laboratory for VOC analysis. The results of the soil gas surveys will be used to guide further field measurement and sampling activities.

For the Assembly Building/Parts Plant perimeter soil gas survey, TIP measurements will be taken at each location followed by the collection of a sorbent tube sample which will be sent to an analytical laboratory for VOC analysis.

Equipment and Supplies

- 6-foot 3/4-inch hollow steel drive rods
- Expendable drive points
- Slide hammer or hydraulic hammer drill
- Hydraulic rod removal jack
- Low volume battery operated sampling pump
- Hand-operated sampling pump
- Petroleum hydrocarbon detector tubes (i.e. Dräger tube)
- Supelco Carbotrap 300 sorbent tubes or equivalent
- Teflon™ 1/4-inch I.D. tubing
- Calibration gas for TIP

4.4 WATER SAMPLING

4.4.1 Groundwater Sampling

4.4.1.1 Conventional Monitoring Wells

Groundwater will be sampled from existing and newly installed conventional monitoring wells at AFP 4 as described in Section 3.0. Conductivity, temperature, and pH will be measured in the field at the time of sampling. On 20 percent of the samples, field measurements of Eh, dissolved oxygen, and alkalinity will also be made (see Appendix A6.6, A6.9, and A6.7 for specific procedures).

Conventional wells will be pumped before sampling for a minimum of three bore volumes where practical, to a maximum of five bore volumes. This will ensure that a representative sample is being collected. The pH, temperature, and conductivity of the discharge water will be monitored during pumping. The probes will be immersed in a flow-through cell soon after pumping begins to monitor the pH, temperature, and conductivity. The standard solutions for calibrating the pH meter will be brought to the temperature of the water in the flow-through bath and the meter will be standardized prior to taking the pH measurements. Electrical conductivity will be measured using a conductivity meter that has been calibrated before sampling. The conductivity probe will be placed in the flow-through bath; pH, temperature, and conductivity measurements will be recorded periodically throughout the time of pumping. The samples will be collected after the pH, temperature, and conductivity have stabilized for at least one-half a bore volume. Stabilization criteria will be ± 0.25 pH, ± 50 µmhos/cm, and ± 0.5 °C.

Existing wells with dedicated pumps will be purged using the existing pump. Newly constructed conventional wells will be purged using a peristaltic suction lift-type pump. This pump will also be used to collect the inorganic samples. Organic samples will be collected using dedicated Teflon™ bailers. Wells that cannot be purged using a suction lift-type pump will be purged and sampled using a submersible bladder-type pump. Two types of pumps may be used: (1) Pump A has a stainless steel housing and Viton™ seals and bladder and (2) Pump B has a stainless steel housing, Teflon™ bladder and Viton seals.

Samples requiring filtration will be filtered through a 0.45-micron cellulose-acetate or nitrate membrane filter in conjunction with a flow-through filtration system. The filtration system consists of a filter holder and Teflon™ support screens on the top and bottom of the filter.

Sample bottles will be filled by allowing the pump or bailer discharge to flow gently down the side of the bottle with minimal entry turbulence. The sample will then be capped and stored at 4 °C. For samples requiring preservation to pH <2 (such as with HNO_3 for metals), the proper amount of preservative will be added and the bottle capped. Samples collected for organics will be preserved, filled, bottled with no bubbles, and cooled to 4 °C.

Purge water will be treated on site prior to disposal, or contained in a tank or barrel and stored until analysis of the water is completed. Disposal will be based on the analytical results of the water.

Equipment and supplies used for groundwater sampling will include the following:

- Masterflex Peristaltic Sampling Pump (to 20-foot sampling depth) or equivalent
- Geofilter Peristaltic Pump (to 20-foot sampling depth) or equivalent
- IEA Poseidon Model Gas-Operated Bladder-Type Pump (to 200-foot sampling depth) or equivalent
- Teflon™ Bailers
- Conductivity Meter (temperature and conductivity)
- Eh Meter
- Dissolved-Oxygen Meter
- pH Meter
- Water-Level Indicator
- Portable Generator
- Filter Holder and Filters
- Latex, Nitrile, and Silver Shield gloves,
- Sample Bottles
- Concentrated HCl
- Concentrated H_2SO_4
- Concentrated HNO_3
- Teflon™ Tubing
- Cooler With Ice (Blue Ice™ or equivalent)
- Maximum-Minimum Thermometer for Cooler
- Chain of Sample Custody Forms (form UNC 1512)

4.4.1.2 Multiple-Level Monitoring Well Sampling

Multiple-level monitor well systems are designed to permit water sampling from several pre-selected depth intervals in one borehole. A measurement port coupling will be sealed off inside a borehole at the depth interval desired. Selection of the measurement port depth will be based on borehole lithology and project sampling goals.

A specialized sampling probe with a sample container attached will be lowered into the well and connected to the measurement port. The sampling probe will be activated from the surface and in turn will open the measurement port. This will allow formation water to flow into the sample container. No well purging is necessary as the measurement port provides a direct connection between the formation and the sample container, and no water sits inside the casing. Detailed procedures for collecting groundwater samples from several ports completed in the same monitoring well are provided in Appendix A, Section A11.3.

4.4.1.3 Groundwater Sampling from Open Boreholes

Groundwater samples will be taken from open boreholes that extend below the water table, but are not completed as monitoring wells. These samples will be used for reconnaissance purposes to determine whether a monitoring well will be needed at a later date. An interface probe will be lowered after the bit has been removed to indicate when the fluid level has stabilized. If LNAPL or DNAPL layers are found, then the procedures in Appendix A6.15 are followed. If only water is detected, then the procedures found in Appendix A6.11c are followed.

4.4.2 Surface Water Sampling

4.4.2.1 Lake Worth and Meandering Road Creek Water Sampling

The container immersion method of water sampling will be used to obtain grab samples from Lake Worth and Meandering Road Creek. Temperature, pH, and electrical conductivity will be measured at the time of sampling. Field personnel will put on disposable gloves and submerge the sample container below the water surface. If the water is flowing, the bottle will be pointed upstream until it is filled to the desired volume. The container will be lifted from the water, capped, rinsed with distilled or deionized water, and wiped with a lint-free tissue. The sample will be labeled and preserved as required. Detailed procedures are provided in Appendix A, Section A6.11g.

4.4.2.2 Meandering Road Creek Seep Sampling

Seep samples will be collected along the Meandering Road Creek drainage at all existing seep sampling locations and any additional seeps present along the drainage at the time of sampling. The bottom of a stainless steel scoop will be pressed against the bank so that water will flow into the scoop without disturbing the bank. When required, preservatives are added to the sample bottle. The sample bottle will then be tilted and the sample poured slowly into the sample container along the side of the bottle. Detailed procedures are in Appendix A6.13.

4.5 FLUID-LEVEL MEASUREMENTS

4.5.1 Water- and Free Product-Level Measurements

An interface probe will be used to measure depth to the top of any free product layers (both DNAPLs and LNAPLs) and to the top of the water in monitoring wells. The depth to fluids will be determined with respect to the casing top and will be measured prior to purging and sampling. The water-

level measurements will be used to estimate groundwater flow directions and velocities. Pressure transducers installed in multiple-level monitoring wells provide measurements of hydraulic head and vertical hydraulic gradients. These measurements will be used in place of water-level measurements.

4.5.2 Continuous Groundwater-Level Measurements

Continuous water-level recorders will be installed in several wells to record fluctuations in the water table. The equipment will consist of electronic pressure transducers and an electronic data logger. The transducers will be set to record data every 15 minutes. The data logger has enough memory to store data collected every 15 minutes for 16 weeks. A laptop computer will be connected to the data logger every 8 to 14 weeks to collect previous data. Before placing the transducer, the water level in each well will be measured. The transducer is then placed in the well at a level below any water level fluctuations. The operator will wait for the water level to stabilize from the effect of placing the transducer and cable into the well before using the data logger.

4.6 AQUIFER TESTS

4.6.1 Single-Well Aquifer Tests

Single-well aquifer tests will be used to measure the hydraulic conductivity of the upper zone. Tests will be conducted on all new monitoring wells and selected existing monitoring wells as specified in Section 3.0 of this plan.

The slug-withdrawal method will be used. The slug-withdrawal test apparatus consists of a capped, weighted bailer and an electronic pressure transducer connected to an automatic electronic data logger. Both the transducer and the bailer are lowered into the well. The bailer-support line and transducer cable will be marked to allow proper positioning within the well.

The transducer is lowered to a position 6 inches above the bottom of the well casing and the cable is taped to the exterior of the casing at the top of the well. The bailer is lowered until the top of the bailer is 6 inches below the fluid level. The data logger is turned on and observed until the water level in the well stabilizes (data-logger reading is constant). The recording interval is then set at "continuous" and the bailer is quickly lifted out of the fluid.

Continuous recording is maintained for the first 5 minutes of the test. At 5 minutes, the recording interval is set to 30 seconds; at 10 minutes, the recording interval is set to 1 minute; at 20 minutes, the recording interval is set to 2 minutes; and at 40 minutes, the recording interval is set to 5 minutes. The maximum recording interval of 10 minutes is set at 2 hours into the test and maintained until the water-level recovery rate becomes negligible.

The data from the slug tests will be entered into individual data files on a microcomputer. The first column will be "time in seconds" and the second column will be "hydraulic head in feet." The computer program BAIL, developed by UNC Geotech personnel, will be used to calculate the hydraulic conductivity from the slug-test data. The program plots the log of the normalized drawdown

versus time. Well-completion information is entered into the data base and the hydraulic conductivity is calculated. Examples of the resulting plots and calculations are presented in Figures 4-1 through 4-3.

4.6.2 Multiple-Level Well Aquifer Test

Multiple-level monitoring systems are designed to allow measurement of the change in pressure during fluid withdrawal or addition. An open/close tool is lowered into the well and a pumping port opened. The open/close tool is removed from the well. An electronic pressure transducer is lowered inside the casing to obtain a record of pressure changes over time. A sealed weighted bailer is then lowered into the fluid and the water level allowed to stabilize. Changes in pressure over time are monitored. The hydraulic conductivity can be calculated by standard methods for slug withdrawal tests. Procedures for conducting aquifer tests on a multiple-level well are provided in Appendix A, Section A11.3.

4.7 MONITORING WELL INSTALLATION

4.7.1 Conventional Monitoring Well Installation

The criteria used to determine whether conventional nested monitoring wells or multiple-level wells, PVC or stainless steel screens and casing, and continuous wire wrapped or slotted screens will be installed at each location are presented in Section 4.7.3. Conventional monitoring wells will be drilled primarily using hollow-stem augers. The well installations will be in accordance with local, state, and federal guidelines.

Conventional monitoring wells will be completed using PVC or stainless steel screen with flush-joint threaded casing. The annular area around the screen and extending 2 feet above the screened area will be packed with well sand. A minimum 3-foot bentonite seal will then be placed on the top of the sand pack. The remainder of the annular space around the casing will be grouted to the surface with an expanding grout mixture of cement and powdered bentonite. The bentonite content of the grout will not exceed 4 percent by total volume. The screen will be installed for the contaminant(s) of interest at each site. Wells installed for the collection of LNAPLs will be screened such that 2 feet will be above the water table and three feet will extend below the water table. This will allow for seasonal water table fluctuation or drawdown from potential pumping operations in other areas. Monitoring wells designed for the collection of soluble organic compounds will be installed such that the screen is located within the central portion of the aquifer or within a layer of interest. Monitoring wells designed for the collection of DNAPLs will be screened such that the bottom foot of the screened interval extends into the underlying confining layer upon which DNAPLs are expected to pool. All monitoring wells will be completed using a sand pack, bentonite seal, and grout as specified above.

All wells will have a locking cover. Flush mounted wells, sealed to prevent surface infiltration, will be installed where necessary to minimize disturbance to contractor activities. Otherwise, a concrete pad will be installed at the surface and, where necessary, steel posts will be installed around the well for protection. The posts will be properly painted to allow visibility in high-traffic areas.

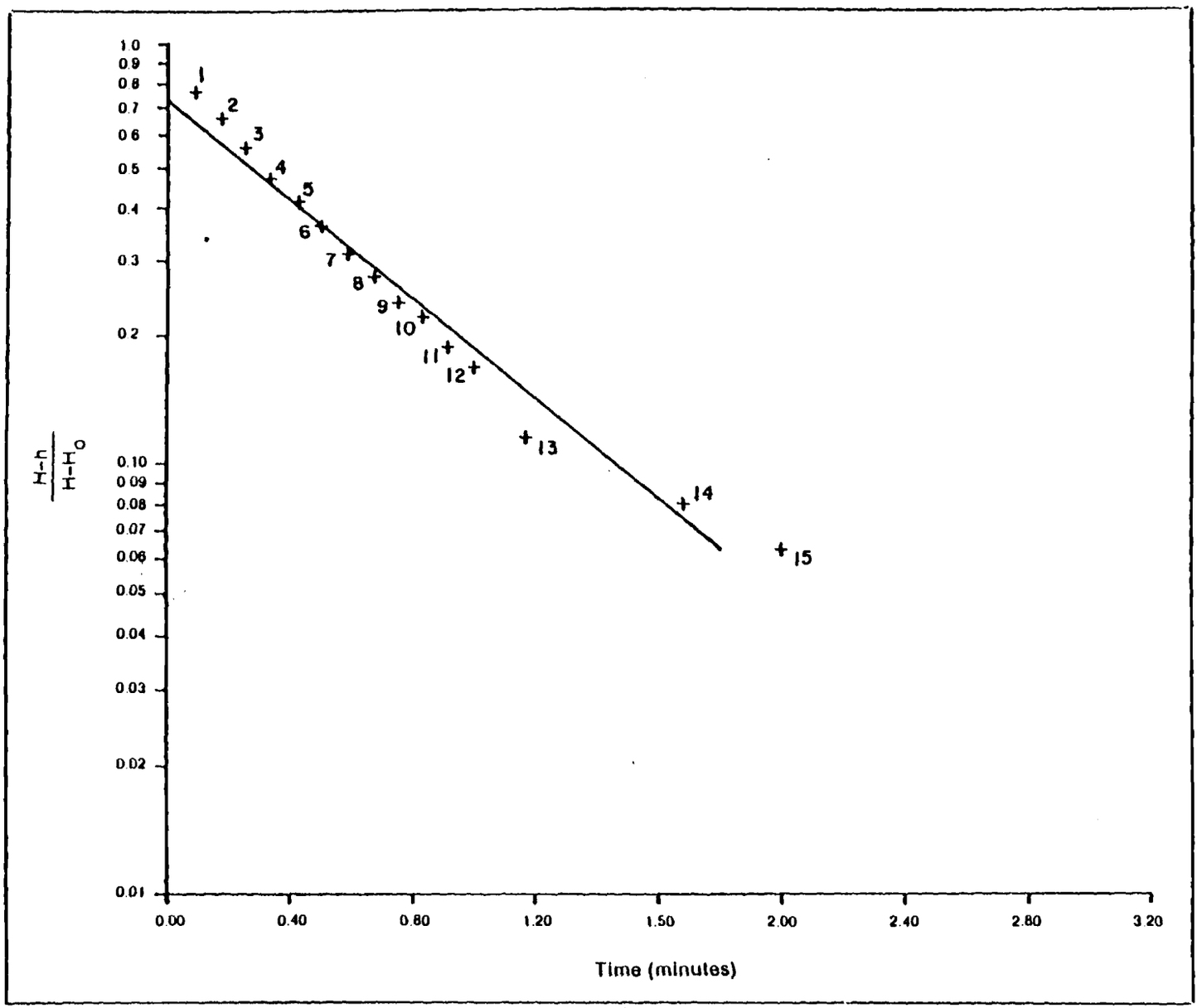


Figure 4-1. Initial Drawdown Versus Time for Bail-Test Data

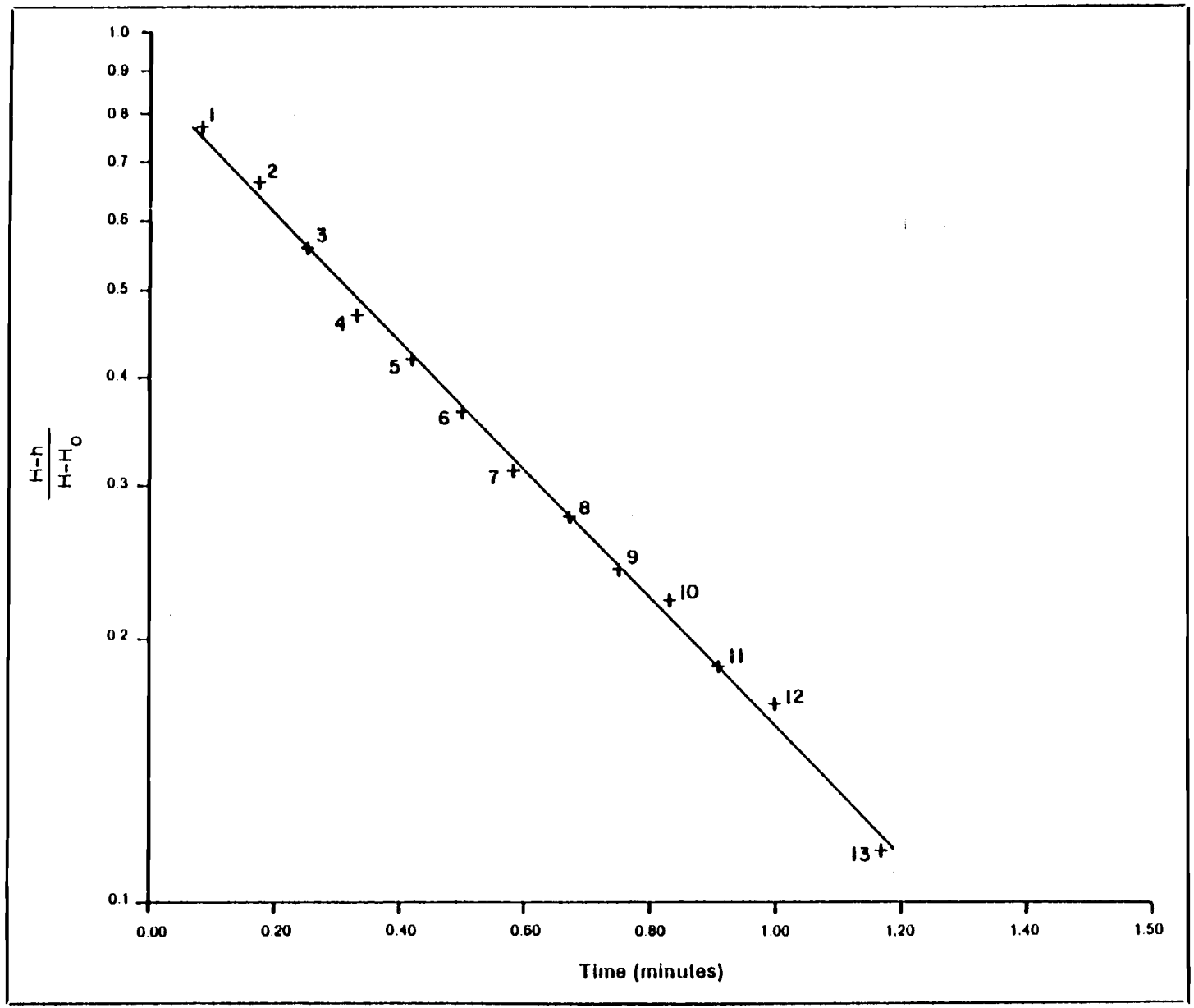


Fig 4-[illegible] Modified [illegible]ndo[illegible] Vers[illegible] Tim[illegible] for P[illegible]-Te[illegible] Data

```
 ENTER NUMBER OF POINT TO BE ELIMINATED
 "0" OTHERWISE
? 0
 ENTER CODE FOR FOR TIME UNITS
 1 = SECONDS
 2 = MINUTES
 3 = HOURS
 4 = DAYS
? 2
 ENTER PIEZOMETER INTAKE LENGTH
? 10
 ENTER CODE FOR PIEZOMETER LENGTH UNITS
 1 = INCHES
 2 = FEET
 3 = YARDS
 4 = MILLIMETERS
 5 = CENTIMETERS
 6 = METERS
? 2
 ENTER RADIUS OF DRILLED HOLE
? 4
 ENTER CODE FOR DRILL HOLE RADIUS UNITS
 1 = INCHES
 2 = FEET
 3 = YARDS
 4 = MILLIMETERS
 5 = CENTIMETERS
 6 = METERS
? 1
 ENTER RADIUS OF CASING
? 2
 ENTER CODE FOR CASING RADIUS UNITS
 1 = INCHES
 2 = FEET
 3 = YARDS
 4 = MILLIMETERS
 5 = CENTIMETERS
 6 = METERS
? 1
 HYDRAULIC CONDUCTIVITY
                        /SEC              /MIN              /HR               /DAY
 INCHES             .1887142323E-02   .1132285394E+00   .6793712365E+01   .1630490967E+03
 FEET               .1572617974E-03   .9435707843E-02   .5661424706E+00   .1358741929E+02
 YARDS              .5242059913E-04   .3145235948E-02   .1887141569E+00   .4529139765E+01
 MILLIMETERS        .4793339431E-01   .2876003659E+01   .1725602195E+03   .4141445268E+04
 CENTIMETERS        .4793339431E-02   .2876003659E+00   .1725602195E+02   .4141445268E+03
 METERS             .4793339431E-04   .2876003659E-02   .1725602195E+00   .4141445268E+01
 ENTER C TO CONTINUE
?
```

Figure 4-3. Input of Well Completion Data and Hydraulic Conductivity Calculations

Drill cuttings and water removed during the drilling process will be screened with a photoionization detector. The cuttings and water will be drummed or otherwise containerized and labeled for later disposal. Those cuttings known to contain VOCs from the photoionization screening will be properly sealed and labeled. Samples will be collected from all containerized material and the disposal requirement will be determined based on the results of analysis of the containerized materials.

Following completion, the wells will be developed through the use of a vented surge block followed by pumping with a submersible pump or a hand- or mechanically-operated "momentum pump" which operates on the principle of imparting an upward velocity to groundwater by rapidly raising and lowering a discharge pipe equipped with a foot-valve at its bottom end. The surging/pumping cycle will continue until the water is free of any sand, silt, or clay. Development will be considered complete when sand is not observed in discharge water pumped from the very bottom of the well, and the turbidity of the water is less than five nephelometric turbidity units (Appendix A6.3a).

4.7.2 Multiple-Level Monitoring Well Installation

A borehole will be drilled as if to install a conventional monitor well. Borehole lithology will be noted at the time of drilling to allow optimum placement of sampling ports. The casing components will be selected and connected together on the surface on clean plastic sheeting. Well screen depth intervals will be selected based on borehole lithology and project sampling goals. The casing assembly will be placed inside the borehole and the different sections of well screen sealed off with bentonite and expanding grout sequentially as the hollow stem augers or drill casing is removed. Packers will not be used at AFP4 due to possible degradation of the packer material by chemical contaminants. After two weeks to allow the grout to set up, the monitoring zones will be developed. Each screened section will contain a measurement and a pumping port. All pumping ports will be opened and fluid pumped from the multilevel casing using suction lift or a foot-valve equipped pump. After the fluid is reasonably clean, the pumping ports will be closed and developed one at a time. Development will be considered complete when no sand is observed in discharge water and the turbidity of the water is less than five nephelometric turbidity units (NTUs). If these criteria cannot be met, development will continue until NTU readings stabilize. Installation procedures for multiple-level monitoring wells are provided in Appendix A, Section A11.3.

4.7.3 Monitoring Well Design Criteria

Both conventional nested and multiple-level monitoring wells will be installed at AFP 4. Table 4-4 summarizes the type of monitoring well to be installed in each study area. Wells will be constructed of PVC and/or stainless steel casing and screens or ports. The screen in each conventional well will be either continuous wire wrapped or slotted, depending on the lithology. The general criteria that follow were used in monitoring well design selection.

4.7.3.1 Conventional Nested Monitoring Wells

- If an LNAPL layer is thin relative to the fluctuations in the water table. (Because of the very small sampling port on a multiple-level

Table 4-4. Summary of New Monitoring Well Design by Study Area at AFP 4

Study Area	Monitoring Well Design[1]
Assembly Building/Parts Plant	Multiple Level
Underground Storage Tanks	Conventional
Landfill No. 3	Conventional
FDTA No. 2	Conventional
FDTA No. 5	Conventional
FDTA No. 6	Conventional
Chrome Pit No. 3	Conventional
Die Yard Chemical Pits	Multiple Level
FSA No. 1	Conventional
FSA No. 2	Conventional
FSA No. 3	Conventional
Jet Engine Test Stand	Conventional
Wastewater Collection Basins	Multiple Level
East Parking Lot/ Flight Line Area	Conventional
Paluxy Aquifer System	Multiple Level

[1] Conventional nested well design is described in Section 4.7; Multiple-Level well design is described in Section 4.7 and Appendix A, Section A11.3a.

monitoring well, it would be difficult to position the port at the exact depth necessary to insure that a sample could be collected.)

- If the monitoring well is likely to be destroyed during remedial action and the expense of a multiple level monitoring well is not justified.

- At locations, such as the fuel saturation areas, where the monitoring wells may be used as part of a groundwater treatment system.

4.7.3.2 Multiple-Level Monitoring Wells

- Wells, such as boundary wells, which will be used as permanent monitoring wells or wells to be sampled for more than three sampling rounds.

- Wells located in areas where the number of boreholes to be drilled should be minimized (i.e within the Assembly Building/Parts Plant).

4.7.3.3 Well Materials

- If LNAPLs or concentrations at or near the solubility limit are known to exist, are suspected, or are found during drilling, all well materials (both casing and screen) installed in the zone of water table/LNAPL fluctuation will be stainless steel. Stainless steel materials will extend above and below the highest and lowest levels of known water table/LNAPL fluctuation. PVC well materials with compatible threads can be connected to the stainless steel outside of this zone.

- If DNAPLs or concentrations at or near the solubility limit are known to exist, are suspected, or are found during drilling, the entire saturated section of the well will be stainless steel. PVC casing with compatible threads can be connected to the stainless steel above the saturated zone.

- If DNAPLs, LNAPLs, and concentrations at or near the solubility limit are not found or suspected, the well will be completed with threaded PVC casing and screen.

- Continuous wire wrapped screens will be used on conventional wells if the screened interval is in a highly permeable material such as gravels, and sands, or the well is designed for product recovery. Slotted screens will be used if the screened interval is in low permeability material, such as bedrock, clay, or silt.

4.7.4 Monitoring Well Development

Well development serves to clean the well screen and filter pack so that finer grained material will not interfere with water quality analyses, and to improve the hydraulic characteristics of the filter pack and hydrologic unit adjacent to the well screen. A vented surge block followed by pumping with a submersible or a hand pump will be used at AFP 4. Development will be considered complete when the discharge water pumped from the bottom of the well is free of sand and the turbidity is less than 5 NTUs. A well completion

diagram will be made that documents the development methods. Detailed procedures are provided in Appendix A11.1.

4.8 WELL-LOCATION SURVEY

Well-location surveys will be conducted after the installation of all monitoring wells and well points. The surveys will include elevation or "level" surveys to establish the elevation of the monitoring well and well-point collars (top of riser extending above ground, not the top of the protective steel casing) and horizontal control surveys to establish horizontal space coordinates of the wells. Well-collar elevations will be measured with respect to mean sea level. Horizontal space coordinates will be measured with respect to existing well coordinates or other survey control. Standard land surveying practices will be used.

4.9 DECONTAMINATION PROCEDURES

4.9.1 Soil Sampling Equipment

All soil sampling equipment will be decontaminated before sampling. A decontamination pad will be established with a plastic ground cover, wash pans, and appropriate cleaning supplies. The following procedure will be used for decontamination of equipment.

1. All visible contamination will be removed with a steel brush and/or paper towels.

2. Equipment will be washed with scrub brushes and soapy water (Alconox or equivalent).

3. Equipment will be rinsed with clean potable water.

4. Equipment will then be rinsed with laboratory-grade methanol.

5. Equipment will then be rinsed with distilled or deionized water.

6. Equipment will be allowed to air dry.

All waste solvents or contaminated water will be contained and properly disposed of by the on-site group responsible for disposal of hazardous wastes.

4.9.2 Drilling Equipment

All drilling equipment will be cleaned with a high-pressure hot-water washer or steam cleaner prior to entry on the site. Between borings, equipment will again be cleaned with hot water or steam. After hot-water or steam cleaning, all down-hole equipment will be rinsed with methanol, then rinsed with deionized water, and allowed to air dry prior to re-use of equipment. A decontamination pad for the cleaning of drilling equipment will be constructed using plastic sheeting spread over a natural or man-made depression. The decontamination pad will be designed to ensure that the decontamination fluids are impounded or containerized for later disposal, based on identification of contaminants through sampling and analysis of waste materials.

4.9.3 Groundwater Sampling Equipment

All measurement and sampling equipment contacting groundwater will be cleaned as the equipment is removed from the well using clean rags or paper towels. Outer-surface areas will then be cleaned using soapy water, clean potable water, methanol, and deionized water.

Equipment, such as pumps and tubing that may become contaminated internally, will be cleaned by circulating soapy water (Alconox™ laboratory soap or equivalent) through the system. This will be accomplished by placing the pump in a bucket of soapy water, followed by a clean-water rinse through the system, and finally a deionized-water rinse. If the equipment is to be used for the collection of volatile organics, a small amount of methanol will be pumped through the system prior to the deionized-water rinse. Discharge water and solvents will be containerized and stored in steel barrels. Chemical analyses will be made of the contents of the containers. Those barrels having hazardous contents will be disposed of by the on-site group responsible for disposal of hazardous wastes. Certain fluids can be allowed to evaporate and the residue handled as routine non-hazardous waste.

4.9.4 Soil Gas Sampling Equipment

All soil gas equipment will be flushed with ultra pure zero air between samples. Before sampling, expendable probe tips will be rinsed with methanol and distilled water and allowed to dry for 24 hours. Sampling probes will be washed with laboratory soap and cleaned on the inside with a brush. This will be followed by tap water and distilled water rinses. Sample probes used in areas with hydrocarbon contamination will be rinsed with methanol before the distilled water rinse and allowed to air dry for a minimum of 24 hours before use. All sampling probes will be vented with ultra pure zero air before use.

4.10 PALUXY CORE SAMPLING

Analyses of Paluxy aquifer cores for vertical hydraulic conductivity, total organic carbon content, organic partition coefficient, and distribution coefficient will be performed by a subcontracted laboratory. Specific procedures required by the laboratory in handling these samples will be followed. They will be made available to the USEPA Region VI for review and concurrence when the subcontract is awarded.

4.11 AIR SAMPLING

One off-site air monitoring station will be placed upwind and one will be placed downwind of AFP 4. Each station will be equipped with a high-volume air sampler for detecting suspended particulates and a low-volume, organic air sampler and activated charcoal tube for detecting organic compounds. A 24-hour sample will be collected from each sampler at each monitoring station once every week for a minimum of four months. Detailed procedures are provided in ASTM Methods D4096-82 and D3686-84 (see Appendix A8).

5.0 ANALYTICAL PROCEDURES AND PROTOCOLS

5.1 INTRODUCTION

The following section describes the analytical procedures to be used in the analysis of samples collected at AFP 4. Included are sample identification requirements, volume requirements, preservation requirements, radioactive screening requirements, sample-handling and storage requirements, and sample-analysis methods and detection limits. Copies of the Standard Operating Procedures (SOPs) used by the subcontracted laboratory for AFP 4 sample analyses will be attached to this *Plan* after award of contract. Quality-assurance and quality-control requirements are briefly discussed below and also presented in the *Quality Assurance Project Plan* (Volume III) for AFP 4.

5.2 SAMPLE IDENTIFICATION

Each sample will be assigned a unique identification number that will be easily identifiable as to the project (AFP4), sample media type (GW, SW, SS, SG, S, FP, B, and PC), and location. For example, samples AFP4-GW-139 through -150 will be assigned to groundwater samples from the new monitoring wells at Fuel Saturation Area No. 3 (see Table 4-1). Lake Worth sediment samples collected near the NARF site, which have a potential for being radioactive, will be assigned a unique identification number containing an R following the media type (e.g. AFP4-SR-001).

5.3 SAMPLE REQUIREMENTS

Table 5-1 presents the laboratory requirements for sample containers, sample volume, preservation, and holding times for each media sampled.

5.4 SAMPLE HANDLING, PACKAGING, AND SHIPPING

All containers used will be pre-cleaned and obtained from an EPA-approved supplier for Superfund sites (e.g., I-Chem). Containers will be visually inspected for integrity and cleanliness prior to use. Suspect containers will not be used and will be labeled "Do Not Use" or will be discarded.

Sample bottles for liquid inorganic analyses will be filled to approximately 90 percent of capacity to allow for expansion of the contents. Sample bottles for organic analyses will be filled with minimum headspace. The 40-milliliter (ml) vials for volatile organic analysis will be filled with no headspace or bubbles.

Sample preservation will be performed immediately upon collection. For acidified samples, pH will be checked prior to shipment to ensure proper preservation. Ice chests will be used to cool samples during field sampling, packaging, and shipping. A refrigerator will be obtained for storing samples that will not be shipped the day of collection. This refrigerator will be kept in a locked room or at a minimum will have chain-of-custody seals placed on the door of the refrigerator to ensure sample security.

Those samples that have background- to low-levels of contaminants will be handled, packaged, and shipped as environmental samples. Those samples that contain high concentrations of contaminants based on field screening methods

Table 5-1. Sample Containers, Preservation, Holding Times, and Analytical Procedures

Analytical Parameter	Matrix	Container Type/Size[a]	Preservation	Holding Time	Analytical Method[b]
TCL Volatile Organics	Water	Glass With Teflon™ Septa/40 mL	No Residual Chlorine, Conc. HCl to pH <2; Cool to 4°C	14 Days	EPA 8240 or 8260 of SW-846 (3rd Ed.) or EPA 624 of 40 CFR 136 or EPA 524.2
TCL Volatile Organics	Soil	Glass With Teflon™ Lined Cap/125 mL	Cool to 4°C	14 Days	EPA 8240 or 8260 of SW-846 (3rd Ed.) or EPA 624 of 40 CFR 136
TCL Semi-Volatile Organics	Water	Glass With Teflon™ Lined Cap/4 to 6 L	No Residual Chlorine Cool to 4°C	Extr. 7 Days; Anal. 40 Days	EPA 8270 of SW-846 (3rd Ed.) or EPA 625 of 40 CFR 136
TCL Semi-Volatile Organics	Soil	Glass With Teflon™ Lined Cap/250 mL	Cool to 4°C	14 Days	EPA 8270 of SW-846 (3rd Ed.) or EPA 625 of 40 CFR 136
Dissolved Priority Pollutant Metals (Sb,As, Be,Cd,Cr,Cu,Pb,Ni,Se, Ag,Tl,Zn)	Water	HDPE/500-mL Amber Bottle	Filter Through 0.45 Micron; HNO_3 to pH <2	6 Months	Anal. by UNC Methods As-2[c], As-5[c], or As-6[d]
Total Priority Pollutant Metals (Sb,As,Be,Cd,Cr,Cu, Pb,Ni,Se,Ag,Tl,Zn)	Water	HDPE/500-mL Amber Bottle	HNO_3 to pH <2	6 Months	Digest by EPA 3005,3010 3020, of SW-846 (3rd. Ed.) Anal. by UNC Methods As-2[c], As-5[c], or As-6[d]
Total Priority Pollutant Metals	Soil	HDPE WM/250-mL	None	6 Months	Digest by UNC Method L-9 Anal. by UNC Method As-2[c], As-5[c], or As-6[d]
Radioisotope Analysis	Soil	HDPE WM/500 mL	None	Unlimited	UNC Method As-6[d] for total-U, Method C-10 for Th-230, and Gamma Spectroscopy for Ra-226, Co-60, and Cs-137
Inorganics (F,Cl,SO_4, PO_4,CrO_4)	Water	HDPE/500 mL	Filter Through 0.45 Micron; Cool to 4 °C	28 Days	UNC Method D-3[g]
Inorganics (NO_3,NO_2) (from same sample bottle as F,Cl,SO_4,PO_4)	Water	HDPE/500 mL	Filter Through 0.45 Micron; Cool to 4 °C	48 Hours	UNC Method D-3[g]
Inorganics (CN)	Water	HDPE/500 mL	NaOH to pH >12; Cool to 4 °C	14 Days	EPA Method 335.2

Table 5-1 (continued). Sample Containers, Preservation, Holding Times, and Analytical Procedures

Analytical Parameter	Matrix	Container Type/Size[a]	Preservation	Holding Time	Analytical Method[b]
Inorganics (Na,Mg,Fe, K,Ca)	Water	HDPE/500 mL	HNO_3 to pH <2	6 Months	EPA Method 6010
Inorganics (Si)	Water	HDPE/125 mL	Cool to 4°C	28 days	EPA Method 6010
TCLP Metals	Soil	HDPE WM/250 mL	None	6 Months	Extract by UNC Method L-20[e]. Digest ext. by EPA 3010, 3020 of SW-846, (3rd Ed.), Anal. by UNC As-2[c], As-5[c], or As-6[d]
TCLP (VOCs and semi-VOCs)	Soil	Glass with Teflon™-Lined Cap/1 L	Cool to 4°C	14 days	Extract by EPA Method 1311, then 8240/8260 (VOCs) or 8270 (semi-VOCs)
Total Petroleum Hydrocarbons	Water	Glass With Teflon™-Lined Cap/1 L	Cool to 4 °C Add 5 mL/L HCl	Not Specified	Analyze by UNC Method CC-1[f]
Total Petroleum Hydrocarbons	Soil	Glass with Teflon™-Lined Cap/125 mL	Cool to 4°C	Not Specified	Analyed by UNC Method CC-1[f]
Oil and Grease	Water	Glass With Teflon™-Lined Cap/1 L	Cool to 4 °C Add 5 mL/L HCl	Not Specified	Analyze by EPA Method 413.2
Oil and Grease	Soil	Glass with Teflon™-Lined Cap/125 mL	Cool to 4°C	Not Specified	UNC Method K-7
Waterborne Petroleum Oil	Water	Glass With Teflon™-Lined Cap/1 L	Cool to 4°C if held longer than 14 days	Not Specified	Analyze by ASTM Method D 3328-78

[a] Sample volumes may vary according to laboratory requirements.
[b] UNC methods are described in the following: *Analytical Chemistry Laboratory Administrative Plan and Quality Control Methods*, *Analytical Chemistry Laboratory Handbook of Analytical and Sample Preparation Methods*, and *Analytical Chemistry Laboratory Gamma-Ray Spectroscopy Systems Operation and Methods Manual*.
[c] UNC Method As-2, SOP for EPA Method 7000 series; As-5, SOP for EPA Method 6010
[d] UNC Method As-6 ICP/MS, SOP for EPA Method 6020.
[e] UNC Method L-20, SOP for EPA Method 1311.
[f] UNC Method CC-1, SOP for EPA Method 418.1.
[g] UNC Method D-3, SOP for EPA Method 300.0

will be handled, packaged, and shipped according to the regulations issued by the U.S. Department of Transportation (DOT), 49 CFR Parts 171 through 178, and EPA sampling, packaging, and shipping methods 40 CFR 260. Lake Worth sediment samples near the former NARF site will be scanned in the field for alpha, beta, and gamma activity. Any samples that exceed background levels of radioactivity will be packaged, labeled, and shipped separately. Any sample(s) with activities greater than 0.5 millirems/hour will be properly packaged, labeled, and shipped according to Department of Transportation regulations in 49 CFR Parts 171 through 178.

All samples will be packaged and shipped in a manner that will protect the integrity of the sample as well as protect against any detrimental effects from possible leakage. Packaging and shipping will include placing sample containers in zip-lock plastic bags, packing samples in vermiculite, and possibly placing samples in foam socks or equivalent packing material. Shipping containers will be properly labeled according to DOT guidelines.

Each shipment of samples will be accompanied by a signed Chain of Sample Custody form (see Figure 6-1) that specifies the analyses required for each sample and any unique handling requirements based on information obtained in the field.

5.5 LABORATORY PROCEDURES

5.5.1 Analytical Methods

All procedures will be checked for accuracy through internal laboratory quality-control checks, such as the running of blind duplicates, splits, and known standards. These checks are described in the *Quality Assurance Project Plan* (Volume III) that accompanies this document for the PA/SI and RI/FS investigations of AFP 4. The following sections briefly describe the analytical methods to be used for samples from AFP 4. Complete procedures for EPA methods are available in the appropriate EPA guidance documents. Procedures for UNC Geotech methods are available in the UNC Geotech *Analytical Chemistry Laboratory Handbook of Analytical and Sample Preparation Methods* and the UNC Geotech *Analytical Chemistry Laboratory Administrative Plan and Quality Control Procedures* manuals.

5.5.1.1 Volatile Organic Compounds (Target Compound List)

Volatile organic analyses will be conducted by UNC Geotech. The required analytical method will be EPA 8240 or 8260 (EPA SW-846, Third Edition), except that EPA Method 524.2, or EPA Method 8260 with a 25 mL purge, will be used for samples collected from Paluxy monitoring wells located on the plant perimeter where Paluxy groundwater flow is in an off-site direction.

5.5.1.2 Semi-Volatile Organic Compounds (Target Compound List)

Semi-volatile organic analyses will be subcontracted to a commercial laboratory. The required analytical method will be EPA 8270 (EPA SW-846, Third Edition).

5.5.1.3 Priority Pollutant List Metals (total and dissolved)

Priority Pollutant List Metals to be analyzed for are antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium and zinc.

For total metals in water analysis, the sample will be digested according to EPA Methods 3005, 3010, or 3020 (EPA SW-846, Third Edition), as appropriate. Analysis of the digested samples (total-metals analysis) and filtered samples (dissolved-metals analysis) will be performed according to UNC Methods As-2 (graphite furnace atomic absorption), As-5 (inductively coupled plasma atomic emission), or As-6 (inductively coupled plasma mass spectrometer).

For total metals in soil analysis, the samples will be digested according to UNC Method L-9 using nitric, perchloric, and hydrofluoric acids. Analysis of digested samples will be performed according to UNC Methods As-2 (graphite furnace atomic absorption), As-5 (inductively coupled plasma atomic emission), or As-6 (inductively coupled plasma mass spectrometer).

5.5.1.4 Cyanide

Samples for cyanide will be analyzed using EPA Method 335.2.

5.5.1.5 Inorganics (F, Cl, CrO_4, SO_4, PO_4, NO_2, NO_3) in Water

Anion analyses will be performed on filtered water samples using UNC Method D-3 (ion chromatography).

5.5.1.6 Inorganics (cyanide) in Water

Cyanide will be analyzed by EPA Method 335.2.

5.5.1.7 Inorganics (Ca, Fe, Mg, K, Si, Na) in Water

UNC Geotech Method As-5 (inductively coupled plasma atomic emission) will be used for analysis.

5.5.1.8 Total Petroleum Hydrocarbons

Total petroleum hydrocarbons will be analyzed by UNC Geotech using UNC Method CC-1 (infrared spectroscopy).

5.5.1.9 Oil and Grease

Oil and grease in water will be analyzed by UNC Geotech using EPA Method 413.2. Oil and grease in soil will be analyzed by UNC Method K-7.

5.5.1.10 TCLP

Soil samples will be extracted according to UNC Method L-20. Extracts for metals analysis will be digested according to EPA SW-846 Methods 3010 and 3020, as appropriate. Analyses of these digested samples will be performed according to UNC Methods As-2 (graphite furnace atomic absorption), As-5 (inductively coupled plasma atomic emission), or As-6 (inductively coupled

plasma mass spectrometry). Extracts for VOCs will be analyzed by EPA Method 8240 or 8260. Analysis for semi-VOCs will be subcontracted to a commercial laboratory. The required analytical method will be EPA 8270 (SW-846).

5.5.1.11 Radioisotopes

Soil samples will be analyzed by UNC Method As-6 (inductively coupled plasma atomic emission) for total uranium, UNC Method C-10 (alpha spectrometry) for thorium-230, and gamma spectroscopy scan for radioisotopes including radium-226, cobalt-60, and cesium-137.

5.5.1.12 Waterborne Petroleum Oils (LNAPLs)

Free-floating product (LNAPL) from monitoring wells will be analyzed by ASTM Method D3328-78 (reapproved 1982).

5.5.2 Paluxy Core Methods

Analyses of Paluxy core samples will be performed by a subcontracted laboratory. The following methods, or their equivalents will be used: vertical hydraulic conductivity (EPA Method 9100), total organic carbon content (ASTM Method E1131), organic partition coefficient (ASTM Method E1147), and distribution coefficient (ASTM Method D4646).

6.0 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

6.1 INTRODUCTION

This section describes the quality-assurance and quality-control measures that will be instituted for the field sampling and analysis phase of the PA/SI and RI/FS processes at AFP 4. The objective is to provide systematic control of all phases of the processes, which includes proper sampling design, sampling procedures, accuracy, precision, comparability, and completeness.

6.2 SAMPLING PROCEDURES

The basic sampling procedures are described in Section 4.0 of this document. References to procedures approved by the EPA and/or the U.S. Department of Energy (DOE) that describe the procedures in more detail are given. Any deviation from these established procedures will be noted in the field logbooks with an explanation of the change(s) and what the resulting impact on data quality might be.

6.3 SAMPLE CONTROL

6.3.1 Sample Identity

To maintain evidence of authenticity, the samples collected must be properly identified and easily discerned from other like samples. Samples collected for AFP 4 will be identified by a label attached to the sample container that will include the sample identification number, date collected, time collected, and the sampler's name. In addition, a label will be attached to the container with the same information that will be kept in the evidentiary files for the project.

6.3.2 Sample Custody

To maintain the integrity of the samples, it will be necessary to demonstrate that the samples were kept under custody from the time they were collected to the time they were analyzed. Chain of Sample Custody records (Figure 6-1) will be used to list all sample possession transfers. This document will show that the sample was in constant custody between collection and analysis.

While the sample is being shipped, the shipping container will have custody seals placed over the container opening to ensure that the integrity of the samples has not been compromised during shipment. The receiving laboratory must examine the seals on arrival and document that the seals were intact. Upon opening the container, the condition of the sample containers will also be noted (i.e., broken bottles, leaking bottles, broken seal around the lid).

6.3.3 Transportation/Shipment of Samples

All shipments will be made in compliance with DOT regulations governing shipment of hazardous materials and substances. A copy of the regulations in 49 CFR 171-179 will be made available to field personnel responsible for marking, labeling, packaging, documenting, and shipping hazardous material,

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2597 B-3/4 Road
Grand Junction, Colorado 81502-5504
Telephone (303) 248-6000

Chain of Sample Custody

1. Page____ of____

2. Date_____

3. Project Name _____ 4. Site Location _____ 5. Analytic Charge Number _____

6. Samplers (print names) _____

7. Sample No.	8. Date	9. Time	10. Sample Location	11. Sample Type	Container 12. Type	Container 13. No.	14. Analyses	15. Remarks	16. Condition Received

17. Relinquished by *(signature)*	Date	Time	Relinquished by *(signature)*	Date	Time	Relinquished by *(signature)*	Date	Time
Received by *(signature)*	Date	Time	Received by *(signature)*	Date	Time	Received by *(signature)*	Date	Time

18. Method of Shipment	19. Laboratory/Destination	20. Airbill or Receipt Number

21. For Contract Laboratories Only—Receiver to sign, date, and return Form by mail.

Company Name _____ Received by _____ Date _____

UNC 1818
Rev. 4/88

Preparation instructions on back of forms.

Distribution: Original accompanies shipment, copies to relinquisher.

Figure 6-1. Chain of Sample Custody Form

53 110

substances, and waste. In addition to meeting all DOT requirements, special care will be taken to ensure the integrity of the sample through proper packaging and shipping.

To determine the proper identification of a hazardous sample, field personnel will review field measurement data and the logbooks for relevant information concerning the sample material in each container. This information will include such things as radioactivity levels, organic vapors detected, pH, explosivity determinations, or any other information useful in classifying the samples for shipment. If a sample is known or suspected to contain a specific hazardous material, the sampler will note the presence of the material on the sample label. This information is necessary for the receiving laboratory to determine proper handling of the sample prior to analysis.

6.4 DOCUMENT CONTROL

6.4.1 Introduction

The preparation, issue, and revision of documents that specify quality requirements or prescribe activities affecting quality will be controlled to assure that the correct documents are being used and enforced during the sampling and analysis phase of the RI/FS process. The following describes the various documents that will be controlled.

6.4.2 Field Logbooks

Bound logbooks with consecutively numbered pages will be used by field personnel for each major field task performed (i.e., soil sampling, groundwater sampling, monitoring-well drilling). The field logbooks will be used to record the daily activities of the field team, record any field measurements taken, sketch maps of measurement and sample locations, and note observations that may indicate the quality of the data. Each page will be signed and dated by the person making the entries on that page and will also be signed and dated by a second person who has reviewed the entries for accuracy and clarity.

Each logbook that is issued will be signed out by the individual responsible for completion of the logbook. This record will be part of the overall Document Control Log. When the books are returned, the receiver will sign and date the return.

6.4.3 Daily Drilling Log

A log will be maintained of each day's drilling activities that contains a record of footage drilled, materials used, problems encountered, and general observations. The log will identify each boring by a specific identification (ID) number and location and will contain the names of drilling personnel and their employer. These logs will be reviewed by the drilling supervisor for completeness and accuracy. Figure 6-2 is an example of a daily drilling log that will be used. Upon completion, these logs will become part of the project evidentiary file.

Drilling Report

State _____ County _____ Project _____ Hole Name _____ Hole No. _____

Drilling Contractor _____ Rig Type _____ Rig No. _____

From A.M. P.M.	To A.M. P.M.	Footage			Drilling (check)					Description of Work
		From	To	Hole Size	Drl	Cor	Rem	Agr	Sam	

Materials Used (e.g., casing, cement, water, mud, etc.)	Remarks

Drill Crew

Driller _____

Helper _____

Helper _____

Other _____

Contract Foreman _____ UNC Representative _____ Report No. _____ Date _____

UNC 1708
Rev. 2/87

White—Return to UNC with Invoice(s) Canary—UNC Field Copy Pink—Rig Copy

Figure 6-2. Daily Drilling Report Log Form

6.4.4 Well Completion Log

A well completion log (Figure 6-3) will be completed for each new well drilled and will include the well ID number, well location, installation description and completion diagram, development information, and a lithologic log. The well completion log will be signed and dated by the person entering the information and will be QA checked by another person for accuracy and clarity.

6.4.5 Instrument Calibration Log

An instrument calibration log will be kept for instruments requiring daily calibration or operational checks to ensure that the data being obtained are within established QA limits. Included in the logbook will be the date of calibration, the type of calibration performed, standards used, and the QA limits established for each particular instrument. The log will be signed and dated by the person performing the calibration. Instruments failing the calibration or operational checks will be adjusted or repaired (if possible) and rechecked, or will be tagged "DO NOT USE."

6.4.6 Soil Sampling Log

A soil sampling log (Figure 6-4) will be completed for each soil sampling location (monitoring-well boring, subsurface auger hole, surface sampling point, trench, etc.). The log will include the sampling location, hole number, sample number, sampling depth interval, analyses to be conducted, and comments, if any. The log will be signed and dated by the person recording the information and will be QA checked for accuracy and clarity.

6.4.7 Groundwater Sample Collection Forms

A groundwater sample collection form will be completed for each sampling location (Figure 6-5). This form is a fairly comprehensive form that documents water quality field measurements taken at the time of sampling and purging. Information recorded includes pump type, purge volumes and rates, and type of sample bottles, preservatives and filters used.

6.4.8 Chain-of-Custody Forms

A copy of each chain-of-custody form (see Figure 6-1) will be retained in a file for the project records for traceability in case of sample loss or delays during shipment. This file will be maintained in the field until completion of fieldwork and then will become part of the permanent project files after completion of the project. Copies received by the laboratory will also be maintained in a project file until completion of the analytical work and will then be transferred to the permanent project files.

6.4.9 Evidentiary File

The Project Manager, or designee, will maintain a project file that will include all pertinent information gathered in the course of fieldwork, such as permits obtained for access, drilling, or excavation, correspondence relating to the project, completed forms, completed logbooks, software programs, training records, accident reports, and other records and files required for the permanent project file.

UNC *Geotech*
2597 B 3/4 Road
P.O. Box 14000
Grand Junction, Colorado 81502-5504

Well Summary Information

Prepared By _____ Date _____ Page ___ of ___

Hole No. _____ Location _____

Total Depth _____ No. of Completions _____ Rig Type _____

Auger Size _____ Sample Type _____

Project _____ Data Verified by _____ Date _____

Depth (feet)	Blows/ 6"	Sample Interval	Well Construction	Graphic Log	Description

UNC 1734
9/89

Figure 6-3. Well Completion Log Form

UNC GEOTECH SOIL SAMPLE LOG

PROJECT:_____ Prepared by:_____

Date: mm.dd.yr. / / Hole no._____ Location: N_____ E_____

Sample No.	Analyses	Depth	Comments
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	
		to	

Page___of___

Figure 6-4. Soil Sample Log Form

UNC Geotech

Documentation of Sample Collection

1. Date_____ Location_____ Site No._____

2. Measure well-water depth and calculate volume.
   Depth to water_____ Depth of well_____ Well diameter_____
   Depth of water_____ Calculated water volume_____

3. Pump three to five bore volumes of water from well.

4. Pump type_____

5. Measure sample temperature: _____°C Time_____ Instrument used_____

6. Measurement of conductivity: Time_____ Sample Conductivity_____mmhos/cm
   Measurement conditions: In situ ( ) Open container ( ) Air exclusion ( )
   Time of last calibration check_____
   Temperature of calibration standard_____°C
   Conductivity reading of calibration standard_____µmhos/cm
   Sample specific conductance at 25 °C_____µmhos/cm

7. Measure pH: Time_____ Sample pH_____
   Measurement conditions: In situ ( ) Open container ( ) Air exclusion ( )
   Time of last two-buffer calibration_____
   Buffer temperature at calibration_____°C Buffers used_____

8. Measure Eh: Time_____ Sample Eh_____mV
   Measurement conditions: In situ ( ) Open container ( ) Air exclusion ( )
   Temperature of ZoBell solution_____°C
   Eh of ZoBell solution_____mV

9. Measure dissolved oxygen (DO): Time_____ Sample DO_____mg/l
   Date and time of last zero check with $NaSO_3$ solution_____
   Atmospheric pressure_____mmHg Altitude_____ft
   Temperature of calibration chamber_____°C
   DO saturation from table_____
   Correction factor_____ Calibration value_____

10. Measure alkalinity: Time_____ Total alkalinity_____ppm as $CaCO_3$
    Hach Kit method: Titration cartridge_____
    Phenolphthalein alkalinity_____

11. Filter and collect samples:

    Number and type of filters used_____

Container Size	Container Type	No. Collected	Filtered Yes	Filtered No	Preservative Used

UNC 1705
9/88

Figure 6-5. Groundwater Sample Collection Form

12.

Date	Time	Total Volume Withdrawn		pH	Ec (µmhos/cm)	Temp. (°C)	Eh	DO	Comments
		(gal)	(bore vol)						
		0.0	0.0	–	–	–			Start Pumping

13. Comments _____

Signature of Sampler _____ Date Signed _____

Checked by _____ Date Checked _____

Figure 6-5. (continued) Groundwater Sample Collection Form
(Back of Form)

6.5 LABORATORY QUALITY CONTROL

6.5.1 Internal Quality Control Checks

For subcontracted analyses, internal quality control will be performed according to EPA SW-846 (Third Edition). Although the laboratory selected will have a thorough internal QA/QC system that meets or exceeds the requirements set forth in EPA SW-846 (Third Edition), the following minimum requirements will be met.

- A reagent blank will be prepared and analyzed to check for contamination caused by reagent preparation for each analytical run.
- A matrix spike sample will be prepared and analyzed on at least 1 sample per analytical batch of a similar matrix. A "batch" consists of 20 or fewer samples.
- At least 1 duplicate sample analysis will be performed on each batch of 20 or fewer samples of a similar matrix.
- For analysis by gas chromatography/mass spectrometry (GC/MS), surrogate spike analyses will be run on all samples.

For UNC Geotech laboratory analyses, the internal quality control will be as specified in EPA SW-846 (Third Edition) and the minimum requirements will be as follows:

ICP Analyses

- For analysis by inductively coupled plasma atomic emission spectroscopy, each instrument will have an initial calibration and a calibration verification using a calibration standard specified for each instrument. The calibration standard will be either an EPA Quality Control Solution or a National Institute of Standards and Technology (NIST)-traceable control solution. Calibration verification during an analysis run will be performed after every 10 samples.
- An interference check sample analysis will be run for each analytical run to verify inter-element and background correction factors on a regular basis for analysis performed using ICP.

Dissolved Metals (waters)

- A portion of 1 sample per analytical batch will be spiked with a known amount of each analyte and analyzed to check for matrix interferences. Each "batch" consists of 20 or fewer samples. Spike recoveries will be between 90 and 110 percent.
- One sample for every analytical batch (in which each batch consists of 20 or fewer samples) will be analyzed in duplicate.
- One check sample containing known amounts of each element will be analyzed for every batch of 20 or fewer samples.

Metals (total metals--waters)

- A portion of 1 digested sample for every batch of 20 or fewer samples will be spiked with a known amount of each analyte and analyzed to check for matrix interferences. Spike recovery will be between 90 and 110 percent.

Metals (total metals--soils)

- One sample for every batch of 20 or fewer samples will be spiked according to SW-846. Standard addition will be performed if the spike recovery is outside the range of 85 to 115 percent.

- One sample for every batch of 20 or fewer samples will be digested and analyzed in duplicate.

- Known reference materials will be included at a frequency of 1 for every batch of 20 or fewer samples.

- A blank will be carried through the digestion procedures with every batch.

TCLP (soil extracts)

- For every batch of 20 or fewer samples, analyze one matrix spike, one matrix spike duplicate, and one blank.

- Percent recoveries will be according to the analytical method and are included as Appendix D of the QAPP.

- One check sample containing known amounts of each analyte will be analyzed for every batch of 20 or fewer samples.

Inorganics (waters)

- One sample for every batch of 20 or fewer samples will be analyzed in duplicate.

- One check sample containing known amounts of each analyte will be analyzed for every batch of 20 or fewer samples.

- A portion of 1 sample for every batch of 20 or fewer samples will be spiked with known amounts of each analyte. Spike recoveries must be between 90 and 110 percent, unless the sample result is less than 10 times the reporting limit, in which case spike recoveries must be between 80 and 120 percent.

Volatiles

- One sample for every batch of 20 or fewer samples will be analyzed in duplicate.

- One check sample containing known amounts of each analyte will be analyzed for every batch of 20 or fewer samples.

- A portion of 1 sample for every batch of 20 or fewer samples will be spiked with known amounts of each analyte. Spike recoveries for each compound are as specified in EPA Method 8240 and are included in Appendix D of the QAPP.

Total Petroleum Hydrocarbons

- One sample for every batch of 20 or fewer samples will be analyzed in duplicate. The duplicates will be within 20 percent of each other if the analyte concentration is greater than 5 times the reporting limit.

Oil and Grease

- One sample for every batch of 20 or fewer samples will be analyzed in duplicate. The duplicates will be within 20 percent of each other if the analyte concentration is greater than 5 times the reporting limit.

Waterborne Petroleum Oil (LNAPL)

- One sample for every batch of 20 or fewer samples will be analyzed in duplicate.

Radioisotopes

- One sample for every batch of 20 or fewer samples will be analyzed in duplicate.

6.5.2 Duplicates

Duplicate samples for both water and soil will be collected and submitted blind to the laboratory at a rate of 10 percent.

6.5.3 Trip and Field Blanks (Water)

A minimum of two trip blanks and two field blanks will be submitted to the contracted laboratories for analysis of volatile organics.

6.5.4 Equipment Blanks (Water)

Water equipment blanks will be collected at a rate of 1 per 10 samples for the purpose of evaluating equipment contamination in the field. The equipment blanks will be analyzed for the same constituents as the water samples.

6.5.5 Reporting Limits

Table 6-1 presents the reporting limits that will be used for analysis of AFP 4 samples. For volatile and semi-volatile organic compounds, the listed limits are the Practical Quantitation Limits (PQLs), as listed in the appropriate EPA methods of SW-846 (Third Edition). Other limits are method detection limits.

Table 6-1. Reporting Limits for Laboratory Analyses

Analytical Parameter	Analytical Method	Reporting Limit Groundwater (µg/L)	Reporting Limit Soil (µg/Kg)
Volatile Organics (Target Compound List)	EPA Method 8240 or 8260[b] (SW-846, Third Edition) except as noted		
Acetone		10	10
Benzene		5 (1)[a]	5
Bromodichloromethane		5	5
Bromoform		5	5
Bromomethane		10	10
2-Butanone		10	10
Carbon disulfide		5	5
Carbon tetrachloride		5 (1)[a]	5
Chlorobenzene		5	5
Chloroethane		10	10
Chloroform		5	5
Chloromethane		10	10
Dibromochloromethane		5	5
1,1-Dichloroethane		5	5
1,2-Dichloroethane		5 (1)[a]	5
1,1-Dichloroethene		5	5
trans-1,2-Dichloroethene		5	5
1,2-Dichloropropane		5	5
cis-1,3-Dichloropropene		5	5
trans-1,3-Dichloropropene		5	5
Ethyl benzene		5	5
2-Hexanone		10	10
Methylene chloride		5	5
4-Methyl-2-pentanone		10	10
Styrene		5	5
1,1,2,2-Tetrachloroethane		5	5
Tetrachloroethene		5	5
Toluene		5	5
1,1,1-Trichloroethane		5	5
1,1,2-Trichloroethane		5	5
Trichloroethene		5 (1)[a]	5
Vinyl acetate		10	10
Vinyl chloride		10 (1)[a]	10
Xylene		5	5
Semi-Volatile Organics (Target Compound List)	EPA Method 8270 (SW-846, Third Edition)		(µg/Kg)
Acenaphthene		10	660
Acenaphthylene		10	660
Anthracene		10	660
Benzoic acid		50	1600

Table 6-1 (continued). Reporting Limits for Laboratory Analyses

Analytical Parameter	Analytical Method	Reporting Limit Groundwater (µg/L)	Reporting Limit Soil (µg/Kg)
Semi-Volatile Organics (continued)			
Benzo(a)anthracene		10	330
Benzo(b)fluoranthene		10	330
Benzo(k)fluoranthene		10	330
Benzo(g,h,i)perylene		10	330
Benzo(a)pyrene		10	330
Benzyl alcohol		10	330
Bis(2-chloroethoxy)methane		10	330
Bis(2-chloroethyl)ether		10	330
Bis(2-chloroisopropyl)ether		10	330
Bis(2-ethylhexyl)phthalate		10	330
4-Bromophenyl phenyl ether		10	330
Butyl benzyl phthalate		10	330
4-Chloroaniline		10	330
2-Chloronaphthalene		10	330
4-Chloro-3-methylphenol		10	330
2-Chlorophenol		10	330
4-Chlorophenyl phenyl ether		10	330
Chrysene		10	330
Dibenz(a,h)anthracene		10	330
Dibenzofuran		10	330
Di-n-butylphthalate		10	330
1,2-Dichlorobenzene		10	330
1,3-Dichlorobenzene		10	330
1,4-Dichlorobenzene		10	330
3,3'-Dichlorobenzidine		20	660
2,4-Dichlorophenol		10	330
Diethylphthalate		10	330
2,4-Dimethylphenol		10	330
Dimethylphthalate		10	330
4,6-Dinitro-2-methylphenol		50	1600
2,4-Dinitrophenol		50	1600
2,4-Dinitrotoluene		10	330
2,6-Dinitrotoluene		10	330
Di-n-octylphthalate		10	330
Fluoranthene		10	330
Fluorene		10	330
Hexachlorobenzene		10	330
Hexachlorobutadiene		10	330
Hexachlorocyclopentadiene		10	330
Hexachloroethane		10	330
Indeno(1,2,3-cd)pyrene		10	330
Isophorone		10	330
2-Methylnaphthalene		10	330
2-Methylphenol		10	330

Table 6-1 (continued). Reporting Limits for Laboratory Analyses

Analytical Parameter	Analytical Method	Reporting Limit Groundwater (µg/L)	Reporting Limit Soil (µg/Kg)
Semi-Volatile Organics (continued)			
4-Methylphenol		10	330
Naphthalene		10	330
2-Nitroaniline		50	1600
3-Nitroaniline		50	1600
4-Nitroaniline		50	1600
Nitrobenzene		10	330
2-Nitrophenol		10	330
4-Nitrophenol		50	1600
N-Nitroso-di-n-dipropylamine		--	--
N-Nitrosodiphenylamine		10	330
Pentachlorophenol		50	3300
Phenanthrene		10	330
Phenol		10	330
Pyrene		10	330
1,2,4-Trichlorobenzene		10	330
2,4,5-Trichlorophenol		50	1600
2,4,6-Trichlorophenol		10	330
Priority Pollutant Metals	EPA Method 6010/ EPA Method 7000 Series	ICP (µg/L)	FAA (µg/L)
Antimony		60	
Arsenic			10
Beryllium		5	
Cadmium		5	
Chromium		10	
Copper		25	
Lead		5	
Nickel		40	
Selenium			5
Silver		10	
Thallium		10	
Zinc		20	
TCLP Metals	EPA Method 6010/ EPA Method 7000 Series	ICP (µg/L)	FAA (µg/L)
Arsenic			10
Barium		2	
Cadmium		5	
Chromium		10	
Lead		5	
Selenium			5
Silver		10	

Table 6-1 (continued). Reporting Limits for Laboratory Analyses

Analytical Parameter	Analytical Method	Reporting Limit	
		Groundwater	Soil
TCLP VOCs and Semi-VOCs (See Table 4-2 for list; reporting limits are same as given under TCL, this table.)			
Inorganics			
Chloride	EPA Method 300.0	0.10 mg/L	
Chromium (hexavalent)		10 µg/L	
Fluoride		0.10 mg/L	
Nitrate		0.10 mg/L	
Nitrite		0.10 mg/L	
Phosphate		0.10 mg/L	
Sulfate		0.10 mg/L	
Cyanide	EPA Method 335.2	0.02 mg/L	
Calcium	EPA Method 6010	1.00 mg/L	
Iron		0.05 mg/L	
Magnesium		1.00 mg/L	
Potassium		1.00 mg/L	
Silica		1.00 mg/L	
Sodium		1.00 mg/L	
Total Petroleum Hydrocarbons	EPA Method 418.1	0.10 mg/L	1 mg/Kg
Oil and Grease	EPA Method 413.2	0.20 mg/L	
	UNC Method K-7		5 mg/Kg
Radioisotopes			
Total Uranium	EPA Method 6010		5 µg/L
Thorium-230	UNC Method C-10 (α-Spec)		c
Radium-226	Gamma Spectroscopy		c
Cobalt-60	Gamma Spectroscopy		c
Cesium-137	Gamma Spectroscopy		c
LNAPLs	ASTM Method D 3328-78	Not established	

[a]EPA Method 524.2 or 8260 with a 25 mL purge will be used for samples collected from Paluxy monitoring wells located on the plant perimeter where Paluxy groundwater flow is in an off-site direction.
[b]EPA Method 8260 meets or exceeds EPA Method 8240 in precision and accuracy.
[c]The detection limits depend on sample types, matrix, and counting time.

7.0 DATA MANAGEMENT

Data collected from the various field measurement and field sampling activities will initially be in various forms. Portions of the data will be handwritten in field logbooks, some will be in the form of instrument data output, other data will be in laboratory analytical reports, and some data will automatically be transferred from instrumentation to a computer data base. A microcomputer data-management system will be used to compile all the data onto a central data base. Files for each type of data will be created that will include data type, identification number (if applicable), location coordinates, and raw data. These files will then be edited as a QA check to ensure that the data was input correctly.

Programs used to correct or reduce data will be programs that have undergone a QA verification prior to their use. A hard-copy output of the various completed data files will be placed in the permanent project files.

8.0 LOGISTICS AND SCHEDULE

8.1 LOGISTICS

8.1.1 Communication and Coordination

Coordination of the sampling activities with AFP 4 will be the responsibility of both the Project Manager and the Field Team Leader. The prime contact for the AFP 4, General Dynamics is:

Luke D. Gilpin
Facility Engineer
General Dynamics
Facilities Engineering
P.O. Box 748, Ft. Worth, Texas 76101
(817) 777-8203

The Project Manager or Field Team Leader will be responsible for contacting the appropriate General Dynamics personnel prior to start of fieldwork to obtain the proper access to all areas, to arrange for escorts if required, to obtain any permits required, or to arrange for facility support. He/she will also need to communicate any changes in scheduled activities while fieldwork is in progress to ensure that fieldwork is not hampered due to logistical problems.

UNC Geotech will arrange to have a trailer available for use by the field team during field investigation activities. The trailer will have a chest freezer and refrigerator for use in sample preparation/storage, telephone, and storage area for hazardous materials (such as acid used for sample preservation). Electrical hookups and access to shower(s) will be provided by General Dynamics. To maintain a chain-of-custody, the trailer will be locked at all times when not occupied by UNC Geotech personnel.

Sampling personnel are not to discuss or provide information on the sampling activities to the public or news media. Any communication outside the AFP 4 will be directed to the Project Manager or the appropriate Air Force (ASD) personnel.

8.1.2 Equipment, Supplies, and Transportation

All field equipment (e.g. sampling equipment, forms, and logs, drilling equipment) will be supplied by UNC and their subcontractors. Sampling equipment and supplies will be shipped to the facility as needed and will be stored in the trailer. Vehicles used on the facility will be obtained from a rental agency. A refrigerator will be required for sample storage prior to shipment. A chest-type freezer will be required for freezing of Blue Ice, or equivalent. Arrangements will be made to obtain these items locally.

Facilities or containers will be required for storage and disposal of small quantities of potentially hazardous waste generated during the sampling program. Arrangements will be made with General Dynamics for disposal of these wastes. Arrangements will also be made for a decontamination pad area for the washing of contaminated drilling equipment, if deemed necessary.

8.1.3 Field Personnel

Field personnel will be in the field on a 10-day-on, 4-day-off schedule, with a variable number of people depending on the specific task and expertise required. All personnel will be properly trained for the task assigned. The Project Manager will maintain documentation of personnel qualifications and training.

8.1.4 Laboratory Assignments

Personnel responsible for shipping samples will ship samples according to the required analyses to either the UNC Analytical Chemistry Laboratory in Grand Junction, Colorado, or the subcontractor laboratory (subcontractor information will be supplied when available). The mailing address of the UNC laboratory is:

UNC Geotech
2597 B3/4 Road
Grand Junction, CO 81501
Attn.: Ersel Reid

8.1.5 Sample Shipments

Due to the short holding times associated with many of the samples, shipments will be made on a daily basis, when possible, using an overnight or priority-mail delivery service.

8.2 SCHEDULE OF FIELD ACTIVITIES

The following is the proposed schedule for the completion of field activities at AFP 4 in support of the RI/FS. This schedule is based on the timely review and approval of the RI/FS planning documents for AFP 4.

Task	Proposed Schedule
PA/SI Investigations:	
Land surveying	June 4 - 13, 1990
Utility Location	June 11 - 15, 1990
Soil Gas Surveying	June 18 - 27 and July 9 - 18, 1990
Soil borings and Soil Sampling	September 10 - 19, 1990 September 24 - October 3, 1990
RI/FS Investigations:	
Surface water, seep, stream sediment, and stream channel sampling	September 10 - 19, 1990
Lake water, lake sediment and biota sampling	September 24 - October 3, 1990
Air Monitoring	September through November, 1990

Task (cont)	Proposed Schedule (cont)
Monitoring well drilling, soil borings and soil sampling, groundwater sampling, surveying	September 24 - October 3, 1990 October 8 - 17, 1990 October 22 - 31, 1990
Groundwater sampling (new wells - 2nd round), aquifer tests	October 22 - 31, 1990 November 5 - 14, 1990 November 19 - 28, 1990
Continuous water -level monitoring (Paluxy aquifer)	September, 1990 - January, 1991

9.0 HEALTH AND SAFETY

The *Health and Safety Plan* (Volume IV) that accompanies this plan will be enforced for field work at the AFP 4 site. The *Health and Safety Plan* is a comprehensive plan that describes the health and safety responsibilities of UNC Geotech personnel, defines the procedures to be used, establishes protective equipment requirements, describes potential contaminants and their exposure limits, describes plans for emergency response, and provides guidance for spill cleanup and abatement.

To ensure that field personnel understand the health and safety requirements and are aware of the potential health and safety hazards for each site, the Field Manager will conduct a daily health and safety briefing.

All personnel will have received the 40-Hour Hazardous Waste Site Safety Training Course from a certified agency or agent.

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11.0 ACRONYMS

ACRONYM	MEANING
AFB	Air Force Base
AFP 4	Air Force Plant No. 4
ARAR	Applicable or relevant and appropriate requirement
ASD	Aeronautics Systems Division
BTEX	Benzene, toluene, ethylbenzene, xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DCA	Dichloroethane
DCB	Dichlorobenzene
DCE	Dichloroethylene
DQO	Data quality objective
EPA	U.S. Environmental Protection Agency
FDTA	Fire Department training area
FID	Flame ionization detector
FS	Feasibility Study
FSA	Fuel saturation area
GC	Gas chromatograph
GD	General Dynamics
GOCO	Government-owned, contractor-operated
gpd/ft	gallons per day per foot
gpm	gallons per minute
HARM	Hazard assessment rating methodology
IRP	Installation Restoration Program
MEK	Methyl ethyl ketone
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
ml	milliliter
MS	Mass Spectrometer
msl	mean sea level
NARF	Nuclear Aerospace Research Facility
NCP	National Contingency Plan
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollution Discharge Elimination System
NPL	National priorities list
OSHA	Occupational Safety and Health Administration
OVA	Organic vapor analyzer
PCB	Polychlorinated biphenyls
PCE	Tetrachloroethylene
PID	Photoionization detector
ppm	parts per million
PQL	Practical quantitation limits
PRP	Potentially responsible party
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RI	Remedial investigation
ROD	Record of decision
SARA	Superfund Amendments and Reauthorization Act
SCBA	Self-contained breathing apparatus

ACRONYM	MEANING
SDWS	Secondary drinking water standards
SCS	Soil Conservation Service
TCA	Trichloroethane
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TRC	Technical Review Committee
TTLC	Total threshold limit concentration
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
UNC	UNC Geotech
USAF	United States Air Force
USDA	United States Department of Agriculture
VOC	Volatile organic compound

APPENDIX A CONTENTS

SOIL SAMPLING

A1.1 Surface Soil Sampling
A2.1 Subsurface Soil Sampling
A3.1 Split Barrel Sampling Utilizing Drill Rigs - ASTM
A4.1 Coring Techniques Utilizing Drill Rigs - ASTM
A5.1 Sampling Sludges and Sediments
A5.1a Sampling Radioactive Sediments
A5.1b Radiation Detectors

WATER SAMPLING

A6.1 Groundwater Sampling : General Considerations
A6.2 Measurement of Water Levels in Monitor Wells
A6.2a Water level Measurements Using an Electric Sounder
A6.2b Water Level Measurements Using an Interface Probe
A6.3 Purging Monitor Wells
A6.3a Determination of Turbidity in Waters (NTU)
A6.4 Field Measurement of pH
A6.5 Field Measurement of Specific Conductance
A6.6 Field Measurement of Eh
A6.7 Field Alkalinity Measurements
A6.8 Field Measurement of Temperature
A6.9 Field Measurement of Dissolved Oxygen
A6.10 Field Measurements Using a Flow Cell
A6.11a Sampling With a Peristaltic Pump
A6.11b Sampling With a Bladder Pump
A6.11c Sampling With a Bailer
A6.11d Sampling With a Submersible Pump
A6.11e Sampling With a COLIWASA Sampler
A6.11f Sampling With a Dip Type Sampler
A6.11g Sampling By Container Immersion
A6.11h Sampling From Taps, Valves, or Faucets
A6.12 Collection, Filtration, and Preservation of Liquid Samples
A6.13 Sampling Seeps and Springs
A6.14 Groundwater Sampling from Open Soil Borings
A6.15 Sampling Light and Dense Nonaqueous Phase Liquids

PHOTOIONIZATION ANALYZERS

A7.1 Photovac TIP II Photoionization Analyzer
A7.2 Hnu Photoionization Analyzer
A7.3 SIP 1000 Photoionization Analyzer

AIR SAMPLING

A8.1 Area Air Monitoring. ASTM Methods for Organic Vapors and Particulates

SOIL GAS SAMPLING

A9.1 Protocol for Measuring Vapor Surface-Flux and Soil-Gas Concentrations from Volatile Organic Compounds
A9.2 Installation of Soil Gas Sampling Probes
A9.3 Procedure for Collecting Volatile Organic Compounds in Soil Gas
A9.4 Colorimetric Indicator Tubes - Dräger

LOCATION SURVEYS

A10.1 Well Location Survey

MONITOR WELLS

A11.1 Monitor Well Design and Installation (including Well Development)
A11.2 Monitor Well Abandonment
A11.3 Multiple-Level Monitor Wells
A11.4 Single Well Aquifer Tests
A11.5 Multiple Well Aquifer Tests
A11.6 Continuous Water Level Recording

BIOLOGICAL SAMPLING

A12.1 Vegetation Sampling
A12.2 Fish Sampling

DECONTAMINATION PROCEDURES

A13.1 Decontamination Procedures

SURFACE SOIL SAMPLING

INTRODUCTION

To maintain a consistent sample volume and to have greater depth control, a hand-operated stainless steel barrel auger will be used to collect surface or shallow subsurface soil samples. Surface-soil samples will generally be procured from depths of 0-6 inches and 0-12 inches. Although scoops and spoons can also be used for surface soil sampling, better sample control is achieved by using the barrel auger.

REFERENCE DOCUMENT

ASTM D1452-80, *Soil Investigation and Sampling by Auger Borings.*

SIGNIFICANCE AND USE

Samples of a relatively uniform depth and volume will be obtained for the determination of the presence or absence of chemical contamination in the near-surface soil environment. The sampling equipment and procedures are designed to minimize the potential for cross-contamination between samples. The level of data quality specified in the project *Quality Assurance Project Plan* (QAPP), Volume III, will be achieved with the use of this sampling procedure.

APPARATUS

The barrel auger to be used consists of stainless steel, 3-inch diameter auger tube with cutting lips hardened and sharpened to penetrate the soil. Attached to the upper end of the auger barrel is a threaded stainless steel extension rod to which a T-handle is attached. The auger assembly is rotated by hand in a clockwise direction.

PROCEDURE

1. Clear immediate sampling area of debris or litter.

2. Begin augering to the desired sampling depth, generally 6 or 12 inches.

3. When the desired depth is reached, remove the auger. If a sample for volatile organic analysis is requested, remove the material immediately using a stainless steel spoon and place in the appropriate glass container "as-is," leaving minimal headspace. The remainder of the material in the barrel will be placed in a precleaned stainless steel or aluminum mixing pan. A photoionization detector will be used to scan the sample for sections with higher VOCs. Samples collected near the NARF area will also be scanned with alpha and beta-gamma radiation detectors to determine personnel protection and DOT shipping requirement needs. If a discrete section of the sample shows evidence of contamination, this section will be sampled without mixing the entire auger sample. The material will be thoroughly mixed prior to bottling in the appropriate containers as specified in the project *Sampling and Analysis Plan.* The sample material will be transferred from the pan to the bottles using a stainless steel spoon.

4. With a clean paper towel clean the outside threads of the bottle prior to placing the lid on the bottle, since dirty threads often result in a poor seal. A tight seal is essential to prevent escape of the sample.

5. Wrap a seal of parafilm tape around the bottle and lid to secure the lid.

6. Measure the actual sampling depth using a steel measuring tape and record on the soil sample log sheet and the individual bottle labels.

7. Record the sampling time, date, sampler's name, sample ID number, and requested analytical parameters on the sample bottles and sample log sheet. On the sample log sheet, note any unusual characteristics observed such as color, texture, or odor.

8. Prepare and store samples as specified in the *Sampling and Analysis Plan* (Volume II)

9. Decontaminate all sampling equipment that came in contact with contamination, as specified in the procedures for decontamination in Section A13 of this appendix.

SUBSURFACE SOIL SAMPLING

INTRODUCTION

This method describes the procedures that will be used to obtain representative subsurface soil samples which are to be analyzed for specific chemical analyses. The method to be used for subsurface soil sampling at AFP 4 is split-barrel soil sampling using hollow-stem augers.

REFERENCE DOCUMENT

ASTM D1586, *Penetration Test and Split-Barrel Sampling of Soils.*

SIGNIFICANCE AND USE

The primary focus of the field investigation when utilizing this method will be to obtain discrete soil samples for analytical determination of in situ chemical contamination and to ensure that the samples are free from cross contamination. The samples will be obtained in a manner consistent with the AFP 4 *Health and Safety Plan* (Volume IV) and *Sampling and Analysis Plan* (Volume II). The sampling procedure will provide the proper level of data as outlined in the Data Quality Objectives (Section 3.0 this plan).

The second focus of the subsurface soils investigation using the split-barrel method is to provide subsurface lithologic information to supplement other geotechnical studies.

APPARATUS

The split-barrel sampler will have a 3-inch O.D., 2.5-inch I.D., and 24-inch length. The barrel will be constructed of stainless steel. Since the standard size used for the ASTM D1586-84 method for penetration testing is 2-inch O.D., the blow count data will be recorded but calculations will not be made. The larger split barrel sampler will be used to ensure sufficient sample material is available for the various chemical analyses required.

A truck-mounted, hollow-stem auger drill rig will be employed to complete the subsurface soil sampling at AFP 4. The auger rig will be equipped with a 140-pound drop hammer having a 30-inch drop or an equivalent hydraulic driver.

DRILLING PROCEDURE

1. All equipment will be decontaminated according to the procedures specified in Section A8.0 of this appendix prior to commencing work.

2. Spread a minimum 6-mil plastic sheet over the borehole location of sufficient size to contain the anticipated volume of drill cuttings.

3. With the truck-mounted auger rig centered over the pre-determined boring location, place the split-barrel sampler on the ground surface and allow the drop hammer to drive the sampler to the desired depth. If samples are to be collected only at discrete intervals, the hollow-stem auger will be used to auger to the top of the interval to be sampled. The

sampler will be lowered to the top of the interval to be sampled and the sampler will then be driven for the full length of the sampler or until no further penetration is achieved after 50 blows for each 6 inches of penetration.

4. Once the sampler is filled, carefully remove the sampler from the borehole and separate from the drive-rod assembly. Using a clean plastic sheet laid on a flat surface, remove the drive head and shoe. This will allow one-half of the split-barrel to be removed, exposing the sample.

5. If the material in the sampler is to be collected for volatile organic analysis, immediately scan the material with a photoionization detector. Upon selection of the zone to be sampled, fill the appropriate container, as soon as possible to avoid substantial loss of volatiles, using a stainless steel spoon. With minimal headspace and with the bottle thread wiped clean, tighten the lid and prepare and store the sample as specified in Section 5.4 of the AFP 4 *Sampling and Analysis Plan* (Volume II).

6. Visually scan the material in the sampler and note on the lithologic log a description of the material including color, odor, texture, particle sizes, moisture condition and, if present, visual evidence of contamination.

7. Discard the top "slough" portion of the sample in an appropriate container. Screen the sample with a photoionization detector to determine the presence of volatile organic compounds. A sample to be analyzed for volatile organic compounds will be removed immediately, directly from the sampling barrel. Transfer remaining sample material from the split-barrel using a stainless steel spatula or spoon to a precleaned stainless steel or aluminum mixing pan. Thoroughly mix the sample material and place into the appropriate containers. If a discrete section of the sample shows evidence of significant contamination, this section will be sampled without mixing the entire sample. Prepare and store as specified in Section 5.4 of the *Sampling and Analysis Plan*.

8. Record the depth, time collected, date collected, sampler's name, sample ID number, boring or well ID, and required analyses on the sample labels and soil sample log sheet.

9. Barrel remaining drill cuttings and label the barrel with the boring ID number, range of depths of the cuttings within the barrel, and date.

10. Decontaminate all drilling and sampling equipment that contacts the potentially contaminated soils as specified in Section A13 of this appendix.

ASTM PROCEDURES USED FOR SPLIT BARREL SAMPLING

The ASTM Standard Method for Penetration Test and Split-Barrel Sampling will be followed to collect split barrel samples from boreholes using drill rigs. These procedures will not be reproduced in this Appendix due to copyright laws. A working copy will be available in the field for use as a reference.

D-1586 - 84 Standard Method for
PENETRATION TEST AND SPLIT-BARREL SAMPLING of
SOILS

ASTM PROCEDURE USED FOR DIAMOND CORE DRILLING

The ASTM Standard Practice for Diamond Core Drilling for Site Investigation will be used at Air Force Plant 4 to collect core samples while drilling monitor wells into the Paluxy aquifer. This procedure will not be reproduced in this Appendix due to copyright laws. A working copy will be available in the field for use as a reference.

D 2113-83 Standard Practice for
Diamond Core Drilling for Site Investigation

STANDARD PRACTICE FOR SAMPLING OF SLUDGES AND SEDIMENTS

1. SCOPE

1.1 This practice covers the sampling of sludges and sediments. Sludge is defined as semi-dry material ranging from dewatered solids to high-viscosity liquids. Sediments are the deposited materials underlying a body of water. When sediments are exposed by evaporation, stream rerouting or other means of water loss, they can be collected by soil- or sludge-collection methods.

2. REFERENCED DOCUMENTS

2.1 U.S. Department of Energy, Environmental Survey Manual: Volume 4, Field Sampling Protocols and Guidance, , USDOE Office of Environmental Audit, Washington, DC, 20585, DOE/EH-0053, August 1987.

2.2 U.S.Environmental Protection Agency, Characterization of Hazardous Waste Sites--A Method Manual: Volume II. Available Sampling Methods, USEPA Environmental Monitoring Systems Laboratory, P.O. Box 15027, Las Vegas, Nevada 89114-5027, EPA-600/4-83-040, September 1983.

3. SIGNIFICANCE AND USE

3.1 Sludges can often be sampled with a stainless-steel scoop or trier. Frequently sludges form as high-density components within the liquid settle. In this instance, the sludge may still have a liquid layer above it. When the liquid layer is sufficiently shallow, the sludge may be collected using a scoop or a thin-tube sampler. The thin-tube sample is preferable since it results in less sample disturbance and also collects an aliquot of the overlying liquid, thus preventing drying or excessive sample oxidation before analysis. Sludges that develop in 55-gal drums can usually be collected by employing the glass tubes used for the liquid portion sample as a thin-tube sampler. The frictional forces which hold the sludge in the tube can be supplemented by maintaining a seal above the tube. When the overlying layer is deep, a small gravity corer such as those used in limnological studies will be useful. Gravity corers, such as Phlegers, are easier to preclean and decontaminate than piston-type corers.

If the sludge is shallow (less than 30 cm) corer penetration may damage the container liner or bottom. In this instance, a Ponar grab may be more applicable.

3.2 Sediment can be collected in much the same manner as sludge; however, a number of additional factors may warrant consideration. Streams, lakes, and impoundments, for instance, will probably exhibit significant variations in sediment composition with respect to distance from inflows, discharges, or other disturbances. It is important to document exact sampling locations by triangulation with stable references on the banks of the stream or lake. In addition, the presence of rocks, debris, and organic material may complicate sampling and preclude the use of or require the modification of some devices. Conduct sediment sampling to reflect these and other variants.

Collect and composite sample aliquots as described for soils. Generally, at least three composite samples should be collected from a location. Large

areas can be divided into grids and multiple samples can be collected and composited. Sample size will depend on the types of analyses required.

4. HAZARD ANALYSIS

4.1 No hazards requiring controls have been identified. Site-specific controls may be found in the Health and Safety Plan for a particular project.

5. PROCEDURE

5.1 Scoop - Sludge and sediment samples can be collected using a stainless steel scoop. This method is more applicable to sludges, but it can be used for sediments provided the water depth is very shallow (a few centimeters). Note, however, that this method can disrupt the water-sediment interface and might cause substantial alterations in sample integrity if extreme care is not exercised.

5.1.1 Sketch the sample area or note recognizable features for future reference.

5.1.2 Insert scoop into material and remove sample. For sludges exposed to air, it may be desirable to remove the first 1 to 2 cm of the material prior to collecting sample.

5.1.3 If compositing a series of aliquots, use a disposable aluminum, stainless steel, or Teflon (preferred) tray for mixing.

5.1.4 Transfer sample into an appropriate sample bottle with a stainless steel lab spoon.

5.1.5 Check that the Teflon liner is present in cap if one is required. Secure the cap tightly. Solids are preserved by refrigeration and subjected to a minimal holding time.

5.1.6 Label the sample container with the appropriate sample label. Be sure to fill out all sample information on the label carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field logbook. Record depth to sediment and any other pertinent sample information.

5.1.7 Decontaminate sampling equipment after use and between sample locations.

5.2 Hand Corer - This device consists of a stainless steel core barrel (with optional liners), a nosepiece, and an 'eggshell' core catcher. It has a handle to facilitate driving the corer and a check valve on top to prevent washout during retrieval through an overlying water layer.

The hand corer is applicable to the same situations as the scoop described in Section 5.1. It has the advantage of collecting a relatively undisturbed sample which can profile the stratification in the sample as a result in changes in the deposition.

Some hand corers can be fitted with extension handles that permit collection of samples underlying a shallow layer of liquid. Most corers can also be adapted to hold liners generally available in brass, polycarbonate plastic, or Teflon. Be careful to choose a material that will not compromise the analytical results.

5.2.1 Select sampling location and inspect the corer for proper precleaning.

5.2.2 Force corer into media with a smooth continuous motion.

5.2.3 Twist corer and withdraw in a smooth motion.

5.2.4 Remove nosepiece and slide sample into a disposable aluminum, stainless steel, or Teflon (preferred) tray.

5.2.5 Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

5.2.6 Check that the Teflon liner is present in cap if one is required. Secure the cap tightly. Solids are preserved by refrigeration and subjected to a minimal holding time.

5.2.7 Label the sample container with the appropriate sample label. Be sure to fill out all sample information on the label carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field logbook. Record depth to sediment, core sample length, and core texture.

5.2.8 Decontaminate sampling equipment after use and between sample locations.

5.3 Gravity Corer - A gravity corer is a metal tube with a replacement tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during recovery. Most corers are constructed of brass or steel and may accept plastic liners and additional weights.

Corers are capable of collection samples of most sludges and sediments. They collect essentially undisturbed samples which represent the strata profile that may develop in sediments and sludges during variations in the depositional process. Depending of the density of the substrate and the weight of the corer, penetration to depth of 75 cm (30 in.) can be attained.

Exercise care when using gravity corers in vessels or lagoons that have liners because penetration depths could exceed that of the substrate and result in damage to the liner material.

5.3.1 Attach a precleaned corer to the required length of sample line. Solid braided 5-mm (3/16-in.) nylon line is sufficient; however, 20-mm (3/4-in.) nylon is easier to grasp during hand hoisting. An additional weight can be attached to the outside of the corer if necessary.

5.3.2 Secure the free end of the line to a fixed support to prevent accidental loss of the corer.

5.3.3 Allow corer to free fall through the liquid to the bottom.

5.3.4 Retrieve corer with a smooth, continuous, up-lifting motion. Do not bump corer as this may result in some sample loss.

5.3.5 Remove nosepiece from the corer and slide sample out sample into a disposable aluminum, stainless steel, or Teflon (preferred) tray.

5.3.6 Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

5.3.7 Label the sample container with the appropriate sample label. Be sure to fill out all sample information on the label carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field logbook. Record depth to sediment, core sample length, and core texture.

5.3.8 Decontaminate sampling equipment after use and between sample locations.

5.4 Ponar Grab - The Ponar grab is a clamshell-type scoop activated by a counterlever system. The shell is opened, latched into place, and slowly

lowered to the bottom. When tension is released on the lowering cable, the latch releases and the lifting action of the cable on the lever system closes the clamshell.

Ponars are capable of sampling most types of sludges and sediments from silts to granular materials. They are available in a 'Petite' version with a 232-cm^2 sample area that is light enough to be operated without a winch or crane. Penetration depths will usually not exceed several centimeters. Grab samplers, unlike corers, are not capable of collecting undisturbed sample. As a result, material in the first few centimeter of sludge cannot be separated from that at lower depths. The sampling action of these devices causes agitation current which may temporarily resuspend some settled solids. This disturbance can be minimized by slowly lowering the sampler the last half meter to allow gentle contact with the bottom. It is advisable, however, to collect sludge or sediment samples only after all overlying water samples have been collected.

5.4.1 Attach a precleaned Ponar to the necessary length of sample line. Solid braided 5-mm (3/16-in.) nylon line is usually of sufficient strength; however, 20-mm (3/4-in.) nylon permits easier hand hoisting.

5.4.2 Measure and mark the distance to bottom on the sampling line. A proximity mark, 1 meter shallower, will provide an indication of when the lowering rate should be reduced to prevent unnecessary bottom disturbance.

5.4.3 Open sampler jaws until latched. From this point on, support the sampler by its lift line or the sampler will be tripped and the jaws will close.

5.4.4 Tie the free end of the sample line to a permanent fixture to prevent accidental loss of sampler.

5.4.5 Begin lowering the sampler until the proximity mark is reached.

5.4.6 Decrease the rate of descent for the last meter until contact is felt.

5.4.7 Allow several centimeters of slack in the sample line to release the latch. In strong currents more slack may be necessary to release the mechanism.

5.4.8 Slowly raise the dredge clear of the water surface.

5.4.9 Place Ponar into a disposable aluminum, stainless steel or Teflon (preferred) tray and open. Lift Ponar clear of the tray.

5.4.10 Collect a suitable aliquot with a stainless steel lab spoon or equivalent and place sample into the appropriate sample bottle.

5.4.11 Label the sample container with the appropriate sample label. Be sure to fill out all sample information on the label carefully and clearly, addressing all the categories or parameters. Complete all chain-of-custody documents and record in the field logbook.

6. PRECISION AND BIAS

6.1 Precision - This practice is not for included tests and analyses. Not applicable.

6.2 Bias - This practice is not for included tests and analyses. Not applicable.

7. KEYWORDS

Grab sampler
Gravity corer
Hand corer
Phlegers
Piston-type corers
Ponar grab
Sediments
Sludges
Stainless steel scoop
Thin-tube sampler
Trier

SAMPLING OF RADIOACTIVE SEDIMENTS

INTRODUCTION

Soil or lake sediments contaminated with radioisotopes may be found in the north area of Air Force Plant 4. The NARF area, adjacent to Lake Worth, was once an experimental nuclear reactor test area. Tests were conducted between 1953 and 1974 on the feasibility of powering aircraft with nuclear reactors. This site was decommissioned in 1974, with over 2 million pounds of parts and 15 million pounds of rubble removed. Post closure studies indicate no radionuclides over the background level remain.

To prevent possible personnel exposure, sampling done near the NARF area, such as the sediment sampling in Lake Worth, will be done with the assistance of a technician from the Geotech Occupational Health and Safety Section (OH&S). The technician will be responsible for determining the activity level of the sample and what personal protective equipment is necessary.

Any subcontractor personnel involved with the sampling operation will be required to have radiation training as part of the OSHA site training.

SAMPLING METHOD

1. Samples from Lake Worth will be taken from the lake bottom, using a tube sampler equipped with an eggshell catcher. The sampling crew will work off of a pontoon or other stable work boat. U.S. Coast Guard regulations will be followed to ensure worker safety.

2. The outside of the sampler will be scanned for both beta-gamma and alpha radiation upon sampler retrieval.

3. The sampler will be opened and the actual sample material will be scanned for radiation.

4. If no radioactive activity is detected sampling activities will proceed through container filling, labeling, and decontamination.

5. If radiation levels above background (100 cpm on the detectors specified below) are detected the sample material will be closely scanned to determine if the dose rate is less than 0.5 mrem/hr. Samples with radiation levels between background and 0.5 mrem/hr will be separated, labeled and shipped in a separate container. Any sample(s) with activity greater than 0.5 mrem/hr will be further separated, packaged, labeled, and shipped according to DOT regulations in 49 CFR Parts 171 through 178.

6. Samples may only be shipped without radioactive labeling if the activity is less than 0.5 mrem/hr on contact or if the concentration is estimated to be less than 2000 pCi/gm. The OH&S technician shall be responsible for determining dose rates or activity levels.

APPARATUS

Beta-Gamma Survey Instrument

- Ludlam Model 12 with Ludlam 43-9 Detector (Appendix Section 5.1b,p.1)
- Radioactive Check Source

Alpha Detector

- Ludlam Model 12 with Ludlam 43-5 Detector (Appendix Section 5.1b, p.3)
- Radioactive Check Source

PROCEDURE

The Occupational Health and Safety technician is responsible for calibration and operation of radiation detection equipment. Only equipment with valid calibration stickers will be used. Equipment must respond properly to operational checks before use.

1. Identify the area(s) to be surveyed, determine what type of survey is to be performed and what type of instruments will be needed.

2. If possible, determine the approximate radiological conditions, (dose rates, airborne concentrations, contamination levels) based on similar conditions and previous surveys.

3. Obtain protective equipment and clothing as necessary for the anticipated radiological conditions.

4. When entering an unknown radiation field, enter the area with the instrument on the highest scale, switching down scale as necessary to obtain a near mid-scale reading.

5. The survey should be conducted so as to adequately identify the general area and specific work area radiation levels. Highly radioactive spots should be identified. Surveys should be conducted so as to limit any unnecessary dose to the surveyor.

6. Periodic open-window readings should be taken to evaluate the beta radiation component. When taking open window readings, care should be taken to avoid puncturing the instrument window.

7. When surveying for field readings, take care to avoid attenuating the radiation field with the body of the surveyor.

8. If at any time during the survey the instrument appears to be malfunctioning, leave the area at once. Sudden and extreme changes in local radiation fields can cause the instrument to apparently malfunction

when in fact the dose rates may well exceed the upper limit of the device.

9. General area readings should be taken at approximately 3 feet (waist height) above the ground. Work area readings should be taken at actual worker locations and positions.

10. To scan surfaces for activity, slowly move the beta-gamma detector over the surface at a distance not to exceed 1/2 inch, but not in direct contact. In the case of alpha surveys, the probe should not exceed a distance from the surface of 1/4 inch but not in direct contact.

11. Equipment, material, and personnel must be surveyed each time they leave a radiation area.

12. Any item inside a contaminated area must be surveyed prior to being released off site.

All radiation levels will be noted by the OH&S technician. No samples will be shipped if the outside of the container has removable contamination.

Operation of Ludlum Model 12 Count Rate Meter and Pancake GM Beta/Gamma Detector

This procedure describes the operation of the Ludlum Model 12 Count Rate Meter and the Pancake GM Detector, both of which are used to measure beta/gamma contamination on equipment and personnel.

Methods for conducting contamination surveys are described in Procedures 3.17 and 3.22 of this manual.

References

- UNC *ES&H Policy Manual*, Chapter 3
- Ludlum Model 12 Count Rate Meter Instruction Manual
- ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration

Equipment and Material

- Ludlum Model 12 Count Rate Meter
- Pancake GM Beta/Gamma Detector
- Appropriate Radioactive Check Source
- Instrument Log/Frisking Log

Procedure

Operational Check

1. Check that the instrument has a calibration sticker attached and that the instrument-calibration interval is valid. The instrument-calibration interval is a period of 6 months following the date of calibration. Record the calibration due date on the appropriate data sheet. If the instrument-calibration interval is invalid, tag instrument DO NOT USE. Record the name, date, and reason for the tag. Return the instrument for calibration.
2. Clean the instrument and inspect it for any physical damage. Particular attention should be paid to the HV cable which connects the detector with the count rate meter. Check the mylar face of the detector. Inspect the face for holes and/or contamination. Replace the cable if necessary.
3. Turn on the instrument by moving the range switch from the OFF position to BAT position. Verify that the rate meter indicates above the BAT TEST line. Check the BAT OK space on the appropriate data sheet. If the instrument does not have sufficient battery power, replace the batteries and repeat step 3.

Background and Response Check

1. Move the rate-meter range switch to "X1." Move the response switch to "S." Place the detector faceup. After approximately 30 seconds, note the background count rate.

Record the rate-meter reading on the BACKGROUND space on the appropriate data sheet. If needed, clean the Mylar face and repeat the background check. If the background count rate is high after cleaning, then the background check is rejected. The GM probe can be replaced with another that has a valid calibration sticker, unless it is marked for use with one instrument only. If the instrument still does not respond properly, reject it. If rejected, tag the instrument DO NOT USE. Record the name, date, and reason for the tag. Return the instrument for repair and calibration.

2. Place the detector on top of the appropriate radioactive source. Adjust the RANGE switch, if necessary. Allow 30 seconds for the rate meter to stabilize. Record the rate-meter reading on the SOURCE COUNT RATE space of the appropriate data sheet.
3. Record the following information concerning the radioactive source on the applicable spaces of the appropriate data sheets:
   - Radioactive Source ID Number
   - Isotope
   - Activity (disintegrations per minute)
   - Acceptance Criteria (± 20 percent of source activity)
4. Record the instrument calibration factor on the appropriate data sheet. The calibration factor relates the indicated count rate (cpm) to actual disintegrations per minute (dpm).
5. To determine the calibration factor on an instrument, perform the background check. Then place the detector on the appropriate source and record the reading after 30 seconds. Subtract the background count rate (B cpm) from the source count rate (S cpm). Record this net value (N cpm). Divide N cpm by the activity of the source (D pm) and record on the instrument.
6. Determine the net count rate (N cpm) by subtracting the background count rate (B cpm) from the source count rate (S cpm):

$$N\ cpm = S\ cpm - B\ cpm$$

7. Multiply the net count rate by the calibration factor (dpm/cpm). Record the result on the OBSERVED ACTIVITY space of the appropriate data sheet.
8. Compare the observed-activity value with the acceptance-criteria values. The source check is accepted if the observed-activity values lie somewhere between the acceptance-criteria values. If the source check is unacceptable, tag the instrument DO NOT USE. The GM probe can be replaced with another that has a valid calibration sticker, unless it is marked for use with one instrument only. If the instrument still does not respond properly, reject it. Record the name, date, and reason for the tag. Return the instrument for repair and calibration.

Operational Use

1. Move the rate-meter AUD switch to the ON position.
2. Move the response switch to "S."
3. Pass the detector slowly (<5cm/sec) over the surface to be surveyed. Keep the detector face within 1 cm of the surface.
4. If surface activity is detected (indicated by speaker response), keep the detector stationary over the area of contamination. Allow 30 seconds for the count rate to stabilize. Record the instrument count rate.
5. Repeat steps 2 through 4 for all locations to be surveyed.

General Notes

Operational, background, and response checks for an instrument need to be performed once per day. Record data in the instrument log or frisking log.

Operation of Ludlum Model 12 Count Rate Meter and Ludlum Model 43-5 Alpha Detector

This procedure describes the operation of the Ludlum Model 12 Count Rate Meter and the Ludlum Model 43-5 Alpha Detector, both of which are used to measure alpha contamination on equipment and personnel.

This procedure also describes how to operate the Model 12 Count Rate Meter and the Model 43-5 Alpha Detector, which together are used to conduct contamination surveys of equipment and personnel. Methods for conducting such contamination surveys are described in Procedures 3.17 and 3.22 of this manual. Calibration procedures for the instruments are provided in the UNC Electronics Laboratory Technical Procedures Manual.

References

- UNC Electronics Laboratory Technical Procedure Manual
- UNC ES&H Policy Manual, Chapter 3
- Ludlum Model 12 Count Rate Meter Instruction Manual
- ANSI N323-1978 Radiation Protection Instrumentation Test and Calibration

Equipment and Material

- Ludlum Model 12 Count Rate Meter
- Ludlum Model 43-5 Alpha Detector
- Th–230 Radioactive Check Source
- Calibration Data Sheets (E-Lab Technical Procedure ELP–24B)
- Instrument Log

Procedure

Operational Check

1. Check that the instrument has an E-Lab calibration sticker attached and that the instrument-calibration interval is valid. The instrument-calibration interval is a period of 6 months following the date of calibration. Record the calibration due date on the appropriate data sheet. If the instrument-calibration interval is invalid, tag instrument DO NOT USE. Record the name, date, and reasonfor the tag. Return the instrument to the E-Lab for calibration.
2. Clean the instrument and inspect it for any physical damage. Particular attention should be paid to the HV cable which connects the detector with the count rate meter. Check the mylar face of the alpha detector. Inspect the face for holes and/or contamination. Replace the cable or mylar face, if necessary.
3. Turn on the instrument by moving the range switch from the OFF position to BAT position. Verify that the rate meter indicates above the BAT TEST line. Check the BAT OK space on the appropriate data sheet. If the instrument

does not have sufficient battery power, replace the batteries and repeat step 3.

Background and Response Check

1. Move the rate-meter range switch to "X1." Move the response switch to "S." Place the detector faceup. After approximately 30 seconds, note the background count rate. Record the rate-meter reading on the BACKGROUND space on the appropriate data sheet. If background count rate exceeds 20 cpm, check the mylar face for holes or obvious contamination. If needed, clean or replace the Mylar face and repeat the background check. If the background count rate still exceeds 20 cpm, then the background check is rejected. If rejected, tag instrument DO NOT USE. Record the name, date, and reason for the tag. Return the instrument to the E-Lab for repair and calibration.
2. Place the detector on top of the radioactive source. Adjust the RANGE switch, if necessary. Allow 30 seconds for the rate meter to stabilize. Record the rate-meter reading on the SOURCE COUNT RATE space of the appropriate data sheet.
3. Record the following information concerning the radioactive source on the applicable spaces of the appropriate data sheets:
   - Radioactive Source ID Number
   - Isotope
   - Activity (dpm)
   - Acceptance Criteria (±20 percent of source activity)
4. Record the instrument calibration factor on the appropriate data sheet. The calibration factor relates the indicated count rate (cpm) to actual disintegrations per minute (dpm). The calibration factor is determined while performing E-Lab Technical Procedure ELP-24B.
5. Determine the net count rate (N cpm) by subtracting the background count rate (B cpm) from the source count rate (S cpm):

   N cpm = S cpm–B cpm
6. Multiply the net count rate by the calibration factor (dpm/cpm). Record the result on the OBSERVED ACTIVITY space of the appropriate data sheet.
7. Compare the observed-activity value with the acceptance-criteria values. The source check is accepted if the observed-activity values lie somewhere between the acceptance-criteria values. If the source check is unacceptable, tag instrument DO NOT USE. Record the name, date, and reason for the tag. Return the instrument to the E-Lab for repair and calibration.

Operational Use

1. Move the rate-meter AUD switch to the ON position.
2. Move the response switch to "S."
3. Pass the alpha detector slowly (<5cm/sec) over the surface to be surveyed. Keep the detector face within 1 cm of the surface.
4. If surface activity is detected (indicated by speaker response), keep the detector stationary over the area of contamination. Allow 30 seconds for the count rate to stabilize. Record the instrument count rate.
5. Repeat steps 2 through 4 for all locations to be surveyed.

General Notes

Operational, background, and response checks for an instrument need to be performed once per day. Record data in the instrument log.

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General Considerations for the Sampling of Liquids

Introduction

The importance of proper sampling techniques for liquids cannot be overemphasized. Many factors shall be considered to obtain a sample that is (1) representative of the population being sampled, (2) collected in a manner that does not compromise the sample, (3) preserved properly until it can be analyzed in the laboratory, and (4) documented so that it can be properly traced. Accurate sampling shall be responsive to all of these considerations and to other items discussed in this procedure.

1. Scope

1.1 Because the objective of most liquid sampling is to obtain a sample that is representative of the population being sampled and retains the physical and chemical properties of the population, the sampler shall make decisions concerning sample types, equipment to be used, quality control, decontamination, etc., that will greatly affect the results obtained from the sampling event. The information provided in this section will guide the sampler and provide the necessary background for the proper collection of liquid samples. The 10 items that shall be considered before collecting a sample are:

	Section
Material Considerations	5
Equipment Selection Considerations	6
Well-Purging Strategies	7
Sample Preservation and Filtration Considerations	8
Decontamination	9
Quality-Control Considerations	10
Documentation	11
Shipping and Handling	12
Sampling Plan	13
Health, Safety, and Environmental-Compliance Considerations	14

2. Hazard Analysis

2.1 Specific hazards requiring controls are identified in the individual procedures. Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 American Public Health Association, American Water Works Association, and Water Pollution Control Federation, *Standard Methods for the Examination of Water and Wastewater: American Public Health Association*, Washington, D.C., 1980.

3.2 American Society for Testing and Materials, *Annual Book of ASTM Standards*, Section 11, Volume 11.01.2, 1984.

3.3 Korte, N. and D. Ealey, *Procedures for Field Chemical Analyses of Water Samples*, Technical Measurements Center, U. S. Department of Energy, Grand Junction Area Office, GJ/TMC-07(83), 1983.

3.4 U.S. Department of Energy, *The Environmental Survey Manual*, Appendix E, Volume 4, DOE/EH-0053, 1987.

3.5 U.S. Environmental Protection Agency, *Handbook Groundwater*, EPA/625/6-87/016, 1987.

3.6 U.S. Environmental Protection Agency, *Practical Guide for Groundwater Sampling*, EPA/600/2-85/104, 1985.

3.7 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," *Techniques of Water-Resources Investigations of the United States Geological Survey*, Chapter D2, Book 1: U.S. Government Printing Office, Washington, D. C., Stock Number 024-001-02879-4, 1976.

4. Significance and Use

4.1 The two general sample types are grab samples and composite samples.

4.1.1 Grab samples are the most widely used type. They provide a sample that represents the characteristics of the liquid being sampled at a particular point in space and time. Grab samples are used where:

4.1.1.1 The flow of liquid is not continuous (e.g., batch discharges or intermittent flows.)

4.1.1.2 The characteristics of the liquid are known to be fairly constant.

4.1.1.3 The samples are to be used for parameters with characteristics that are likely to change significantly with time (e.g., dissolved gases, bacterial decay, hydrolysis reactions, oxidation/reduction reactions, etc.).

4.1.1.4 The compositing process would significantly affect the concentration of an analyte.

4.1.2 Composite samples are composed of small aliquots of constant volume collected at constant time intervals or flow increments. Composite samples are used to generate data that describe average characteristics. Composite samples are collected in several ways depending upon the particular variability being studied. The five types of composite samples are:

4.1.2.1 *Simple composite samples* consist of small aliquots of constant volume collected at constant time intervals.

4.1.2.2 *Flow-proportional composite samples* are collected by varying the time intervals with flow or by proportionally varying the volume collected with flow. Flow-proportional sampling is used where the liquid flow is highly variable.

4.1.2.3 *Sequential composite samples* require a series of individual samples collected per container, with each container representing a specific time period. This sampling technique is used where the liquid being sampled varies significantly over short periods.

4.1.2.4 *Continuous composite samples* are collected by extracting a small continuously flowing stream from the bulk source and directing it into the sample container.

4.1.2.5 *Areal composite samples* are a composite of individual grab samples collected on an areal or cross-sectional basis. Areal composite samples are generally used to collect a sample from a lake or stream.

4.1.3 Interpretation of results depends upon knowledge of groundwater flow direction and formation transmissivity, lithologies sampled, and a properly collected, preserved, and uncontaminated sample.

4.1.4 See Table 1 through Table 5 for advantages and disadvantages of different sampling devices. A description of the depth of monitoring wells and a depth to the sampie interval are necessary before proper sampling strategies can be chosen.

5. Material Considerations

5.1 The quality of the analytical data can be greatly affected by interactions between the sample and the sampling device. These interactions include chemical attack, microbial colonization, sorption, and leaching effects. To ensure the integrity of the sample and maximize the analytical quality, the sampling device shall be constructed of a nonreactive material.

5.2 The following materials are generally used in construction of sampling devices and sampling containers. They are listed in order of preference (least reactive to most reactive).

5.2.1 Rigid materials.

a. Teflon®.

b. Stainless steel.

c. Polyvinylchloride (PVC).

d. Low-carbon steel.

e. Galvanized steel.

f. Carbon steel.

5.2.2 Flexible materials.

a. Teflon®.

b. Polypropylene.

c. Linear polyethylene.

d. Flexible PVC.

e. Viton®.

f. Conventional polyethylene.

g. Tygon®.

h. Silicone/neoprene.

5.3 The choice of materials used shall be considered with respect to the parameter being sampled. The factors to be considered are:

5.3.1 *Negative contamination*—The potential for the measured analyte concentration to be artificially low because of losses due to precipitation, volatilization, or absorption.

Table 1. Grab-Type Mechanism

Advantage	Disadvantage
Virtually any material can be used for construction.	Sampling is labor-intensive and time-consuming.
Device is inexpensive.	Aeration, degasing, and turbulence occur during sampling.
No external power source is required.	Sampler susceptible to exposure to any contaminants in the sample.
Mechanism can be constructed in any size and shape.	Does not provide a continuous supply of sample.
Device is easy to use and easily cleaned; requires little training for operation and little maintenance.	

5.3.2 *Positive contamination*—the potential for the measured analyte to be artificially high because of leaching or introduction of foreign matter into the sample by particle fallout or gaseous air contaminants.

5.3.3 *Cross-contamination*—a type of contamination caused by the introduction of part of one sample into a second sample.

6. Equipment Selection Considerations

6.1 Because each sampling situation is unique, the sampler may have to modify equipment and applications to ensure that a representative sample is collected and to maintain the sample's physical and chemical integrity. No one particular device will fit every situation. The sampler shall understand the various sampling devices and their advantages and disadvantages to effectively use them to collect samples. The following items shall be considered when selecting a sampling device.

6.1.1 Potential impact of the device on sample integrity.

6.1.2 Method of sample delivery.

6.1.3 Flow controllability.

6.1.4 Depth of sampling interval.

6.1.5 Ease of operation, cleaning, and maintenance.

6.1.6 Reliability and durability.

6.1.7 Portability of the device.

6.1.8 Initial cost and operational cost.

6.2 There are basically four types of sampling devices: (1) grab mechanisms, (2) suction-lift mechanisms, (3) positive displacement mechanisms, and (4) submersible pumps. Discussion of the uses, advantages, and disadvantages of these devices follows.

6.2.1 Grab mechanisms consist of bailers and dip-type samplers. These devices are the oldest and simplest for collection of liquid samples. They can be made of virtually any material and can be used to collect liquid samples from almost any source. Table 1 presents the advantages and disadvantages of a grab-type mechanism.

6.2.2 Suction-lift mechanisms consist of peristaltic-type pumps and centrifugal pumps that apply a vacuum, which causes the liquid to be drawn upward through a suction line. Their use is generally limited to purging wells of stagnant water and sampling for inorganic analytes. Table 2 presents the advantages and disadvantages of a suction-lift mechanism.

6.2.3 Positive-displacement mechanisms consist of gas-driven devices and gas-operated bladder pumps. These devices are generally used to sample groundwater when the liquid must be pumped to the surface. Positive-displacement devices can be constructed of a variety of materials to fit most sampling situations. Tables 3 and 4 present the advantages and disadvantages of positive-displacement mechanisms.

6.2.4 Submersible pumps are generally not used for sample collection. They are useful in purging large-volume wells of stagnant water; however, severe aeration and turbulence of the sample occur due to their method of sample delivery. Table 5 lists the advantages and disadvantages of using a submersible pump.

7. Well-Purging Strategies

7.1 To obtain a representative groundwater sample, it is necessary to remove the stagnant water from the well casing. The water within the

Table 2. Suction-Lift Mechanism

Advantage	Disadvantage
Flow rates are easily adjustable. Device has no contact with the sample. Device can be used in wells of any diameter. High flow rates are obtainable for well purging. Only the tubing requires cleaning (peristaltic pumps only).	Use is limited to situations where the liquid level is less than 25 feet below the surface. Drop in pressure of suction-lift mechanisms causes degasing of the sample and loss of volatiles. Choice of construction material is limited. Centrifugal pumps need to be primed, resulting in possible sample contamination. Severe aeration and turbulence occur with centrifugal pump.

Table 3. Gas-Driven Device

Advantage	Disadvantage
Device can be used in wells of 1.5-inch inside diameter. Device inexpensive and highly portable for most sampling applications. Permanent installation is possible in boreholes without casing. Inert materials can be used for construction of device. Sample delivery rate can be controlled. Burst strength of the materials used to make device and tubing is only limiting factor in determining sampling depth.	Oxidation and gas-stripping of volatiles may occur if air or oxygen is used used as the driving gas. Requires air compressor or large compressed-air tanks. Application of excessive air pressure can rupture the gas entry or discharge tubing. Difficult to retrieve for repair, cleaning, and maintnance when installed permanently in boreholes without casing.

Table 4. Gas-Operated Bladder Pumps

Advantage	Disadvantage
Pump is constructed of inert materials; most pumps are designed specifically to sample for low levels of contaminants. Driving gas does not contact the sample, thus minimizing sample aeration and gas stripping. Pump is portable, though accessory equipment may be cumbersome. Relatively high pumping rate allows well evacuation and collection of large sample volumes. Sample delivery rate can be controlled easily on some models. Most models are capable of pumping lifts in excess of 200 feet. Pump diameters are variable, depending on the application.	Deep sampling requires large volumes of gas and longer cycles, thus increasing operating time and expense and reducing portability. Check valves in some models are subject to failure in water with high solids content. Most available models are expensive. Minimum rate of sample discharge of some models may be higher than ideal for sampling of volatile compounds. Pump is easily disassembled for cleaning.

Table 5. Submersible Pump

Advantage	Disadvantage
High pumping rates are possible for well purging. Pump can be used at depths of more than 200 feet.	Sampler has little control of flow rates; not possible to adjust from a high rate for purging to a low rate for sampling. Severe aeration and degasing of sample occurs, thus volatilizing organics and other sensitive compounds. Pump has limited portability and requires a power source for operation. Pump is not easily disassembled for cleaning.

well casing and in proximity to the well is probably not representative of the overall groundwater at the sampling site. Drilling contaminants may be near the well; and important environmental conditions, such as the oxidation/reduction potential, may differ drastically near the well from the conditions in the surrounding water-bearing formation. The recommended amount of water to be purged from the well prior to sampling varies on a case-by-case basis. The amount of water to be purged is based on the hydraulic properties of the geologic materials surrounding the well, well-construction parameters, desired pumping rates, and sampling methodology employed. There is no one single number of well volumes to be pumped that is best or fits all situations. The goal is to obtain water from the well that is representative of the groundwater, while minimizing the disturbance of the regional flow system and the collected sample.

7.2 The most common procedure is to pump or bail the well until three to five casing volumes of water have been removed. This requirement is stated in the U.S. Environmental Protection Agency (EPA) *RCRA Technical Enforcement Guidance Document* and in the EPA *Test Methods for Evaluating Solid Wastes* (SW-846). The sampler shall use the following guidelines to determine when sufficient water has been removed from the well prior to sampling.

7.3 Guidelines for Well Purging Prior to Sampling [LQ-3(P)].

7.3.1 Purging accomplished by pumping from near the water surface within the well casing is the most reliable way to ensure removal of stagnant water within the well casing.

7.3.2 Removal of three to five casing volumes by surface pumping is sufficient to remove virtually all stagnant water within the well.

7.3.3 Monitoring pH, conductivity and temperature during purging is an indicator that when stabilized (± 10 percent), the well is providing formation water.

7.3.4 Pumping or bailing a well dry and allowing it to recover is sufficient to remove the stagnant water within the well.

7.3.5 Documentation of the purging process should be provided so that the data user can assess the quality of the data.

8. Sample Preservation and Filtration Considerations

8.1 *Sample Preservation Consideration*—Preservation of samples is necessary to stabilize specific parameters during shipment to a laboratory and while the samples are being held for analysis. Preservation is intended to (1) retard biological effects, (2) retard hydrolysis, (3) reduce sorption, and (4) reduce volatility of constituents. Preservation techniques are parameter-specific and include many different methods. Generally, the Sampling and Analysis Plan and/or the laboratory performing the analysis will determine the specific requirements. Table 6 can be used as a guide for preservation requirements, container types and sizes, and holding times; but contains only some of the more common practices.

8.2 *Sample Filtration Considerations*—Predictions of contaminant migration, whether made empirically or with a computer model, require that a distinction be made between soluble species and

Table 6. Preservation Requirements

Parameter	Container Size and Material[a]	Preservation	Holding Time	Comments
Metals	125-mL HDPE	HNO_3 pH <2	6 months	Protect Ag from light
Anions NO_3 and PO_4	125-mL HDPE	Cool to 4 °C	48 hours	
Anions F, Cl, and SO_4	125-mL HDPE	Cool to 4°C	28 days	
Cyanide	1,000-mL HDPE	NaOH pH >12	14 days	Protect from light
Sulfide	1,000-mL HDPE	2-mL 2 N zinc acetate, cool	28 days	
Total Organic Carbon	125-mL glass	H_2SO_4 or HCl, pH <2, 4 °C	28 days	
Volatile Organics	2 each, 40-mL glass	Cool to 4 °C	14 days	No bubbles
Semi-Volatile Organics	2 each, 1,000-mL glass	Cool to 4 °C	14 days	Protect from light

[a]HDPE = High-density polyethylene.

suspended matter. Determining the soluble species requires the samples to be filtered prior to analysis. A filter pore size of 0.45 micometer (µm) has been accepted as the cutoff size to be used for determining dissolved versus suspended matter. Samples requiring filtration shall be filtered as soon after collection as possible, preferably at the time of collection. Many devices are available to filter the sample and include large and small disposable cartridges and large and small filter holders with replaceable filters. The device chosen will vary depending upon the amount of suspended matter in the sample, amount of sample requiring filtration, and equipment available to filter the sample. Many different types of filter media are available (including cellulose nitrate, cellulose acetate, Teflon®, nylon, and polycarbonate) in a 0.45-µm filter size. The choice of filter media will depend on the constituents being analyzed and the amount and size of the suspended matter in the sample. The following guidelines will be helpful in the choice of sampling device and filter media.

8.2.1 The preferred device is an in-line filtration module that operates from sampling pump pressure.

8.2.2 The required filter pore size is 0.45 µm.

8.2.3 Samples containing high suspended solids or large volumes can be best filtered using a high-capacity cartridge filter.

8.2.4 Clear samples or samples requiring small volumes can be filtered using small cartridge filters or filtration devices with replaceable filter media.

8.2.5 Thoroughly clean all devices that use replaceable filters and discard the initial 50 to 100 millliter (mL) of sample as a rinse prior to sample collection.

9. Decontamination

9.1 A major part of the work effort and cost spent during an investigation is associated with collecting and analyzing samples. To that end, effective decontamination of reusable equipment is critical to the credibility of the data generated during the investigation. No universal standards exist for equipment decontamination, but most state and federal regulatory agencies have established guidelines that should be considered when developing decontamination protocols. Therefore, the

individuals conducting the sampling shall develop protocols that will best fit the requirements of the investigation being conducted.

9.2 Decontamination consists of a physical cleaning of the equipment followed by a chemical cleaning. The process shall be designed to minimize the spread of contaminants to clean areas and to minimize the cross-contamination of sampling sites. The following general guidelines provide a basis for achieving this goal.

9.2.1 Physical decontamination methods consist of cleaning with brushes, clean rags, and high-pressure water to physically remove the contamination. This is followed by a distilled or deionized water rinse and drying with lint-free tissues.

9.2.2 Chemical decontamination methods shall depend on the nature and extent of contamination. At a minimum, chemical cleaning would consist of washing the contaminated equipment in a soap solution, rinsing with tap water, rinsing with distilled or deionized water, and air drying or wiping dry with lint-free tissues. Some situations might call for a chemical cleaning with acids such as HNO_3 or HCl, or organic solvents such as methanol, acetone, or hexane.

10. Quality-Control Considerations

10.1 The fundamental goal of field quality control is to ensure that the sampling protocol is being executed faithfully and that situations leading to error are recognized before they seriously impact the data. This goal can be achieved only through knowledge, training, experience, and continued refinement of procedures. The use of field quality-control samples such as blanks, standards, and spiked samples can account only for changes that occur after sample collection. The following guidelines are quality-control measures that are generally used by the sampler in the field.

10.1.1 *Field blanks* are used to enable quantitative correction for bias that arises due to handling, storage, transport, and laboratory procedures. They can also detect problems in inadequate field decontamination procedures or potential cross-contamination problems in field procedures or both. Field blanks consist of water that is metal-free or organic-free, or both, which contacts the sampling equipment under field conditions. Field blanks are also considered equipment blanks.

10.1.2 *Trip blanks* are used to detect any contamination or cross-contamination resulting from handling and transportation. They consist of water that is metal-free or organic-free, or both, which is placed in the sampling containers that accompany the samples to and from the field.

10.1.3 *Field duplicates* are actual samples collected in the field in duplicate and sent to the laboratory. They are used to document the precision of the sampling and analytical technique.

10.1.4 *Field spikes* are actual samples collected in the field and spiked with a known amount of analyte. They are used to determine the loss of analytes of interest during sampling and shipment. They are not generally used because they are susceptible to errors that are difficult to control in a field situation.

10.1.5 *Control samples* are samples of known analyte concentration prepared in a laboratory and then submitted with the field samples as a field sample. They are used to document the accuracy of the analytical technique.

11. Documentation

11.1 The documentation of the field activities and sample collection activities shall contain the information necessary for reconstruction of the sampling event at a later date. This documentation process consists of (1) field logbooks, (2) sample identification forms, (3) documentation of sample collection forms, (4) sample labels, and (5) chain-of-custody forms. Keep in mind that the documentation process should be able to provide answers to the questions who, why, what, when, where, and how.

11.1.1 *Field logbooks* are used to record the activities of the field team and to record information about the sampling event that is not contained on other forms. The logbook shall be bound and have consecutively numbered pages. The field team leader shall maintain the logbook. Items that would normally be recorded in the field logbook are (1) sampling team members; (2) equipment used on the sampling event; (3) source and expiration date of calibrating solutions used; (4) date, time, and sample number of samples collected; (5) weather conditions, if they are important to understanding the data; and (6) other quantitative information or measurements that are important to the data reviewer.

11.1.2 *Sample identification forms* may vary from project to project but all are designed to provide information about where the sample was collected, who collected the sample, date of collection, and comments by the sampler to document other important information.

11.1.3 *Sample labels* are necessary to prevent misidentification of the samples. Each label shall include, at a minimum, (1) sample number, (2) name of sampler, (3) date and time of collection, (4) place of collection, and (5) name and address of organization collecting the sample.

11.1.4 *Chain of custody* is an essential part of the sampling scheme to ensure the integrity of the sample from collection to data reporting. The possession and handling of the samples should be traceable from the time of collection through analysis and final disposition. This documentation is known as the chain of custody. A sample is considered to be under a person's custody if it is (1) in a person's physical possession, (2) in view of the person after taking possession, and (3) secured by that person so that no one can tamper with it or secured by that person in an area that is restricted to authorized personnel. The chain-of-custody form shall accompany the samples and each person relinquishing or receiving the samples shall sign and date the form and retain a copy for their records.

11.1.5 *Custody seals* are used to detect unauthorized tampering of samples. They shall be affixed to the shipping container in such a way that, if the shipping container is properly secured and arrives at the laboratory with the custody seals intact, the integrity of the sample can be demonstrated. Custody seals can also be placed directly over the lid of the sample container to further ensure that there has been no tampering with the sample. Custody seals may also be placed on the door of the sample storage area to document that no unauthorized entry was made while the sample was stored.

12. Shipping and Handling

12.1 The storage and transport of samples are often the most neglected elements of a sampling program. Samples shall be stored in a manner that does not compromise the sample integrity and shall be shipped to the laboratory in a timely manner to satisfy holding times. In addition, all shipments shall comply with the Department of Transportation (DOE) regulations governing shipment of hazardous materials and substances. Coordination with the laboratory is critical to ensure that samples will arrive in a timely manner and the laboratory can meet the required holding times. This may require adjustment to sampling schedules.

12.2 The DOT regulations governing shipment of hazardous materials and substances are available in Hazardous Materials Regulations (49 CFR 171–179). The sampler should be familiar with and shall comply with these regulations. The regulations describe proper marking, labeling, packaging, documentation, and shipping procedures. Samples of a substance listed in the Hazardous Materials Table (49 CFR 172.101) shall be identified, packaged, marked, labeled, documented, and shipped according to the regulations listed for that material. However, if the composition of the sample is unknown, the shipper shall select the appropriate transportation category in accordance with 49 CFR 172.402(h). A material for which reasonable doubt exists as to its class and labeling requirements, and for which a sample must be transported for laboratory analysis, may be labeled according to the shipper's tentative class assignment based upon: (1) defining criteria (i.e., definitions of the hazard classes); (2) hazard precedence prescribed in 49 CFR 173.2; and (3) shipper's knowledge of the material.

12.3 The hazards listed in 49 CFR 173.2 fall into five classes: (1) flammable liquids, (2) radioactive materials, (3) oxidizers, (4) flammable solids, and (5) corrosives. The sampler should be familiar with the definitions of these classes to properly ship the samples.

13. Sampling Plan

13.1 A sampling plan shall be prepared after all the previous items have been properly considered. The sampling plan is the road map that should be followed during sample collection. It is a collection of separate steps arranged in a specific order that, when properly followed, results in a unique sample being obtained. It shall be flexible enough to allow for changes in data-quality objectives, information needs, and the variety of situations found at a particular site. The generalized plan presented in this section describes the steps and the goal each step is to accomplish. The steps are arranged in the order in which they should be executed, but some steps may be executed concurrently. However, some steps are not applicable to all liquid types and can

be eliminated. For example, the hydrologic-measurement and the well-purging steps are not applicable to surface or containerized liquids.

13.1.1 *Identify Sampling Site*—Consult the planning documents, maps, and other instructions to identify the sampling site. Review the documents for the specific site and determine the sampling requirements (i.e., samples to be collected, analyte requirements, required field measurements, and any personal protective equipment that might be necessary).

13.1.2 *Determine Equipment Requirements*—After reviewing the documents described in Section 13.1.1, select the appropriate equipment. The appropriate sections of this manual or other referenced documents should also be reviewed. Select equipment that has the least potential of affecting the sample and yet can provide the necessary volume required for the purging and sampling steps.

13.1.3 *Establish Documentation Requirements*—At a minimum, each sample requires a sample label and an entry in the field logbook. See the documentation section of this manual and review the planning documents for site-specific requirements.

13.1.4 *Inspect the Site*—Inspect the sampling site to identify any health and safety problems, verify the sample collection point, and identify any conditions that could affect the quality of the sample. If the site is a monitoring well, examine the condition of the surface seal and well protector to determine if there is any evidence of frost-heaving, cracks, or vandalism. Record this inspection in the field logbook.

13.1.5 *Take Appropriate Protective Measures and Conduct Area Monitoring*—Monitor the area with an organic vapor meter (OVM) and an explosivity meter to determine if special personal protective equipment will be necessary. Consult the planning documents for details of monitoring and personal protective equipment requirements. Record these monitoring results in the field logbook.

13.1.6 *Prepare the Area for Sampling*—Clear the area around the sampling point of weeds and other materials prior to beginning sampling activities. Sampling equipment shall not be placed on the ground. Place sampling equipment on a card table or drop cloth on the ground.

13.1.7 *Take Water-Level Measurements and Determine Purging Requirements*—This step is only applicable when sampling monitoring wells. Unlock the well protector, remove the cap from the well, and take OVM and water-level measurements.

13.1.8 *Calibrate Monitoring Equipment*—Calibrate or check the equipment to be used for making field measurements. Record this information in the field logbook or document the information on the sample collection form.

13.1.9 *Assemble Equipment*—Assemble the equipment to be used according to the operating manual for each piece of equipment.

13.1.10 *Purge Stagnant Water and Monitor pH, Temperature, Conductivity, and Other Parameters*—Stagnant water in the well shall be removed prior to sampling. Monitoring of pH, conductivity, and temperature is used to determine if stagnant water has been removed. These parameters should stabilize to ± 10 percent prior to sampling.

13.1.11 *Label Sample Bottles and Collect and Preserve Samples*—Label the sample bottles and collect and preserve the samples. Consult the planning documents or the appropriate sections of this manual for requirements.

13.1.12 *Record Field Measurements and Perform any Field Analysis*—Record the field monitoring parameters and conduct the field analyses at this time. Consult the planning documents for requirements at the site.

13.1.13 *Clean Equipment*—Clean and decontaminate the equipment according to the decontamination procedure in this manual. Planning documents for each site will describe site-specific decontamination procedures.

13.1.14 *Review Documents and Prepare for the Next Sample*—Review the field logbook and other records such as sample labels and field documentation forms for completeness and accuracy. Clean up the site and put away any equipment that was used for sampling. Prepare for collection of the next sample.

13.1.15 *Storage and Transport of Samples*—Place samples in secure storage and prepare the sample for transport. The samples that require storing at

4 °C shall be placed in an ice chest with ice and kept cool until shipment to the laboratory.

14. Health, Safety and Environmental Compliance Considerations

14.1 The sampling of liquids comprises numerous activities that involve the consideration of health, safety, and environmental compliance issues. Site-specific planning documents and procedures shall address these issues. Where appropriate, include these issues in procedures. However, many of these issues are site specific and should be thoroughly covered in planning documents. Health, Safety, and Environmental Compliance Specialists shall review all procedures, planning documents, and activities to verify that all items have been adequately addressed. Items that are to be considered include, but are not limited to, the following.

14.1.1 Assignment of responsibilities.

14.1.2 Medical program requirements.

14.1.3 Training program requirements.

14.1.4 Personnel protective equipment requirements.

14.1.5 Personnel decontamination requirements.

14.1.6 Emergency procedures.

14.1.7 Disposal of contaminated wastes.

14.1.8 Compliance with environmental regulations.

14.1.9 Compliance with hazardous materials transportation.

SITE SPECIFIC PROCEDURE CHANGE or NOTICE

PROCEDURE Measurement of Water Levels in Groundwater Monitoring Wells

PROJECT or SITE Air Force Plant 4

References to Electric Sounder

The only well sounder acceptable for use at Air Force Plant 4 will be an interface probe able to distinguish between immiscible layers of different conductivity. Ordinary electric sounders without this capability will not be used for fluid level measurements.

Standard Test Method for the Measurement of Water Levels in Groundwater Monitoring Wells

Introduction

Water-level measurements shall be taken prior to any sampling or well purging. These measurements are needed to determine the casing volume of water in the well; the data are used when interpreting the monitoring results. High water levels could indicate recent recharge to the system, resulting in the dilution of the sample. Low water levels may reflect the influence of nearby production wells. Documentation of the nonpumping water levels shall also provide historical information on the hydraulic conditions at the site.

1. Scope

1.1 The water-level measurements shall be made from the top of the well casing and, for consistency, shall always be made from the same spot on the well casing. If the planning documents do not specify, and other reference points do not exist, then the measurement shall be made on the north side of the well casing.

1.2 Two methods are provided in this test method for water-level measurements. One uses an electric sounder with a conductivity cell. When the cell contacts water it completes an electrical circuit and sounds a buzzer or lights a lamp. The other method uses an interface probe. This instrument has an optical liquid sensor and a conductivity cell and can distinguish between the presence of a non-conductive layer and a conductive layer. For example, oils, fuels, and many organics are non-conductive and are immiscible in water. With this instrument the sampler can measure the thickness of a light-phase immiscible, which would float on the water surface; or a dense-phase immiscible, which would sink to the bottom of the well.

	Section
Method A — Water-Level Measurements Using an Electric Sounder	5–7
Method B — Water-Level Measurements Using an Interface Probe	8–10

2. Hazard Analysis

2.1 This test method uses methanol for decontaminating the apparatus. Methanol is a Department of Transportation (DOT)-regulated material; its hazard class is Flammable Liquid; and it is an Occupational and Safety Administration (OSHA)-listed toxic and hazardous substance. Avoid eye and skin contact by wearing eye protection and disposable gloves. Avoid breathing vapors. Use only in a well-ventilated area. Keep away from heat, sparks, and flames.

2.2 Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 American Society for Testing and Materials, *Standard Guide for Sampling Groundwater Monitoring Wells*, D4448–85a, 1986.

3.2 U.S. Department of Energy, *The Environmental Survey Manual*, Appendix E, Volume 4, DOE/EH–0053, 1987.

3.3 U.S. Environmental Protection Agency, *Handbook Groundwater*, EPA/625/6–87/016, 1987.

3.4 U.S. Environmental Protection Agency, *Practical Guide for Groundwater Sampling*, EPA/600/2–85/104, 1985.

4. Significance and Use

4.1 Accurate measurements of water depth are necessary to calculate well-bore volumes; measurements to the nearest 0.01 foot are routine.

Method A
Water-Level Measurements Using an Electric Sounder

5. Apparatus

5.1 Electric sounder. (There are many adequate electric sounders available. This procedure covers most models.)

5.2 Kimwipe® or equivalent lint-free tissue.

5.3 Distilled or deionized water in a squeeze wash bottle.

5.5 Measuring tape with an engineering scale.

6. Procedure

6.1 The following procedure is supplemental to the instruction in the instrument-specific operating manual.

6.1.1 Check sounder to ensure that batteries are operating.

6.1.2 Clean probe with distilled or deionized water and wipe dry with a lint-free disposable tissue.

6.1.3 Slowly lower the probe into the well until the indicator sounds.

6.1.4 Raise the probe slightly until the indicator stops sounding.

6.1.5 Carefully lower the probe until the indicator sounds again and read the depth to water to the nearest 0.01 foot.

6.1.6 Repeat steps 6.4 and 6.5 until a repeatable measurement is achieved.

6.1.7 Record the depth to water to the nearest 0.01 foot.

6.1.8 Slowly withdraw the probe from the well while wiping the tape with a clean lint-free tissue moistened with distilled or deionized water.

6.1.9 Clean the probe with distilled or deionized water and wipe dry with a lint-free tissue.

7. Procedure Bias

7.1 With this method, water-level measurements shall be repeatable to ±0.01 foot. The accuracy of the instrument shall routinely be checked against a steel tape to ensure that the cable has not stretched or twisted.

Method B
Water-Level Measurements Using an Interface Probe

8. Apparatus

8.1 Soiltest Model 447–000 interface probe or equivalent.

8.2 Kimwipes® or equivalent lint-free tissue.

8.3 Deionized or distilled water in a squeeze wash bottle.

8.5 Methanol. (Department of Transportation-regulated material; its hazard class is Flammable Liquid.)

9. Procedure

9.1 The following procedure is supplemental to the instruction found in the instrument-specific operating manual.

9.1.1 Clean the probe with methanol, followed by a distilled or deionized water rinse, and wipe dry with a lint-free tissue.

9.1.2 Check the battery level and replace if low.

9.1.3 Slowly lower the probe into the well until the probe comes in contact with liquid. A steady audible alarm indicates an immiscible non-conductive liquid, while an oscillating alarm indicates a conductive liquid (water).

9.1.4 When the alarm sounds, raise the probe slightly until the alarm stops. Lower carefully until the alarm sounds again and note the depth. Repeat as necessary until a repeatable measurement of ± 0.01 foot is achieved. Record this measurement.

9.1.5 If a light-phase immiscible layer is present as indicated by a continuous audible alarm, the thickness can be measured by recording the point at which the continuous alarm begins and the point at which the oscillating alarm begins. The difference between the two measurements is the thickness of the light-phase immiscible layer.

9.1.6 If a dense-phase immiscible layer is suspected, it can be measured by slowly lowering the probe to the bottom of the well. If a dense-phase immiscible layer is present, it can be measured by recording the point at which the continuous alarm begins and the point that the probe reaches the bottom of the well.

9.1.7 Carefully withdraw the probe from the well while wiping the tape with a Kimwipe® moistened with distilled or deionized water. If the well contained any light-phase immiscible layers, the tape shall be rinsed with methanol followed by a distilled or deionized water rinse and wiped dry with a lint-free tissue as it is being removed from the well.

9.1.8 Clean the probe with methanol, followed by a distilled or deionized water rinse, and dry with a lint-free tissue.

10. Procedure Bias

10.1 When using the interface probe for liquid level measurements, readings of ± 0.01 foot can be achieved. The accuracy shall be routinely checked using a steel tape to determine if the tape has stretched or coiled.

11. Quality Assurance

11.1 The following information shall be logged when taking water-level measurements:

11.1.1 Date.

11.1.2 Well identification.

11.1.3 Depth to water.

11.1.4 Depths of light-phase and/or dense-phase immiscible liquids.

11.1.5 Name of person performing the measurement.

SITE SPECIFIC PROCEDURE CHANGE or NOTICE

PROCEDURE Standard Practice for Purging Monitor Wells

PROJECT or SITE Air Force Plant 4

VARIANCE

The introduction section of the Standard Practice for Purging Monitor Wells states that "a general rule of thumb is to monitor purge water using an in-line flow cell for pH, conductivity, and temperature. When these parameters stabilize to +/- 10 percent for two successive well volumes, the sampler can be reasonably assured that the stagnant water has been removed from the well casing."

As per guidance from EPA Region VI, well purging criteria are revised to specify that water quality parameter measurements are to be taken after three to five well volumes have been removed at a rate of one measurement for every 1/2 well volume until the measurements stabilize or until a maximum of five bore volumes have been removed. Stabilization criteria will be:

pH	+/-	0.25
Conductivity	+/-	50 µmhos/cm
Temperature	+/-	0.5 degrees C

If the well is pumped dry, it will be sampled 24 hours later, after recovery.

Standard Practice for Purging of Monitoring Wells

Introduction

To obtain a representative groundwater sample, the stagnant water in the well casing shall be removed. The recommended amount of purging depends on many factors such as the hydrogeological nature of the aquifer, the characteristics of the well, the type of sampling equipment to be used, and the parameters to be sampled. There is no one standard that will fit all situations. The general rule-of-thumb is to monitor the purge water using an in-line flow cell for pH, conductivity, and temperature. When these parameters stabilize to ± 10 percent for two successive well volumes, the sampler can be reasonably assured that the stagnant water has been removed from the well casing.

1. Scope

1.1 The four methods provided here are representative of those generally used to purge monitoring wells. Each method has advantages and disadvantages that must be considered. A review of the Well Purging Strategies in Section 7 of General Considerations for the Sampling of Liquids [LQ–1(G)] provides guidance for selecting the proper method.

	Section
Method A—Well Purging Using a Peristaltic-Type Pump	6–8
Method B—Well Purging Using a Bladder-Type Pump	9–11
Method C—Well Purging Using a Bailer	12–14
Method D—Well Purging Using a Submersible Pump	15–17

2. Hazard Analysis

2.1 These procedures use gasoline-powered electric generators, gasoline-powered air compressors, and battery-powered pumps and accessories. The following safety precautions shall be followed.

2.1.1 Air compressors that are belt driven shall have a belt guard in place.

2.1.2 Care shall be taken when connecting and disconnecting equipment powered by lead-acid batteries so as not to generate sparks that have the potential of creating an explosive hazard.

2.1.3 Gasoline shall be stored in Factory Mutual (FM)-approved safety cans. Safety cans shall be well secured in the vehicle during transport. Gasoline-powered equipment shall be cool before filling and care shall be taken not to spill any gasoline.

2.1.4 Air compressors shall not be operated above rated capacities and shall be configured so as not to have any dead end fittings above 20 pounds per square inch (psi). Carefully check for loose connections before operating.

2.1.5 Gasoline is a Department of Transportation (DOT)-regulated material; its hazard class is Flammable Liquid. Avoid eye and skin contact by wearing eye protection and disposable gloves. Avoid breathing vapors. Use only in a well-ventilated area and keep away from heat, sparks, and flames.

2.1.6 Gasoline-powered generators shall not be operated above their rated capacity.

2.1.7 Care shall be taken when lifting generators and air compressors. Proper lifting techniques shall be taken when lifting heavy equipment.

2.1.8 Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 American Society for Testing and Materials, *Standard Guide for Sampling Groundwater Monitoring Wells*, D4448–85a, 1986.

3.2 U.S. Department of Energy, *The Environmental Survey Manual*, Appendix E, Volume 4, DOE/EH–0053 1987.

3.3 U.S. Environmental Protection Agency, *Practical Guide for Groundwater Sampling*, EPA/600/2–85/104, 1985.

3.4 U.S. Environmental Protection Agency, *Handbook Groundwater*, EPA/625/6–87/016, 1987.

4. Significance and Use

4.1 Water may become stagnant in a well and will not reflect the local resident water's chemical and physical properties. The purging of a well can reduce this bias. Care shall be taken to allow screened intervals to come to equilibrium before sampling is performed

5. Calculation of Volume of Standing Water in a Well

5.1 Calculations are performed for the amount of water in the well with the following formula:

$$r^2 \times \pi \times (h1 - h2) \times 7.48 = \text{gallons per casing volume}$$

where

r = radius of well casing (feet) (the radius of the well is obtained from the well completion logs or can be measured with a tape measure),

h1 = depth of well (feet) from the top of the well casing (the depth of the well is obtained from the well completion logs), and

h2 = depth to water (feet) measured from the top of the well casing (the depth of water is measured using the Standard Test Method for the Measurement of Water Levels in Groundwater Monitoring Well [LQ–2(T)]).

Method A
Well Purging Using a Peristaltic-Type Pump

6. Apparatus

6.1 Peristaltic-type pump.

6.2 Silicone, C-FLEX®, or neoprene tubing for the pump head.

6.3 Silicone, Teflon®, polyethylene, or vinyl tubing for placing in the well.

6.4 Generator or other source of electricity.

6.5 Gasoline for generator. (Gasoline is a DOT-regulated material; its hazard class is Flammable Liquid.)

7. Procedure

7.1 The following procedure is supplemental to the instruction in the instrument-specific operating manual.

7.1.1 Place the suction line in the well so it is just below the liquid surface.

7.1.2 Connect the suction line to the pump.

7.1.3 Connect the pump outlet to the in-line flow cell, see Standard Practice for the Use of a Flow Cell for Field Measurements [LQ–10(P)], or place the pump outlet hose into an open container to be used to make the field measurements.

7.1.4 Place calibrated pH, conductivity, and temperature electrodes into the in-line flow cell or the open container.

7.1.5 Initiate pumping and follow the water level down the well bore if the recovery rate of the well is below the pumping rate.

Note: Purge water may have to be contained and properly disposed. Consult the site-specific planning documents for requirements.

7.1.6 Routinely monitor and record the volumes purged and the readings for the pH, conductivity, and temperature.

7.1.7 When these readings have stabilized to ± 10 percent for two successive well volumes, sampling can begin.

7.1.8 Remove the suction line from the well, clean and decontaminate the suction line and pump tubing, as required.

8. Procedure Bias

8.1 The advantages of purging with a peristaltic pump are that (1) a peristaltic pump is relatively portable, inexpensive, and convenient; (2) it requires a minimum of down-hole equipment; and (3) it can be cleaned easily or the entire tubing can be changed between wells.

8.2 The disadvantages of purging with a peristaltic pump are that (1) purging is limited to situations where the water levels are less than about 25 feet and (2) degasing occurs whenever there is a head difference between the pump and the water level.

Method B
Well Purging Using a Bladder-Type Pump

9. Apparatus

9.1 Bladder-type pump.

9.2 Air compressor.

9.3 Teflon®, polyethylene, or vinyl tubing for the air and sample line.

9.4 Gasoline for the air compressor. (Gasoline is a DOT-regulated material; its hazard class is Flammable Liquid.)

10. Procedure

The following procedure is supplemental to the instruction found in the instrument-specific operating manual.

10.1 Lower the pump gently to a position just above the screened interval.

10.2 Connect the air line to the pump controller.

10.3 Connect the pump outlet to an in-line flow cell, see Standard Practice for the Use of a Flow Cell for Field Measurements [LQ-10(P)], or place the pump outlet hose in an open container used to make the field measurements.

10.4 Place calibrated pH, conductivity, and temperature electrodes in the flow cell or the open container.

10.5 Initiate pumping and routinely monitor and record the volume purged and the pH, conductivity, and temperature measurements.

Note: Purge water may have to be contained and properly disposed. Consult the site-specific planning documents for requirements.

10.6 When these readings have stabilized to ± 10 percent for two successive well volumes, sampling can begin.

10.7 Remove the pump from the well, clean and decontaminate as required.

11. Procedure Bias

11.1 The advantages of using a bladder-type pump for purging are that (1) the system is not damaged by dry pumping, (2) there is no air/water contact, and (3) the entire assembly can be made of Teflon® or stainless steel.

11.2 The disadvantages of using a bladder-type pump are that (1) pumping rates are relatively slow, (2) there is a high rate of air consumption during prolonged pumping, and (3) cleaning and decontamination are more difficult than with the apparatus used in methods A or C.

Method C
Well Purging Using a Bailer

12. Apparatus

12.1 Teflon® or stainless steel bailer.

12.2 Teflon® or stainless steel cable or line.

12.3 Bailer reel.

13. Procedure

13.1 Attach the bailer to the cable or line.

13.2 Lower the bailer slowly until it contacts the liquid.

13.3 Allow the bailer to sink until it is totally submerged.

13.4 Slowly raise the bailer to the surface.

13.5 Tip the bailer or use a bottom-emptying device and fill a container in which calibrated pH, conductivity, and temperature probes have been placed.

Note: Purge water may have to be contained and properly disposed. Consult the site-specific planning documents for requirements.

13.6 Routinely monitor and record the pH, conductivity, temperature, and volume purged.

13.7 When the readings have stabilized to ± 10 percent for two successive well volumes, sampling can begin.

13.8 Clean and decontaminate the bailer, as required.

14. Procedure Bias

14.1 The advantages of using bailers for well purging are that (1) bailers can be constructed of a variety of materials, (2) external power sources are not needed, (3) bailers are inexpensive, (4) bailers are easily cleaned and decontaminated, and (5) bailers can be used in wells of virtually any depth.

14.2 The disadvantages of using bailers are that (1) evacuating large amounts of stagnant water is labor intensive; (2) aeration, degasing, and turbulence will occur; (3) it is difficult to determine the depth to which the bailer has been submerged; and (4) bailer check valves may not operate properly under conditions of high suspended solids.

Method D
Well Purging Using a Submersible Pump

15. Apparatus

15.1 Submersible-type pump.

15.2 Discharge tubing of vinyl, polyethylene, polyvinyl chloride, or Teflon®.

15.3 Power source of generator or batteries.

15.4 Gasoline for generator. (Gasoline is a DOT-regulated material; its hazard class is Flammable Liquid.)

16. Procedure

The following procedure is supplemental to the instructions provided in the instrument-specific operating manual.

16.1 Set up the pump according to the operating manual.

16.2 Gently lower the pump down the well so that the pump head is submerged sufficiently and will not run dry.

Caution: Submersible pumps cannot be allowed to run dry.

16.3 Connect the pump outlet to an in-line flow cell, see Standard Practice for the Use of a Flow Cell for Field Measurements [LQ–10(P)], or place the pump outlet in an open container used for the field measurements.

16.4 Place calibrated pH, conductivity, and temperature electrodes in the flow cell or the open container.

16.5 Initiate pumping, and monitor and record the volumes purged and the pH, conductivity, and temperature measurements.

Note: Purge water may have to be contained and properly disposed. Consult the site-specific planning documents for requirements.

16.6 When pH, conductivity, and temperature have stabilized for two successive well volumes, sampling can begin.

16.7 Remove the pump from the well; clean and decontaminate.

17. Procedure Bias

17.1 The advantages of using a submersible pump for well purging are that (1) relatively high pumping rates are possible, (2) some designs are relatively portable and easy to use, and (3) these pumps can pump from greater depths than the pumps used in methods A or B.

17.2 The disadvantages of using a submersible pump are that (1) high pumping rates and the mechanical actions cause turbulence, aeration, and degasing of the water; (2) pumps are easily damaged by dry pumping; and (3) these pumps can be difficult to clean and decontaminate.

18. QualityAssurance

18.1 All of the methods listed above require the following information to be logged for quality-assurance documentation.

18.1 Depth to water.

18.2 Depth of well.

18.3 Well diameter or radius.

18.4 Depth of water.

18.5 Calculated water volume.

18.6 Type of mechanism used to evacuate the well.

18.7 Date.

18.8 Well identification.

18.9 Name of person performing the purging.

18.10 Volume purged.

18.11 Conductivity, pH, and temperature measurements.

DETERMINATION OF TURBIDITY IN WATERS

1.0 INTRODUCTION

This method is applicable to drinking, surface, and saline waters in the range of turbidity from 0 to 40 nephelometric turbidity units (NTU). Higher values may be obtained with a dilution of the sample.

The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of scattered light, the higher the turbidity. NTU readings are made in a nephelometer designed in accord with specifications outlined in Section 5.0 of this method.

A commercially available polymer standard is approved by the EPA for use as a calibration standard (1). This standard is identified as AMCO-AEPA-1, which is available from Amco Standard International, Inc.

2.0 INTERFERENCES

Preservation of the sample is not practical and analysis should begin as soon as possible. Refrigeration or icing to 4 °C, to minimize microbiological decomposition of solids, is recommended (2,3) if the sample cannot be analyzed immediately.

The presence of floating debris and coarse sediments which settle out rapidly will give low readings. Finely divided air bubbles will give high readings.

3.0 PRECISION AND REPORTING LIMIT

The sensitivity of the instrument should permit detection of a turbidity difference of 0.02 unit or less in waters having turbidities less than 1 unit.

4.0 REAGENTS

For turbidity-free water, pass distilled water through a 0.2 µm Gelman nuclepore filter, if such filtered water shows a lower turbidity than the distilled water.

5.0 METHODS

5.1 Instrument Conditions

- See the Hach Instruction Manual for the Model 16800, Portalab Turbidimeter, for operating instructions (4).

o To maximize the intensity of light passing through the solution, the sample tubes must be of clear, colorless glass. They should be thoroughly cleansed, both inside and out, and discarded when they become scratched or etched. They should be provided with a protective case or be of sufficient length to prevent any handling on that part of the tube through which light will pass.

5.2 Standards

The AMCO-AEPA-1 standard as supplied requires no preparation or dilution prior to use.

5.3 Analytical Method

1. Linear calibration should be performed within six months of analysis.

   a. Empty and rinse chosen cuvette twice with approximately 5 ml of the highest NTU value in range to be calibrated.

   b. Dry exterior with lint-free paper.

   c. Fill cuvette with the highest standard for the range and insert the cuvette into the instrument well, making sure to align index marks.

   d. Adjust the 'standardize' controls so the instrument reads the known value.

   e. Empty the cuvette, rinse, and fill the same cuvette with the next lower value for that range. Clean cuvette, place in instrument, index, and read.

   f. Repeat for all standards in that range.

   g. Set up tables for standard true values versus instrument readings. Plot each range on linear paper.

2. Daily calibration should be performed whenever samples are run and include a blank.

   a. If sample and/or standard are refrigerated, allow to reach room temperature in the cuvette before taking a reading.

   b. Select a clean, scratch-free, indexed cuvette and rinse twice with 5 ml of the daily calibration standard.

   c. Fill and clean cuvette and insert it into the instrument well, making sure to align the index marks.

   d. From the linear calibration curve for the range under

standardization and the known value of the standard, determine what the reading should be. Note: Adjust the instrument to the calibration curve value, not to the value indicated on the bottle of standard.

e. For turbidities less than 40 units, shake the sample to thoroughly disperse the solids. Wait until air bubbles disappear, then pour the sample into the turbidimeter tube.

Read the turbidity directly from the appropriate calibration curve.

f. For turbidities exceeding 40 units, dilute the sample with one or more volumes of filtered (0.45-µm pore size) sample until the turbidity falls below 40 units. Diluting with water may dissolve some of the turbidity (4).

6.0 CALCULATIONS

Multiply sample readings by the appropriate dilution to obtain final readings. Report results as follows:

NTU	Record to Nearest:
0.0 - 1.0	0.05
1 - 10	0.1
10 - 40	1
40 - 100	5
100 - 400	10
400 - 1000	50
> 1000	100

The data and results are then recorded on the appropriate analytical worksheet (see Introduction, Section 4.0, of this manual). The actual conditions during measurement, if different from those called for in this method, should be noted on the back of the worksheet.

7.0 NOTES

The sample size for all turbidity measurements should be 18 ml. Use the line on the sample cell as a level indicator. Variations in sample volume can affect the accuracy of the determinations.

NTU is considered comparable to the Formazin Turbidity Unit (FTU) and the Jackson Turbidity Unit (JTU).

8.0 REFERENCES

1. EPA 600/4-79-020, Method 180.1.

2. Annual Book of ASTM Standards, Part 31, 'Water,' Standard D1889-71, p. 223 (1976).

3. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p. 132, Method 214A (1975).

4. Hach Instruction Manual, Portalab Turbidimeter, Model 16800.

Standard Test Method for the Field Measurement of pH

Introduction

Perhaps no water-quality parameter is measured as frequently as pH. The pH measurement is so easily made that the attention given to it is often inadequate. An accurate pH is critical for the prediction and interpretation of the reactions and migration of dissolved species. This procedure provides a useful pH measurement under most field situations.

1. Scope

1.1 This method contains the procedures for the measurement of pH in an aqueous solution. The pH is determined using a glass hydrogen-ion electrode compared against a reference electrode of known potential by means of a pH meter.

2. Referenced Documents

2.1 American Society for Testing and Materials, *Annual Book of ASTM Standards*, Section 11, Volume 11.01, D1293-78, 1984.

2.2 American Public Health Association, American Water Works Association, and Water Pollution Control Federation, *Standard Methods for the Examination of Water and Wastewater: American Public Health Association*, Washington, D.C., 1980.

2.3 Korte, N., and D. Ealey, *Procedures for Field Chemical Analyses of Water Samples*, Technical Measurements Center, U.S. Department of Energy, Grand Junction Area Office, GJ/TMC-07(83), 1983.

2.4 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," *Techniques of Water-Resources Investigations of the United States Geological Survey*, Chapter D2, Book 1: U.S. Government Printing Office, Washington, D.C., Stock Number 024-001-02879-4, 1976.

3. Hazard Analysis

3.1 No hazards requiring controls have been identified. Site-specific controls are available in the planning documents of a particular project.

4. Significance and Use

4.1 The pH of a solution is defined as the negative logarithm to the base 10 of the hydrogen-ion activity in moles per liter: $pH = -\log [H^+]$. Because pH is exponentially related to concentration, great care shall be taken in making the measurement.

4.2 Natural waters usually have pH values in the range of 4 to 9. The primary control over pH in natural waters is the carbonate system, including gaseous and dissolved carbon dioxide, bicarbonate, and carbonate ions.

5. Interferences

5.1 Temperature, atmospheric contamination, and ionic strength are factors that affect pH measurements. The pH measurement is relatively free from interference from color, turbidity, colloidal matter, oxidants, or reductants.

5.1.1 *Temperature*—The temperature compensation on a pH meter only permits adjustment of the electrode slope. It does not compensate for changes in the potential of the reference electrode, the asymmetry potential of the glass electrode, or the liquid-junction potential. Nor does it compensate for changes in pH due to temperature. Thus, the temperature of the buffer and the unknown shall be recorded at the time of measurement. Ideally, their temperatures shall be within 10 °C.

5.1.2 *Atmospheric Contamination*—Atmospheric contamination can be a significant problem for groundwater samples. Dissolved oxygen and carbon dioxide can be evolved or dissolved when the sample is exposed to air, and a considerable change in pH may result. In situ measurements should be taken where possible but, for groundwater that must be pumped, the use of a flow cell gives the best results. See Standard Practice for the Use of a Flow Cell for Field Measurements [LQ-10(P)].

5.1.3 *Ionic Strength*—Because of errors due to ionic strength (which are not worth correcting in the field), pH measurements shall be accompanied by a measurement of the specific conductance. The pH is a measurement of the hydrogen-ion activity. An ideal solution is assumed in which other ions

do not affect the hydrogen activity. This assumption deteriorates if the ionic strength is too high. Similarly, samples with low ionic strength will cause difficulties because the resistance of the sample approaches that of the glass electrode. For best results, samples with very low ionic strength should be stirred for a few seconds prior to the reading. Even then, it may require several minutes for the reading to stabilize.

5.1.4 *High Sodium and Alkalinity*—High sodium and alkalinity may also produce errors in the pH measurement. For pH 9 and a sodium concentration of 10 moles per liter, a special electrode is needed. Similarly, any pH value that is less than 1 or greater than 9 will have a greater uncertainty associated with it because the electrode response is non-Nernstian in these regions.

6. Apparatus

6.1 Numerous pH meters are available; the meter used should have a temperature compensating device, a slope adjustment, and be capable of reading pH to ± 0.01 units.

6.2 A flow cell to be used for continuous-flow measurements.

6.3 Standard pH-buffer solutions of 4.00, 7.00, and 9.00 or 10.00.

6.4 Combination pH electrode.

6.5 Temperature-measuring device capable of reading temperatures to ± 0.1 °C.

6.6 Distilled or deionized water in a squeeze wash bottle.

6.7 Kimwipes® or equivalent lint-free tissue.

6.8 Disposable beakers, test tubes, or centrifuge tubes.

7. Calibration

7.1 In each case, samplers shall follow the manufacturer's instructions for the pH meter and electrode used. Electrodes shall be kept wet when not in use. Recommended solutions for storage are the pH 4.00 or pH 7.00 buffer.

7.2 Before use, remove electrode from the storage solution, rinse with distilled water, and blot dry with a lint-free tissue.

7.3 Adjust buffer solution and electrode to ± 10 °C of the sample temperature. This can be done by storing the buffer solutions and electrode in an ice chest or by letting sample water run over the buffer bottles and electrode until the temperatures have equilibrated.

7.4 Place the electrode in the pH 7.00 buffer, adjust the temperature compensation control to the temperature of the buffer (or use an automatic temperature compensator), and adjust the calibration control to read the pH of the buffer. The pH of the buffer is equal to 7.00 only at 25 °C; therefore, it is necessary to use the temperature-correction curve supplied by the manufacturer of the buffer.

7.5 Remove the electrode from the 7.00 buffer, rinse with distilled water, and blot dry. Place the electrode in either pH 4.00 or pH 10.00 buffer, bracketing the expected pH of the sample. Allow the reading to stabilize before making adjustments. Adjust the slope control to read the correct pH, again consulting the temperature-correction curve supplied by the manufacturer.

7.6 Rinse electrode with distilled water and blot dry. Recheck value of the pH 7.00 buffer. The value shall be within ± 0.02 pH of the correct value. If not, repeat steps 7.4, 7.5, and 7.6.

8. Procedure

8.1 The following general procedure supplements the instruction in the instrument-specific operating manual.

8.1.1 Rinse calibrated electrode (see Section 7) with distilled water, blot dry, and immerse electrode in the solution.

8.1.2 Use of a flow cell is recommended for making pH measurements; this reduces the interferences due to atmospheric contamination. If possible, in situ measurements are the best.

8.1.3 Allow the measurement to stabilize and record the reading.

8.1.4 Remove the electrode from the solution, rinse with distilled water, blot dry, and store in pH 4.00 or pH 7.00 buffer solution.

9. Quality Assurance

9.1 The following information about the field measurement of pH shall be logged for quality-assurance documentation.

9.1.1 Time of the last two-buffer calibration. The two-buffer calibration shall be performed a minimum of once each hour.

9.1.2 Buffer temperature at time of calibration.

9.1.3 Sample temperature at time of measurement.

9.1.4 Measurement conditions (i.e., in situ, open container, or air-exclusion container).

9.1.5 Source and expiration date of buffers used.

9.1.6 Instrument manufacturer and model number.

9.1.7 Name of person performing the measurement.

10. Precision and Bias

10.1 Precision of ± 0.02 pH units and an accuracy of ± 0.05 pH units can be achieved. However, ± 0.1 pH units represent the limit of accuracy under normal conditions.

Standard Test Method for the Field Measurement of Specific Conductance

Introduction

Specific conductance is a widely used indicator of water quality. It measures the ability of water to carry an electrical current under specific conditions. This ability depends on the presence of ions, their total concentration mobility, and temperature. Specific conductance is a simple indicator of change within a system and is used as an aid in evaluating whether a sample is representative of the water in the system.

1. Scope

1.1 This procedure describes the field measurement of the specific conductance of a aqueous sample. The specific conductance is measured using a conductance meter and a platinum or stainless steel electrode.

2. Hazard Analysis

2.1 No hazards requiring controls have been identified. Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 American Public Health Association, American Water Works Association, and Water Pollution Control Federation, *Standard Methods for the Examination of Water and Wastewater: American Public Health Association*, Washington, D.C., 1980.

3.2 Korte, N. and D. Ealey, *Procedures for Field Chemical Analyses of Water Samples*, Technical Measurements Center, U.S. Department of Energy, Grand Junction Area Office, GJ/TMC-07(83), 1983.

3.3 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," *Techniques of Water-Resources Investigations of the United States Geological Survey*, Chapter D2, Book 1: U.S. Government Printing Office, Washington, D.C., Stock Number 024-001-02879-4, 1976.

4. Significance and Use

4.1 The specific conductance or conductivity of a sample is defined as the conductance of the sample between opposite sides of a cube, 1 centimeter (cm) in each direction. Because it is impractical to build electrodes with these characteristics, electrodes are manufactured in various forms. A cell constant is determined by measuring a solution of known conductivity. Solutions of known conductivity are purchased or can be made from reagent-grade KCl. Samplers shall consult operating instructions for the specific instrument used for the determination of the cell constant. This conductivity is expressed in micromhos per centimeter (µmhos/cm).

5. Intereferences

5.1 Temperature, ionic strength, and the determination of the cell constant are features that affect the measurement of conductivity.

5.1.1 *Temperature*—The conductivity of a solution increases with temperature at approximately 2 percent per degree C. Significant errors can result from inaccurate temperature measurements.

5.1.1.1 If the conductivity meter does not have automatic temperature correction, the sampler can use the following formula to correct the conductivity reading for temperature.

$$K = \frac{Em}{1 + 0.0191(t - 25)}$$

where

K = corrected conductivity in µmhos/cm,

Em = measured conductivity in µmhos/cm, and

t = temperature in °C.

5.1.2 *Ionic Strength*—The conductivity of a solution is a function of the concentration and charge of the ions in solution and of the rate the ions move under the influence of an electrical potential. As the ionic strength increases, the rate the individual ions move decreases. Conductivity varies linearly with ionic strength for values below 1,000 µmhos/cm. As conductivity increases above 5,000 µmhos/cm, the line curves significantly; beyond 50,000

µmhos/cm, the conductivity is an unsatisfactory index of ionic concentration.

5.1.3 *Cell Constant*—The cell constant shall be checked and verified on a regular basis. A significant change in the cell constant indicates that the electrode needs cleaning or changing. Consult the instrument operating manual for procedures to check the cell constant, or see Section 7 of this procedure.

6. Apparatus

6.1 Specific conductance meter capable of measuring conductivity in the range of 0 to 100,000 µmhos/cm. This meter should also measure temperatures in the range of –5 °C to 50 °C.

6.2 Conductivity check solutions. Normally, 0.001 N, 0.01 N, and 0.1 N KCl solutions will cover the range of expected sample conductivity..

6.3 Distilled or deionized water in a squeeze bottle.

6.4 Disposable beakers, test tubes, or centrifuge tubes.

6.5 Kimwipes® or equivalent lint-free tissue.

7. Calibration

7.1 An actual calibration of the instrument is not performed. The cell/instrument calibration is confirmed by use of standard check solutions as described below.

7.1.1 Connect the temperature probe and conductivity cell to the instrument.

7.1.2 Rinse the temperature probe and conductivity cell with distilled water and blot dry with a lint-free tissue.

7.1.3 Place the temperature probe and conductivity cell in the 0.001 N KCl standard and allow the readings to stabilize. Record the temperature and conductivity reading in the field logbook.

7.1.4 Repeat steps 7.3 and 7.4 for the 0.01 N and the 0.1 N KCl standards.

7.1.5 Correct the readings to 25 °C using the formula in Section 5.1.1.1 and compare these readings to the standard values. If these readings are within ± 10 percent of the accepted value, the cell instrument-calibration check is acceptable.

7.1.6 If the cell/instrument calibration check is unacceptable, consult the instrument operation manual for cell cleaning and instrument troubleshooting procedures.

8. Procedure

8.1 The following general procedure is supplemental to the instructions in the instrument-specific operating manual.

8.1.1 Rinse the conductivity cell and temperature probe with several volumes of sample water.

8.1.2 Immerse the probe and cell in the sample.

8.1.3 Allow the readings to stabilize and record the temperature and conductivity readings on the field log form.

8.1.4 Remove the probes from the solution, rinse with distilled water, blot dry, and store according to the manufacturer's recommended procedures.

9. Quality Assurance

9.1 The following information about the field measurement of specific conductance shall be logged for quality-assurance documentation.

9.1.1 Source and expiration date of standards.

9.1.2 Instrument manufacturer and model number.

9.1.3 Date and time of calibration check.

9.1.4 Temperature and conductivity of standards used to check calibration.

9.1.5 Sample temperature and conductivity reading.

9.1.6 Name of person performing the measurement.

10. Precision and Bias

10.1 Precision and accuracy of ± 5 percent can be achieved with this procedure at conductivity readings between 100 and 5,000 µmhos/cm. Readings between 0 and 100 µmhos/cm and above 5,000 µmhos/cm should provide ± 10 percent precision and accuracy. Readings above 20,000 µmhos/cm shall not be attempted with this procedure.

Standard Test Method for the Field Measurement of the Oxidation-Reduction Potential (Eh)

Introduction

Knowledge of a system's oxidation/reduction potential (Eh) is useful for predicting the migration or attenuation of contaminants in groundwater or surface water. The measurement, however, should be applied with caution. Only under certain conditions are Eh measurements reliable; they are primarily used as a descriptive tool.

1. Scope

1.1 This method describes the procedure for the measurement of the Eh in aqueous samples; it does not address the theoretical interpretation of the oxidation-reduction potential. This procedure has been designed for routine field measurements.

2. Hazard Analysis

2.1 This test method uses a ZoBell solution for an Eh reference. This solution contains small concentrations of potassium cyanide. Potassium cyanide is a poison and is a Department of Transportation (DOT)-regulated material; its hazard class is Poison B. Samplers shall wear eye protection and disposable gloves to avoid eye and skin contact and shall keep the solution away from strong acids that will liberate hydrogen cyanide gas, which is extremely toxic.

2.2 Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 American Society for Testing and Materials, *Annual Book of ASTM Standards*, Section 11, Volume 11.01, D1498-76, 1984.

3.2 Korte, N., and D. Ealey, *Procedures for Field Chemical Analyses of Water Samples*, Technical Measurements Center, U.S. Department of Energy, Grand Junction Area Office, GJ/TMC-07(83), 1983.

3.3 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," in *Techniques of Water-Resources Investigations of the United States Geological Survey*, Chapter D2, Book 1: U.S. Government Printing Office, Washington, D.C., Stock Number 024-001-02879-4, 1976.

4. Significance and Use

4.1 The oxidation-reduction potential is defined as the electromotive force developed when a noble metal electrode and a reference electrode are placed in an aqueous sample. This potential, sometimes referred to as the redox potential, is related to the standard potential by the Nernst equation:

$$Eh = E^\circ + \frac{RT}{nF} \ln \frac{\text{oxidized state}}{\text{reduced state}}$$

where

E° = standard potential of the reaction,

R = gas constant,

T = absolute temperature,

F = Faraday constant, and

n = number of electrons involved in the half-cell reaction.

The potential is reported as volts (V) or millivolts (mV) relative to the standard hydrogen electrode taken as zero.

5. Interferences

5.1 Eh is sensitive to temperature change of the solution. Because the reference-electrode potential and the liquid-junction potential also vary with temperature, instrumental compensation is not possible. Reference solutions used to check the accuracy of the electrode system should be within ± 10 °C of the sample temperature for the readings to be valid.

5.2 Reproducible Eh measurements cannot be obtained for chemical systems that are not reversible. Samples containing dissolved oxygen above 0.01 parts per million (ppm) are essentially irreversible, and Eh measurements are not recommended. Since exposure to the atmosphere can cause rapid

changes in dissolved oxygen, all sample measurements shall be taken in a closed, flow-through container or in situ.

5.3 Samples containing hydrogen sulfide will poison the electrode as will other ions that are stronger reducing agents than platinum.

5.4 Eh measurements are relatively free from interferences from color, turbidity, colloidal matter, and suspended matter.

6. Apparatus

6.1 Most field pH meters have the capability of measuring Eh by substitution of an appropriate set of electrodes. The meter should be capable of measuring Eh to ± 1 mV.

6.2 Combination Eh electrode.

6.3 ZoBell reference solution.

Caution: This solution is poisonous and shall be handled with care. Potassium cyanide is a DOT-regulated material; its hazard class is Poison B.

6.4 Temperature-measuring device capable of reading temperatures to ± 0.1 °C.

6.5 A flow cell. See Standard Practice for the Use of a Flow Cell for Field Measurements [LQ–10(P)].

6.6 Distilled or deionized water in a squeeze wash bottle.

6.7 Kimwipes® or equivalent lint-free tissue.

6.8 Disposable beakers, test tubes, or centrifuge tubes.

7. Calibration

7.1 An actual calibration of the Eh electrode system is not performed. Instead, samplers shall make a performance check to determine if the electrode and meter are functioning properly. The performance check is as follows:

7.1.1 Record temperature of ZoBell solution. This solution should be within ± 10 °C of sample temperature.

7.1.2 Place electrode in the ZoBell solution and compare the reading with the theoretical value for the ZoBell solution (see Figure 1). The reading should be within ± 10 mV of the theoretical value.

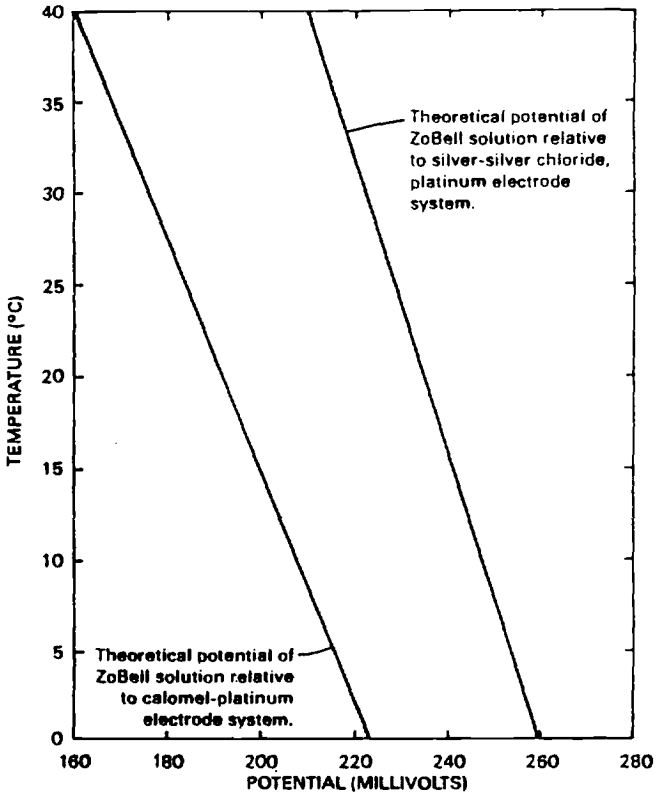

Figure 1. The Potential of ZoBell Solution Relative to Reference-Electrode Systems at Various Temperatures

7.1.3 If the reading is not within ± 10 mV, one of the following steps will usually solve the problem.

7.1.3.1 Check reference electrode filling solution; fill or replace.

7.1.3.2 Polish the platinum end of the electrode (see manufacturer's instructions).

7.1.3.3 Replace electrode.

7.1.4 Rinse electrode with distilled water, blot dry, and store according to manufacturer's suggestions.

8. Procedure

8.1 Check electrode performance according to Section 7.1.2.

8.2 Rinse electrode with distilled water and blot dry with a lint-free tissue.

8.3 Place electrode in flow-through cell and pump sample through cell for several minutes to exclude air.

8.4 Turn function switch on meter to the millivolt mode.

8.5 Allow the readings to stabilize. Stabilization should occur within 20 minutes. Turn off sample flow to prevent any streaming potential.

8.6 Record the Eh reading and temperature.

8.7 Remove the electrode from the cell, rinse with distilled water, blot dry, and store according to manufacture's suggestion.

9. Quality Assurance

9.1 The following information about the Eh measurement shall be logged for quality-assurance documentation.

9.1.1 Temperature of sample.

9.1.2 Temperature of ZoBell solution.

9.1.3 Eh of ZoBell solution.

9.1.4 Theoretical Eh of ZoBell solution relative to the reference electrode used (Figure 1).

9.1.5 Eh of sample.

9.1.6 Theoretical Eh of ZoBell solution relative to the standard hydrogen electrode (Figure 2).

9.1.7 Name of person performing the measurement.

10. Calculation

10.1 The Eh of the sample is calculated relative to the standard hydrogen electrode as follows:

$$D = A - B + C$$

where

D = Eh of sample relative to the standard hydrogen electrode,

A = Observed Eh of sample,

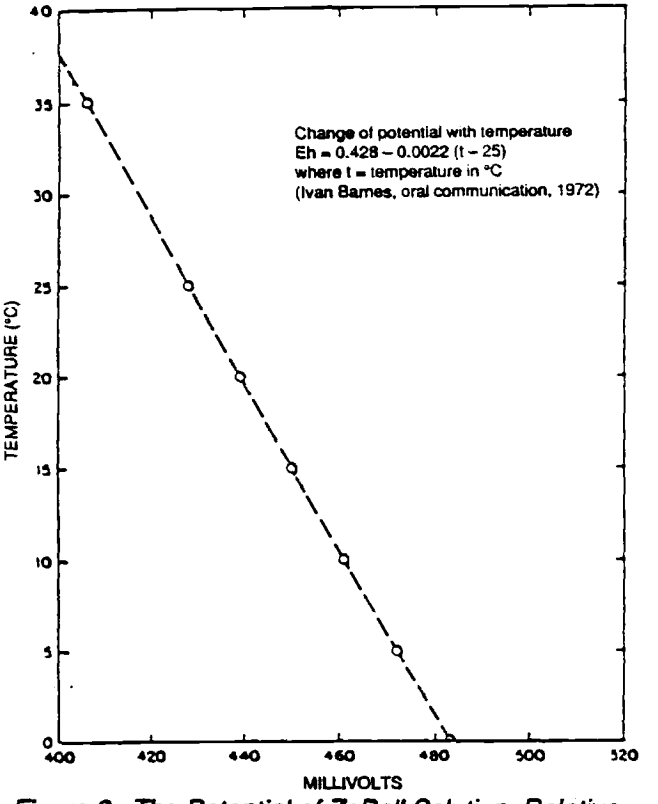

Figure 2. The Potential of ZoBell Solution, Relative to the Standard Hydrogen Electrode at Various Temperatures.

B = Observed Eh of ZoBell solution, and

C = Theoretical Eh of ZoBell solution relative to the standard hydrogen electrode.

Report D to the nearest ± 10 mV.

11. Precision and Bias

11.1 Precision and accuracy of the measurement depend largely on the condition of the electrode system and the degree to which the sample fits the interference problems mentioned in Section 5. In the absence of substances that coat or poison the electrode, the precision is ± 10 mV.

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LQ-7(T)
5/90 Rev. 0

Standard Test Method for the Field Measurement of Alkalinity

Introduction

The alkalinity of a water sample is a quantitative measurement of the ability of the sample to react with a strong acid to a designated pH. The alkalinity of natural waters is primarily a measure of the carbonate, bicarbonate, and hydroxide content. It is also a general indicator of groundwater quality.

1. Scope

1.1 This method describes the field measurement of alkalinity of aqueous samples. It is a measure of the aggregate property of the sample and can be interpreted in the terms of specific substances, such as carbonate and bicarbonate, only when the chemical composition of the sample is known.

1.2 The sample is titrated with a standard acid solution to a designated pH, and the end point is determined by a color change of an internal indicator.

2. Hazard Analysis

2.1 This test procedure uses sulfuric acid (H_2SO_4). Sulfuric acid is a corrosive material and is a Department of Transportation (DOT)-regulated material; its hazard class is Corrosive Liquid. Avoid contact with eyes, skin, and clothing. Adequate ventilation, eye protection, and disposable gloves are required. First aid for eye and skin contact is to immediately flush with water for 15 minutes, remove contaminated clothing, and call a physician.

2.2 Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 American Public Health Association, *Standard Methods for the Examination of Water and Wastewater*, American Water Works Association, and Water Pollution Control Federation, Washington, D.C., 1980.

3.2 American Society for Testing and Materials, *Annual Book of ASTM Standards*, Section 11, Volume 11.01, 1984.

3.3 Korte, N. and D. Ealey, *Procedures for Field Chemical Analyses of Water Samples*, Technical Measurements Center, U. S. Department of Energy, Grand Junction Area Office, GJ/TMC-07(83), 1983.

3.4 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," *Techniques of Water-Resources Investigations of the United States Geological Survey*, Chapter D2, Book 1: U.S. Government Printing Office, Washington, D. C., Stock Number 024-001-02879-4, 1976.

4. Significance and Use

4.1 The alkalinity of natural water is commonly used to obtain a value for the carbonate and bicarbonate concentrations. Carbonate and bicarbonate determinations shall be made in the field at the time of sampling if the concentrations are to accurately reflect those concentrations originally present in the sample.

4.2 The following equations govern the reactions involved:

$CO_3 + H = HCO_3$ (this reaction is complete near pH 8.3),

$HCO_3 + H = H_2O + CO_2$ (this reaction is complete near pH 4.5).

The end point of pH 8.3 is determined by the color change of the phenolphthalein indicator, and the end point of the pH 4.5 is determined by the color change of the Bromocresol Green-Methyl Red indicator.

Note: If the measured pH of the sample is less than 4.5, there is no carbonate or bicarbonate alkalinity and this test method is not applicable.

5. Interferences

5.1 The measured values may include contributions from borates, phosphates, or silicates if these are present in the sample.

5.2 Natural color or the formation of precipitate while titrating the sample may mask the color change of the indicator, or waste materials may interfere chemically with the color change by destroying the indicator.

5.3 Varying results may be experienced with samples containing oxidizing or reducing substances.

6. Apparatus

6.1 Hach alkalinity test kit Model AL-DT. (This kit contains sulfuric acid which is a DOT-regulated material; its hazard class is Corrosive Liquid.)

6.2 Distilled or deionized water in a squeeze bottle.

6.3 Kimwipes® or equivalent lint-free tissue.

7. Procedure

7.1 Attach a clean, straight-stem delivery tube to a sulfuric acid titration cartridge. If the expected alkalinity is below 100 milligrams per liter (mg/L) as $CaCO_3$, use a 0.16 N H_2SO_4 cartridge; if it is above 100 mg/L as $CaCO_3$, use a 1.6 N H_2SO_4 cartridge; or if it is above 1,000 mg/L, use a 8.0 N H_2SO_4 cartridge. Twist the cartridge onto the titrator body.

7.2 Flush out the delivery tube by turning the small knob until a few drops of titrant are ejected from the tube. Wipe the tip and reset the counter to zero. Ensure that there are no air bubbles in the cartridge.

7.3 Take a sample by filling a clean 100-mL graduated cylinder to the 100-mL mark with water that has been filtered through a 0.45 micrometer (µm) filter. Pour the sample into a clean 250-mL Erlenmeyer flask.

7.4 Measure the pH of the sample, see Standard Test Method for the Field Measurement of pH [LQ-4(T)]. If the pH of the sample is less than 8.3, proceed to step 7.8; if the pH of the sample is greater than 8.3, proceed to step 7.5.

7.5 Add the contents of one Phenolphthalein Indicator Powder Pillow and swirl to mix.

7.6 If the color turns pink, titrate with the sulfuric acid standard solution to a colorless end point. If the pink color does not develop, proceed with step 7.8.

7.7 Read and record the amount of acid used. This is the amount of carbonate alkalinity, sometimes referred to as phenolphthalein alkalinity. See Section 8 for calculations.

7.8 Add the contents of one Bromocresol Green-Methyl Red Indicator Powder Pillow to the sample and swirl to mix.

7.9 Titrate the sample with the sulfuric acid standard solution until a light pink color is obtained. Read and record the amount of acid used. This is the amount of total alkalinity. See Section 8 for calculations.

7.10 Pour the titrated sample into a properly labeled disposal container, rinse the Erlenmeyer flask and the graduated cylinder with distilled or deionized water, and place the items back in the kit.

8. Calculations

8.1 The results are reported in mg/L of $CaCO_3$. The calculation depends on the normality of the sulfuric acid titration cartridge used. The calculations are performed as follows.

8.1.1 When using the 0.16 N H_2SO_4 titration cartridge, the digital readout from the titrator is multiplied by 0.1 to obtain alkalinity results in mg/L as $CaCO_3$.

8.1.2 When using the 1.6 N H_2SO_4 titration cartridge, the results from the digital readout of the titrator are equivalent to mg/L as $CaCO_3$

8.1.3 When using the 8.0 N H_2SO_4 titration cartridge, the results from the digital readout of the

titrator are multiplied by 5.0 to obtain alkalinity in mg/L as $CaCO_3$.

9. Quality Assurance

9.1 The following information about the field measurement of alkalinity shall be logged for quality-assurance documentation.

9.1.1 Normality of the titration cartridge.

9.1.2 Phenolphthalein alkalinity.

9.1.3 Total alkalinity.

9.1.4 Name of person performing the measurement.

10. Precision and Bias

10.1 Under normal conditions, precision and accuracy of ± 15 percent can be expected from this procedure.

Standard Test Method for the Field Measurement of Temperature

Introduction

Temperature readings are important for numerous applications. They are used in the measurement of Eh, pH, conductivity, and dissolved oxygen; and in saturation and stability studies. It is important to know the temperature of surface waters and groundwaters for the accurate geochemical evaluation of equilibrium thermodynamics. Temperature readings of ± 1 °C are necessary for the above applications.

1. Scope

1.1 This procedure gives general guidance and recommendations that shall be considered when taking a temperature measurement. There are numerous instruments on the market that can provide adequate temperature measurements. Each instrument-operating manual shall be consulted for detailed procedures.

2. Hazard Analysis

2.1 No hazards requiring controls have been identified. Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 American Public Health Association, *Standard Methods for the Examination of Water and Wastewater*, American Water Works Association, and Water Pollution Control Federation, Washington, D.C., 1980.

3.2 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," *Techniques of Water-Resources Investigations of the United States Geological Survey*, Chapter D2, Book 1: U.S. Government Printing Office, Washington, D. C., Stock Number 024-001-02879-4, 1976.

4. Significance and Use

4.1 Temperature is a basic physical property that is measured by the response of matter to heat. There are many devices that, once calibrated, are acceptable for taking temperature measurements. These devices include liquid in glass (mercury in glass), thermocouples, bimetallic, and electrical-resistance thermometers. At a minimum, the device should measure temperature to ± 0.1 °C readability.

5. Interferences

5.1 The instrument-operating manual shall be consulted to identify any interferences particular to the device being used.

5.2 In general, the true sample temperature is affected by the atmospheric temperature of the surroundings and the temperature of the devices used to collect the sample.

6. Apparatus

6.1 Temperature-measuring device.

6.2 Distilled or deionized water in a squeeze wash bottle.

6.3 Kimwipes® or equivalent lint-free tissue.

7. Calibration

7.1 The instrument-operating manual shall be consulted for specific calibrating procedures.

8. Procedure

8.1 Rinse the thermometer with distilled or deionized water and blot dry.

8.2 Immerse the thermometer in the sample.

8.3 Allow the reading to stabilize and record the temperature.

9. Quality Assurance

9.1 The following information about the temperature measurement shall be logged for quality-assurance documentation.

9.1.1 Instrument used.

9.1.2 Temperature of sample.

9.1.3 Name of person performing the measurement.

10. Precision and Bias

10.1 Precision is instrument-dependent. Most measurement devices for field use are accurate to ± 0.1 °C.

SITE SPECIFIC PROCEDURE CHANGE or NOTICE

PROCEDURE Standard Test Method for the Field Measurement of Dissolved Oxygen

PROJECT or SITE Air Force Plant 4

8. Procedure

8.1.2 The standard test method states: "Move the probe through the water or pump through a flow cell to ensure a velocity of at least 1 foot per second past the probe." At AFP4, a YSI stirring device will be attached directly to the tip of the sampling probe that guarantees a minimum velocity of at least 1 foot per second. A separate flow cell, designed to prevent atmospheric contact with the sample stream, and incorporating the probe and stirrer will be used to take the measurements.

Standard Test Method for the Field Measurement of Dissolved Oxygen

Introduction

Dissolved oxygen (DO) is required for the survival and growth of many aquatic organisms and the absence of dissolved oxygen may permit anaerobic decay of organic matter and the production of toxic and esthetically undesirable materials in the water. The measurement of dissolved oxygen is needed to accurately characterize the oxidation-reduction potential of a hydrologic system and can be an indicator of atmospheric contact of water before recharge to an aquifer.

1. Scope

1.1 This method contains the field procedures used to determine dissolved oxygen in aqueous samples using a polarographic technique with a membrane-covered electrode. The probe method is much more rapid and efficient than other methods, has fewer interferences, and can be used for continuous monitoring.

2. Referenced Documents

2.1 American Public Health Association, American Water Works Association, and Water Pollution Control Federation, *Standard Methods for the Examination of Water and Wastewater: American Public Health Association*, Washington, D.C., 1980.

2.2 American Society for Testing and Materials, *Annual Book of ASTM Standards*, Section 11, Volume 11.01, 1984.

2.3 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," *Techniques of Water-Resources Investigations for the United States Geological Survey*, Chapter D2, Book 1: U.S. Government Printing Office, Washington, D.C., Stock Number 024-001-02879-4, 1976.

2.4 Korte, N. and D. Ealey, *Procedures for Field Chemical Analyses for Water Samples*, Technical Measurements Center, U.S. Department of Energy, Grand Junction Area Office, GJ/TMC-07(83), 1983.

3. Hazard Analysis

3.1 This test method uses sodium sulfite and cobaltous chloride for the preparation of the zero-oxygen check solution. These chemicals are toxic in the concentrated form and the following precautions must be taken in the preparation of this solution. Avoid contact with the eyes and skin. Avoid breathing suspended particles. Adequate ventilation, eye protection, and disposable gloves are required. First aid for eye contact is to flush the eyes with water for 15 minutes and contact a physician. First aid for skin contact is to wash the area thoroughly with soap and water.

3.2 Site-specific controls are available in the planning documents for a particular project.

4. Significance and Use

4.1 Oxygen-sensitive membrane electrodes are composed of two solid metal electrodes separated from the sample by an oxygen-permeable membrane. The membrane serves as a diffusion barrier against impurities. The rate of oxygen diffusion across the membrane creates a current that is directly proportional to the amount of dissolved oxygen in the sample. This current is converted to concentration units during the calibration.

5. Interferences

5.1 Membrane electrodes are sensitive to temperature variations. Most DO meters have automatic temperature compensators that correct for these variations. If not, thermal equilibrium must be established between the sample being measured and the calibrating solution.

5.2 Oxygen-permeable membranes are also permeable to other gases that can affect the measurement. Chlorine and hydrogen sulfide will eventually desensitize the probe during long-term exposures. These gases are not normally found in groundwater samples, or their concentrations are too small to cause significant problems.

5.3 Because atmospheric oxygen is rapidly absorbed by water samples, use of an air-exclusion

chamber is required if in situ measurements cannot be made.

6. Apparatus

6.1 Dissolved oxygen meter, Yellow Springs Instruments (YSI) Model 57.

6.2 Yellow Springs Instruments (YSI) 5739 dissolved-oxygen probe.

6.3 Bottle of electrolyte and extra membranes for probe.

6.4 Sodium sulfite and cobaltous chloride.

6.5 Distilled or deionized water in a squeeze wash bottle.

6.6 Kimwipes® or equivalent lint-free tissue.

6.7 Flow cell, see Standard Practice for the Use of a Flow Cell for Field Measurements [LQ–10(T)].

7. Calibration

7.1 The following steps describe the calibration of the YSI Model 57 meter and the YSI 5739 probe in water-saturated air.

7.1.1 Adjust the mechanical ZERO with the instrument turned OFF.

7.1.2 Turn the control knob to the "red line" position and adjust if necessary.

7.1.3 Plug probe into instrument and wait about 15 minutes for the probe to polarize.

7.1.4 Turn the control knob to ZERO and adjust if necessary.

7.1.5 Turn the salinity knob to FRESH. A salinity correction will not be needed because the calibration is performed with distilled water.

7.1.6 Insert the probe about 4 centimeters (cm) into the open end of the bottomless plastic storage bottle containing a small sponge soaked with deionized water. Ensure that there is a tight fit between the probe and bottle and that there are no droplets of water on the probe membrane.

7.1.7 Allow at least 10 minutes for the system to reach constant temperature and 100 percent relative humidity. Be careful that this step is carried out in a constant temperature environment. Typically, bathe the bottle in a stream of the water to be tested, or at least keep the bottle in the shade during equilibration.

7.1.8 Turn the meter control knob to TEMP position and read the temperature inside the bottle to the nearest 0.5 °C.

7.1.9 Determine the DO saturation value in part per million (ppm) for that temperature from Table 1.

7.1.10 Determine the correction factor from Table 2 on the basis of either the atmospheric pressure (most accurate method) or the altitude

Table 1. Dissolved Oxygen Saturation Values at Various Temperatures

Temp (°C)	Sat. Value (ppm)	Temp (°C)	Sat. Value (ppm)	Temp (°C)	Sat. Value (ppm)	Temp (°C)	Sat. Value (ppm)
0	14.6	12	10.8	35	8.5	36	7.0
1	14.2	13	10.6	25	8.6	37	6.8
2	13.9	14	10.4	26°	8.2	38	6.7
3	13.5	15	10.2	27	8.1	39	6.6
4	13.2	16	9.9	28	7.9	40	6.5
5	12.8	17	9.7	29	7.8	41	6.4
6	12.5	18	9.5	30	7.7	42	6.3
7	12.2	19	9.3	31	7.5	43	6.2
8	11.9	20	9.2	32	7.4	44	6.1
9	11.6	21	9.0	33	7.3	45	6.0
10	11.3	22	8.8	34	7.2		
11	11.1	23	8.7	35	7.1		

above sea level. (Tables 1 and 2 are also available on the back of the YSI 57).

Table 2. Correction Factors for Dissolved Oxygen Saturation Values as Determined by Pressure or Altitude

Pressure (mm)	Altitude (ft)	Correction Factor
775	-540	1.02
760	0	1.00
745	542	0.98
730	1094	0.96
714	1688	0.94
699	2274	0.92
684	2864	0.90
669	3466	0.88
654	4082	0.86
638	4756	0.84
623	5403	0.82
608	6065	0.80
593	6744	0.78
578	7440	0.76
562	8204	0.74
547	8939	0.72
532	9694	0.70
517	10472	0.68
502	11272	0.66

7.11 Multiply the correction factor by the saturation value to obtain the calibration value.

7.12 Turn the meter control knob to the desired range and adjust the calibration knob to set the meter to the calibration value.

7.13 Perform zero oxygen check as follows. Prepare a solution containing 1 gram of sodium sulfite (Na_2SO_3) and about 1 milligram of cobaltous chloride ($CoCl_2$) in 1 liter of deionized water. Insert the probe into this solution and measure the dissolved oxygen. The instrument will read less than 0.2 milligram per liter (mg/L) if the probe is functioning properly.

Caution: These chemicals are toxic in the concentrated form. Avoid eye and skin contact by wearing eye protection and disposable gloves.

7.14 Leave the meter turned on during the entire day on which measurements are being taken.

Note: If the high sensitive membrane (0.0005-inch thick FEP Teflon®) is being used on the probe, the DO readings from the meter must all be divided by 2 to obtain the true DO value.

8. Procedure

8.1 The following steps outline the field measurement of dissolved oxygen using the YSI Model 57.

8.1.1 Remove the probe from the storage bottle and place it in the solution to be measured. An in situ measurement is preferred. If the sample is being pumped from a well, the measurement shall be made in an air-exclusion cell.

8.1.2 Move the probe through the water or pump through a flow cell to ensure a velocity of at least 1 foot per second past the probe. This prevents depletion of oxygen at the membrane-water interface.

8.1.3 Turn the meter control knob to TEMP position and record the temperature to the nearest 0.5 °C.

8.1.4 Turn the meter control knob to the proper DO scale; after the meter reading has stabilized, record DO concentration to the nearest 0.1 mg/L.

Note: If the the high-sensitive membrane (0.0005-inch thick FEP Teflon®) is being used, the readings need to be divided by 2 to obtain the DO concentration.

8.1.5 Remove the probe, rinse with distilled water, blot dry, and return the probe to the storage bottle.

9. Quality Assurance

9.1 The following information about the field measurement of dissolved oxygen shall be logged for quality-assurance documentation:

9.1.1 Date and time zero check was last performed.

9.1.2 Atmospheric pressure or altitude.

9.1.3 Temperature of calibration chamber.

9.1.4 DO saturation from table.

9.1.5 Correction factor used for altitude or pressure.

9.1.6 Calibration value.

9.1.7 Sample temperature.

9.1.8 Measured DO.

9.1.9 Instrument manufacturer and model number.

9.1.10 Name of person performing the measurement.

10. Precision and Bias

10.1 Under normal conditions, precision an accuracy of ± 0.5 mg/L can be expected from this procedure.

Standard Practice for the Use of a Flow Cell for Field Measurements

Introduction

Reliable field measurements are an essential part of a groundwater sampling program. Some properties or constituents in groundwater may change considerably within a few minutes of collection. These changes are caused by turbulence, heating or cooling, depressurization, and gas exchange with the atmosphere. Use of a closed flow-through cell will minimize these changes.

1. Scope

1.1 This procedure describes the use of a closed flow-through cell for monitoring selected chemical parameters in groundwater. The cell is used when monitoring the purging of stagnant water from monitoring wells prior to sample collection and for the measurement of pH, Eh, conductivity, temperature, and dissolved oxygen under conditions as close to in situ as practical. A flow-through cell can be purchased from various suppliers or can be constructed as described in references 3.1 and 3.2.

2. Hazard Analysis

2.1 No hazards requiring controls have been identified. Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 Garske, E., and R. Schock, "An Inexpensive Flow-Through Cell and Measurement System for Monitoring Selected Chemical Parameters in Ground Water," *Ground Water Monitoring Review*, Summer 1986.

3.2 Korte, N., and D. Ealey, *Procedures for Field Chemical Analyses of Water Samples*, Technical Measurements Center, U.S. Department of Energy, Grand Junction Area Office, GJ/TMC–07(83), 1983.

3.3 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples for Selected Unstable Constituents," Chapter D2 in *Techniques of Water-Resources Investigations of the United States Geological Survey*, Book 1, 1976.

4. Significance and Use

4.1 Flow cells allow the sampler to obtain test results that are more representative of conditions found in the water when it resided in the ground. That is, fewer chemical and physical changes occur if the test is made immediately through a flow cell than if the water is exposed to air and to a longer period of time before measurements are made.

5. Apparatus

5.1 Flow-through cell.

5.2 Stoppers, fittings, valves, and tubing, as required.

6. Procedure

6.1 Connect the pump outlet to the inlet of the flow cell.

6.2 Insert calibrated electrodes into the flow cell.

6.3 Turn on the pump and pump the water through the flow cell and into a container where the pH buffers and other calibrating solutions are submerged to allow them to reach the sample-water temperature. Another technique to get calibrating solutions close to sample temperature is to store the solutions in an ice chest with ice. The requirement is to have the calibrating solutions within ±10 degrees of the sample temperature.

6.4 Once temperature equilibrium has been established between the sample water, electrodes, and calibrating solutions, the electrodes shall be recalibrated.

6.5 Recheck electrode calibration as necessary during the purging of the well and just prior to sampling.

6.6 Turn off the pump, disconnect the tubing, and remove the electrodes form the flow cell.

6.7 Clean the flow cell with distilled water and prepare for sample collection.

7. Procedure Bias

7.1 The flow rate through the cell shall not be more than 1 liter per minute (L/m). If flow rates exceed 1 L/m, streaming potentials could occur. Streaming potentials are caused by the static-charge effect of water moving through small openings. These potentials can cause erroneous pH readings. If necessary, reduce the flow rate or stop pumping to take readings.

7.2 The cell assembly, electrodes, and hoses should be insulated or kept out of direct sunlight to reduce the effect of atmospheric temperature on the readings.

8. Quality Assurance

8.1 The use of a closed flow-through cell should be noted on the sample documentation form or in the field logbook.

SITE SPECIFIC PROCEDURE CHANGE or NOTICE

PROCEDURE Standard Practice for the Sampling of Liquids

PROJECT or SITE Air Force Plant 4

Sampling of Liquids Using Bailers - Support Line

Bailers used for monitor well sampling or purging shall be lowered and raised with a Teflon coated, stainless steel braided line. This line will be decontaminated after use at each well following the methods outlined in Section A-13. If the fluid level measurements taken prior to sampling indicate the presence of a light nonaqueous phase liquid (LNAPL), a disposable nylon line shall be used for bailing operations and disposed of upon completion of activity at each well.

Standard Practice for the Sampling of Liquids

Introduction

The type of sampling equipment shall depend on the sample to be collected, which analytes the sample is being collected for, and the site-specific requirements such as depth to water, depth of well, etc. Because each sampling situation is unique, the equipment used and its application may have to be modified to ensure that a representative sample is collected and its physical and chemical integrity is maintained.

1. Scope

1.1 The procedures listed here are used to collect liquid samples. There are eight methods that can be used to collect liquid samples. Some sampling situations use a combination of these methods. For example, a peristaltic pump could be used to collect the inorganic samples and a bailer used to collect the organic samples. The eight methods are:

	Section
Method A—Sampling With a Peristaltic Pump	5–7
Method B—Sampling With a Bladder Pump	8–10
Method C—Sampling With a Bailer	11–13
Method D—Sampling With a Submersible Pump	14–16
Method E—Sampling With a Composite Liquid Waste Sampler (COLIWASA)	17–19
Method F—Sampling With a Dip-Type Sampler	20–22
Method G—Sampling by Container Immersion	23–25
Method H—Sampling From Taps, Valves, or Faucets	26–28

Method A
Sampling With a Peristaltic Pump

2. Hazard Analysis

2.1 These procedures use gasoline-powered electric generators, gasoline-powered air compressors, and battery-powered pumps and accessories. The following safety precautions shall be followed.

2.1.1 Air compressors that are belt-driven shall have a belt guard in place.

2.1.2 Care shall be taken when connecting and disconnecting equipment powered by lead-acid batteries so as not to generate sparks that have the potential of creating an explosive hazard.

2.1.3 Gasoline is a Department of Transportation-regulated material; its hazard class is Flammable Liquid. Gasoline shall be stored in Factory Mutual-approved safety cans. Safety cans shall be well secured in the vehicle during transport. Gasoline-powered equipment shall be cool before filling, and care should be taken not to spill any gasoline.

2.1.4 Air compressors shall not be operated above rated capacities and shall be configured so as not to have any dead-end fittings above 20 pounds per square inch (psi).

2.1.5 Care shall be taken when lifting heavy equipment; proper lifting techniques shall be used.

2.1.6 Site-specific controls are available in the planning documents for a particular site.

3. Referenced Documents

3.1 American Society for Testing and Materials, *Standard Guide for Sampling Groundwater Monitoring Wells*, D4448–85a, 1986.

3.2 U.S. Department of Energy, The *Environmental Survey Manual*, Appendix E, Volume 4, DOE/EH–0053, 1987.

3.3 U.S. Environmental Protection Agency, *Handbook Groundwater*, EPA/625/6–87/016, 1987.

3.4 U.S. Environmental Protection Agency, *Practical Guide for Groundwater Sampling*, EPA/600/2–85/104, 1985.

3.5 U.S. Environmental Protection Agency, *Test Methods for Evaluating Solid Waste* (SW–846), Volume 2, 1986.

4. Significance and Use

4.1 The usefulness and limitations for each of the first four sampling methods are listed in

General Considerations for the Sampling [LQ–1(G)], Table 1 through Table 5. COLIWASA samplers are useful to obtain representative samples of multiphase materials from drums or other containerized vessels. Limitations are their relative high costs and the difficulty of decontaminating the sampler. Dip samplers only collect grab samples with a limited vertical extent. The sampler must be aware of this limitation and also exclude surface debris or films from liquid surfaces if this is not desired. Contamination from plumbing is a primary concern when sampling taps, valves, or faucets.

5. Apparatus

5.1 Peristaltic-type pump.

5.2 Silicone, C-FLEX®, or Norprene® tubing for the pump head.

5.3 Silicone, Teflon®, polyethylene, or vinyl tubing for placing in the liquid to be sampled (suction line).

5.4 Generator or other source of electricity.

6. Procedure

6.1 The following procedure supplements the instruction in the instrument-specific operating manual.

6.1.1 Place the suction line in the liquid to be sampled. If sampling a monitoring well, place the tubing inlet just above the screened interval.

6.1.2 Connect the suction line to the pump.

6.1.3 Turn on the pump and adjust the flow rate so sample turbulence is at a minimum. Allow several liters to flow and recheck stability parameters (i.e., pH, conductivity, and temperature).

6.1.4 Fill the necessary sample bottles by allowing the pump discharge to flow gently down the side of the bottle with minimal turbulence.

6.1.5 Label, preserve, and document the samples as required.

6.1.6 Remove the tubing from the liquid and clean and decontaminate as required.

7. Procedure Bias

7.1 Sampling organics using a peristaltic pump is not recommended. The suction lift action will strip volatiles and degas the sample. The silicone tubing tends to absorb some organics and slowly release them, contaminating subsequent samples.

Method B
Sampling With a Bladder Pump

8. Apparatus

8.1 Bladder-type pump.

8.2 Air compressor.

8.3 Teflon®, polyethylene, or vinyl tubing for the air and sample line.

9. Procedure

9.1 The following procedure is supplemental to the instruction in the instrument-specific operating manual.

9.1.1 Lower the pump gently to a position just above the screened interval.

9.1.2 Connect the air line to the pump controller.

9.1.3 Initiate pumping and allow several liters of water to be pumped prior to sample collection (recheck stability parameters, i.e., pH, conductivity, and temperature).

9.1.4 Fill the necessary sample bottles by allowing the pump discharge to flow gently down the side of the bottle with minimal turbulence.

9.1.5 Label, preserve, and document the samples as required.

9.1.6 Remove the pump from the well, clean and decontaminate as required.

10. Procedure Bias

10.1 Bladder-type pumps constructed of stainless steel, Teflon®, or both provide superior performance for most applications. The use of Teflon® sample- and air-line tubing allows the bladder

pump to be used for the collection of organics. The main disadvantage is the slow pumping rate, large consumption of compressed air, and difficulty in cleaning and decontaminating.

Method C
Sampling With a Bailer

11. Apparatus

11.1 Teflon® or stainless steel bailer.

11.2 Teflon® or stainless steel cable or line.

11.3 Bailer reel.

12. Procedure

12.1 Attach a properly cleaned bailer to the cable or line.

12.2 Lower the bailer slowly until it contacts the liquid.

12.3 Allow the bailer to sink until it reaches the screened interval of the well or the desired sampling point.

12.4 Slowly raise the bailer to the surface.

12.5 Tip the bailer or use a bottom-emptying device and fill a container to recheck the stability parameters (i.e., pH, conductivity, and temperature).

12.6 Repeat steps 12.2 through 12.5 as many times as necessary to fill the sample bottles.

12.7 Label, preserve, and document the samples as required.

12.8 Clean and decontaminate the bailer as required.

13. Procedure Bias

13.1 Bailers constructed of Teflon®, stainless steel, or both provide adequate performance for most applications. Bailers expose part of the sample to the atmosphere during sample withdrawal and should not be used to collect samples where contact with the atmosphere is important (i.e., field measurement of dissolved oxygen and Eh). A bottom-emptying device is recommended for the collection of volatile organics using a bailer.

Method D
Sampling With a Submersible Pump

14. Apparatus

14.1 Submersible-type pump.

14.2 Discharge tubing of vinyl, polyethylene, or Teflon®.

14.3 Power source of generator or batteries.

15. Procedure

15.1 The following procedure is supplemental to the instructions provided in the instrument-specific operating manual.

15.1.1 Set up the pump according to the operating manual.

15.1.2 Gently lower the pump to a position just above the screened interval.

15.1.3 Initiate pumping and allow several tubing volumes of liquid to be pumped prior to sample collection. Recheck stability parameters, (i.e., pH, conductivity, and temperature).

15.1.4 Fill the necessary sample bottles by allowing the pump discharge to flow gently down the side of the bottle with minimal turbulence.

15.1.5 Label, preserve, and document the samples as required.

15.1.6 Remove the pump, clean and decontaminate as required.

16. Procedure Bias

16.1 Considerable sample agitation results when using a submersible pump. Submersible pumps are not recommended for the collection of dissolved gases, organics, or oxidation/reduction-sensitive samples. They also have a higher potential of sample contamination because of the construction material.

Method E
Sampling With a COLIWASA Sampler

17. Apparatus

17.1 COLIWASA-type sampler constructed of stainless steel, Teflon®, polyethylene, or glass.

17.2 Teflon®, stainless steel, or nylon suspension line.

17.3 Disposable gloves.

17.4 Kimwipes® or equivalent lint-free tissue.

18. Procedure

18.1 Slowly lower the sampler into the liquid to be sampled. Lower the sampler at a rate that permits the levels of liquid inside and outside the sample tube to be about the same.

18.2 When the sample interval has been reached, seat the bottom check valve.

18.3 Slowly withdraw the sampler with one hand while wiping the outside of the sampler using a disposable tissue.

18.4 Carefully discharge the sample into the sample container.

18.5 Repeat steps 18.1 through 18.4 as many times as necessary to fill all the sample bottles.

18.6 Clean and decontaminate the sampler as required.

19. Procedure Bias

19.1 The COLIWASA-type sampler is appropriate for collecting samples of containerized liquids. The material of construction should be considered for the particular type of liquid to be sampled. A COLIWASA sampler is also difficult to decontaminate adequately.

Method F
Sampling With a Dip-Type Sampler

20. Apparatus

20.1 Dip-type sampler constructed of Teflon®, stainless steel, polyproplylene, or glass.

21. Procedure

21.1 Assemble the sampler.

21.2 Slowly submerge the sampler into the liquid to be sampled causing minimal surface disturbance.

21.3 Retrieve the sampler from the liquid causing minimal surface disturbance.

21.4 Slowly empty the sampler into the sample bottle allowing the sample to flow gently down the side of the bottle.

21.5 Repeat steps 21.2 through 21.4 as many times as necessary to fill all of the sample bottles.

21.6 Clean and decontaminate the sampler as required.

22. Procedure Bias

22.1 A dip-type sampler is appropriate for surface liquids such as ponds, open tanks, pits, lagoons, and sewers. It can only be used for a grab-type sample, and its material of construction shall be compatible with the liquid to be sampled and the analytes of interest.

Method G
Sampling by Container Immersion

23. Apparatus

23.1 Sample container.

23.2 Disposable gloves.

23.3 Distilled or deionized water in a squeeze bottle.

23.4 Kimwipes® or equivalent lint-free tissue.

24. Procedure

24.1 After putting on the appropriate gloves, submerge the sample bottle below the liquid surface. If the liquid is flowing, point the bottle upstream.

24.2 Allow the container to fill to the desired volume.

24.3 Remove the container, cap and rinse the container's outside surface with clean water, and dry with a tissue.

24.4 Label and preserve the sample as required.

25. Procedure Bias

25.1 The container-immersion method can only be used to collect samples from shallow streams, near the shore of ponds or lakes, or from open-top containerized liquids. It can only be used for a grab-type sample and requires immersing the hands; it is not acceptable for highly polluted or hazardous liquids.

Method H
Sampling From Taps, Valves, or Faucets

26. Apparatus

26.1 Distilled or deionized water in a squeeze bottle.

26.2 Kimwipes® or equivalent lint-free tissue.

26.3 If the sample bottle cannot be placed under the tap, valve, or faucet, a hose or other device shall be attached to the outlet to allow the sample to be collected.

27. Procedure

27.1 Turn on the tap, valve, or faucet and allow sufficient liquid to flow to ensure that any rust or residue is removed from the lines and that fresh liquid is flowing.

27.2 Remove the cap from the sample container and place the container under the source.

27.3 Fill the sample bottle to the desired volume.

27.4 Repeat steps 27.2 and 27.3 as many times as necessary to fill all of the sample containers.

27.5 Shut off the tap, valve, or faucet; clean the outside of the sample container using clean water and wipe dry.

27.6 Label, preserve, and document the sample as required.

28. Procedure Bias

28.1 This procedure is used to collect grab-type samples from piped systems. Strainers, aerators, and hose attachments should be removed prior to sample collection. The material of construction for the piping system influences sample impurities and should be documented in the field logbook.

29. Quality Assurance

29.1 All of the methods listed above require the following information to be logged for quality-assurance documentation.

29.1.1 Date of sample collection.

29.1.2 Location of sample.

29.1.3 Sample number.

29.1.4 Type of sampling mechanism used.

29.1.5 Container type, size, and number of samples collected.

29.1.6 Preservatives used.

29.1.7 Signature of sampler.

SITE SPECIFIC PROCEDURE CHANGE or NOTICE

PROCEDURE Standard Practice for the Collection, Filtration, and Preservation of Liquid Samples

PROJECT or SITE Air Force Plant 4

Sampling For Total Metals

Whenever a "metals" or "total metals" sample is specified in the Work Plan (Volume I) or Sampling and Analysis Plan (Volume II), a total metals (unfiltered) sample will always be collected. If a dissolved metals (filtered) sample is needed for geochemical modeling purposes, a dissolved metals sample will be collected in addition to the total metals sample.

Standard Practice for the Collection, Filtration, and Preservation of Liquid Samples

Introduction

Many factors should be considered during the sample-collection phase. These factors include bottle type, bottle size, preservative, whether the sample should be filtered or not, in what order the samples should be collected, etc. The procedures listed here are general guidelines. Site-specific requirements vary and no one procedure will fit all situations. In many cases, the judgment of a well-trained, experienced team leader is required to make the necessary decisions in the field to obtain the best sample possible and meet all requirements.

1. Scope

1.1 This procedure covers the collection, filtration, and preservation of liquid samples. Section 6 gives the general collection procedures. Sections 7 and 8 are specific for the collection of organics. Section 9 provides the procedure for sample filtration. Section 10 provides procedures for sample preservation and Table 1 summarizes the generally accepted bottle types, volume requirements, preservatives, and holding times for most analytes. It shall be noted that the analytical laboratory providing the analytical support in most cases will determine the bottle type, volume, and preservative needed for a particular sampling event.

	Section
General Sample Collection Procedures	6
Sampling for Non-Volatile Organics	7
Sampling for Volatile Organics	8
Sample Filtration Procedure	9
Sample Preservation Procedure	10

2. Hazard Analysis

2.1 This procedure uses a variety of chemicals for preserving the samples. The sampler shall have a copy of and review the Material Safety Data Sheets (MSDSs) for each of the chemicals that will be used at a particular site. Most of the preservatives can be categorized as strong acids or strong bases. These are Department of Transportation (DOT)-regulated materials; their hazard class is Corrosive.

2.2 The personal protective measures for strong acids (hydrochloric acid, nitric acid, and sulfuric acid) are to avoid eye and skin contact, provide adequate ventilation, wear eye protection, and wear disposable gloves. Use baking soda to neutralize spills. First aid measures are to flush immediately with water for 15 minutes and contact a physician.

2.3 The personal protective measures for strong bases (such as sodium hydroxide) are to avoid eye and skin contact, provide adequate ventilation, wear eye protection, and wear disposable gloves. First aid measures are to flush immediately with water for 15 minutes and contact a physician.

2.4 Site-specific controls are available in the planning documents for a particular project.

3. Referenced Documents

3.1 American Public Health Association, American Water Works Association, and Water Pollution Control Federation, *Standard Methods for the Examination of Water and Wastewater: American Public Health Association*, Washington, D.C., 1980.

3.2 American Society for Testing and Materials, *Annual Book of ASTM Standards*, 1984, Section 11, Volume 11.01, 1984.

3.3 Korte, N. and D. Ealey, *Procedures for Field Chemical Analyses of Water Samples*, Technical Measurements Center, U. S. Department of Energy, Grand Junction Area Office, GJ/TMC-07(83), 1983.

3.4 U.S. Department of Energy, *The Environmental Survey Manual*, Appendix E, Volume 4, DOE/EH-0053, 1987.

3.5 U.S. Environmental Protection Agency, *Practical Guide for Groundwater Sampling*, EPA/600/2-85/104, 1985.

3.6 U.S. Environmental Protection Agency, *Test Method for Evaluating Solid Waste* (SW-846), Volume 2, 1986.

3.7 Wood, W.W., "Guidelines for Collection and Field Analysis of Ground-Water Samples

for Selected Unstable Constituents," in *Techniques of Water-Resources Investigations of the United States Geological Survey*, Chapter D2, Book 1: U.S. Government, Printing Office, Washington, D. C., Stock Number 024–001–02879–4, 1976.

4. Significance and Use

4.1 Table 1 lists many of the standard methods for sample preservation and bottles that may be required for sample collection. Improper filtration, preservation, or residence time before analysis may compromise sample integrity.

5. Apparatus

5.1 Sample bottles.

5.2 Sample labels.

5.3 Preservative solutions as required by the planning documents. These solutions are DOT-regulated materials; their hazard class is Corrosive.

5.4 Dispensers for preservative solutions.

5.5 Coolers and ice for storing collected samples at 4 °C.

5.6 In-line filter holders and filters of 0.45-micrometer (µm) pore size.

6. General Sample Collection Procedures

6.1 All samples shall be collected as close to the source as possible. The order in which samples are taken for specific types of analyses is provided in Sections 6.3, 6.4, and 6.5.

6.1 Choose the appropriate bottles for the analytes needed (see Table 1). Visually inspect the bottle for cleanliness, breaks, and missing parts prior to sampling.

6.2 Label the bottles as required by the planning documents or Standard Practice for Sample Labeling [GN–2(P)].

6.3 Collect the samples by allowing the liquid to flow gently down the side of the bottle with minimal turbulence. Unfiltered samples shall be collected prior to filtered samples.

6.4 Unfiltered samples shall be collected in the following order:

6.4.1. Volatile organics and total organic halides (TOX).

6.4.2. Dissolved gases and total organic carbon (TOC).

6.4.3. Large-volume samples for organic compounds.

6.4.4. Sensitive inorganics, NO_2^-, NH_4^+, Fe(II), etc.

6.4.5. Total metals.

6.5 Filtered samples shall be collected in the following order:

6.5.1. Alkalinity.

6.5.2. Sensitive inorganics.

6.5.3. Trace metals.

6.5.4. Major cations/anions.

6.6. Add preservative as required.

6.7. Cap the bottle securely.

6.8. Store as required. Some samples may require storing at 4 °C immediately after collection. An ice chest with ice shall be used for storage.

7. Sampling for Non-Volatile Organics

7.1 Samples for non-volatile organics are collected directly into the sample container. The container shall be cleaned to U.S. Environmental Protection Agency (EPA) standards or purchased from a distributor that has cleaned them to EPA standards (i.e., I-CHEM). Do not filter samples for organics.

7.1.1 Choose the appropriate bottle for the analyte requested.

7.1.2 Label the bottle as required by the planning documents or other sections of this manual.

7.1.3 Add preservative to the bottle, if required.

7.1.4 Slowly fill the bottle by allowing the liquid to flow gently down the side of the bottle with minimal turbulence.

7.1.5 Cap the bottle securely.

7.1.6 Store as required. Most organic samples require storage at 4 °C.

8. Sampling for Volatile Organics.

8.1 When sampling for volatile organics, special care shall be taken when collecting the sample to reduce the possibility of losing the volatile

Table 1. Guidelines for Preservation of Samples

Analytical Parameter	Container Type/Size[a]	Preservation
Inorganic Anions		
Chloride, sulfate, nitrate, fluoride, bromide, nitrite, and ortho-phosphate	P (500 mL)	Filtered 0.45 µm, cool to 4 °C
Ammonia	P (125 mL)	Filtered 0.45 µm, H_2SO_4 pH <2
Inorganic Cations		
Dissolved metals	P (500 mL)	Filtered 0.45 µm, HNO_3 pH <2
Total metals	P (500 mL)	HNO_3 pH <2
Radioisotopes		
U-234/U-238	P (1,000 mL)	Filtered 0.45 µm, HNO_3 pH <2
Th-230	P (1,000 mL)	Filtered 0.45 µm, HNO_3 pH <2
Po-210	P (1,000 mL)	Filtered 0.45 µm, HNO_3 pH <2
Pb-210	P (1,000 mL)	Filtered 0.45 µm, HNO_3 pH <2
Ra-226	P (1,000 mL)	Filtered 0.45 µm, HNO_3 pH <2
Ra-228	P (3 each; 1,000 mL)	Filtered 0.45 µm, HNO_3 pH <2
Gross alpha/beta	P (100 mL)	Filtered 0.45 µm, HNO_3 pH <2
Organics		
Volatile organics	G (2 each; 40 mL)	Cool to 4 °C
Semi-volatile organics	G (1,000 mL)	Cool to 4 °C
Polychlorinated biphenyls and pesticides	G (1,000 mL)	Cool to 4 °C
Herbicides	G (1,000 mL)	Cool to 4 °C
Total organic halides (TOX)	G (1,000 mL)	Cool to 4 °C
Total organic carbon (TOC)	G (125 mL)	H_2SO_4 pH <2, cool to 4 °C
Phenols	G (1,000 mL)	H_2SO_4 pH <2, cool to 4 °C
Oil and grease	G (1,000 mL)	H_2SO_4 pH <2, cool to 4 °C
Other		
Biochemical oxygen demand and chemical oxygen demand	G (1,000 mL)	Cool to 4 °C
Total dissolved solids	P (250 mL)	Filtered 0.45 µm, cool to 4 °C
Cyanide	P (1,000 mL)	NaOH pH <2, cool to 4 °C
Sulfide	P (1,000 mL)	2 mL zinc acetate, NaOH pH <2, cool to 4 °C

[a]P = polyethylene; G = glass.

constituents. Volatile organics are collected in a 40-milliliter (mL) glass vial that has a Teflon®-lined, silicone-septum lid. The procedure for collection is as follows:

8.1.1 Label the bottle.

8.1.2 Preserve as required.

8.1.3 Slowly fill the vial to overflowing.

8.1.4 Hold the container level or carefully set on a level surface.

8.1.5 Place the septum Teflon®-side down on the convex water meniscus and seal with the screw cap.

8.1.6 Test the seal by inverting the container and lightly tapping. There can be no air-bubbles entrapped in the sample. If bubbles are present, uncap the container, add additional sample, and reseal as stated above.

9. Sample Filtration Procedure

9.1 Samples requiring filtration shall be collected after unfiltered samples. To maintain closed-system conditions, an in-line membrane filter is connected directly to the pump outlet. This allows the sample to be filtered prior to atmospheric contact, which could alter the sample. A filter-pore size of 0.45 µm is used for sample filtration.

9.1.1 Connect the in-line filter directly to the pump outlet.

9.1.2 Start the pump and discard the first 100 mL of sample. This flushes the filter of any excess distilled water used during prior cleaning of the filter holder.

9.1.3 Place the sample bottles directly under the filter outlet and fill to the desired volume.

9.1.4 Preserve the sample, as required.

9.1.5 Stop the pump, and disconnect and disassemble the filter.

9.1.6 Discard the used filter and clean all surfaces of the filter holder with distilled water and wipe dry with a lint-free tissue.

9.1.8 Place a new filter in the holder and reassemble.

10. Sample Preservation Procedure

10.1 Samples are preserved by a variety of means to stabilize specific parameters so that the samples can be shipped to a laboratory for analysis. Preservatives are intended to (1) retard biological effects, (2) retard hydrolysis, (3) reduce sorption effects, and (4) reduce volatility of constituents. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. The following guidelines shall be considered during sample preservation.

10.1.1 Preservation of samples uses a variety of strong acids and bases. Care shall be taken in their storage and use. Review the Material Safety Data Sheet for each chemical. Eye protection and disposable gloves shall be worn when working with chemicals.

10.1.2 Samples shall be preserved as soon after collection as possible.

10.1.3 Care shall be taken not to cross contaminate samples with preservatives.

10.1.4 Samples requiring cooling to 4 °C shall be placed in an ice chest with wet ice immediately after collection.

10.1.5 Table 1 or the planning documents should be consulted for recommended sample-preservation techniques for each parameter. Generally, the laboratory performing the analysis shall determine the bottle type, size, and preservative to be used.

11. Quality Assurance

11.1 The following information about the sample collection, filtration, and preservation shall be logged for quality-assurance documentation.

11.1 The number and type of filter used for filtration.

11.2 The container size, container type, and number of samples collected.

11.3 Whether the sample was filtered or not.

11.4 What preservative was used to preserve the sample.

11.5 Name of person performing the sampling.

SAMPLING of SEEPS and SPRINGS

Introduction

Seeps and springs are generally, but not always, found where the surface contour intersects the water table. They can develop above the water table where infiltrated water percolates downward to a perching horizon and then migrates laterally to the intersection of that horizon and the surface contour. These areas usually have well-established microbiological populations marked by extensive moss and algal growths. These microbiological populations usually extend for some distance into the water-bearing formation (aquifer) and are generally more populous and of different species than those associated with the bulk of the aquifer. Their effect on the oxygen content, pH, nutrient, and metals concentrations in the groundwater can be extensive. Thus, the water that seeps from these areas may be substantially altered, and not represenative of the conditions deeper in the subsurface. However, seeps and springs can yield some information if the data are properly interpreted. If the area in question is without developed wells, seeps and springs are certainly worth sampling, especially because of the ease with which they can be sampled.

1. Scope

1.1 This method contains the field procedure used to collect grab samples of fluid emanating from seeps or springs. It is important to collect the sample as close to the actual seep as possible to reduce contact time with the atmosphere and potential for surface contaminants.

2. Reference Documents

1.1 U.S. Environmental Protection Agency, Characterization of Hazardous Waste Sites - A Method Manual, EPA-600/4-84-076.

1.2 U.S. Department of Energy, 1987, The Environmental Survey Manual, Appendix E, Volume 4, DOE/EH-0053

1.3 U.S. Environmental Protection Agency, Handbook Groundwater, 1987, EPA/625/6-87/016

1.4 U.S. Environmental Protection Agency, Practical Guide for Groundwater Sampling, 1985, EPA/600/2-85/104.

3. Hazard Analysis

Seeps and springs are normally found in areas where there is contour relief. Personnel should take precautions against slipping or falling. Hazardous materials may be seeping along with the water, and caution should be taken when approaching or working at a site.

4. Significance and Use

4.1 This method should be used for reconnaissance surveys of areas where seeps provide easy access to locations for aquifer sampling. Data should be examined for possible alteration of the aquifer fluids due to contact with the atmosphere or surface materials. This procedure may indicate the need for further, more accurate, aquifer sampling.

5. Interferences

Represenative water samples can be biased with the inclusion of foreign material. Fluid emanating from an aquifer interacts with surface conditions at a seep or spring by degassing dissolved gases, absorbing surface gases, mixing with surface fluids, reacting with biological agents, and mixing with surface solids.

6. Procedure

6.1 Using a stainless steel scoop (such as those used in ice machines), press the bottom of the scoop against the bank. With very little additional disturbance, water will flow into the scoop.

6.2 Retrieve the scoop from the seep with minimal disturbance.

6.3 Remove the cap from the sample container and slightly tilt the mouth of the sample container.

6.4 Empty the scoop into the sample container, allowing the sample fluid to flow down the side of the bottle with minimal entry disturbance.

6.5 Allow adequate space for expansion if required, add preservatives if required, and secure the container lid.

6.6 Label the sample container with the appropriate sample tag.

6.7 Properly clean and decontaminate the sampling equipment for the next sample.

Groundwater Sampling From Open Soil Borings

Procedure

Groundwater samples will be taken from boreholes drilled for the collection of subsurface soil samples. Upon completion of soil sample collection, the borehole will be drilled in five foot increments to bedrock or the top of the first confining layer. After each five foot section has been drilled, the center rod will be pulled to determine if fluid is present. If fluid is present the center bit will be removed from the borehole and the fluid level allowed to stabilize. An interface probe will be lowered inside the hollow stem to monitor fluid level. When the interface probe indicates the fluid level is stable, the fluid will be sampled. If LNAPL or DNAPL (light or dense layers) are found the procedure for Sampling Light or Dense Nonaqueous Phase Layers will be followed. If no layers are detected, a Teflon or stainless steel bailer will be lowered into the casing until centered in the water column. Raise the bailer smoothly from the casing and follow the procedures outlined in *Standard Practice for the Sampling of Liquids, Method B: Sampling With a Bailer* to fill the sample containers.

This procedure is intended as a reconnaissance method to quickly determine if groundwater is grossly contaminated and may indicate the need for further, more accurate, sampling efforts.

SAMPLING LIGHT AND DENSE NONAQUEOUS PHASE LIQUIDS

INTRODUCTION

Light nonaqueous phase liquids (LNAPLs) are relatively insoluble organic liquids that are less dense than water and spread across the water table. Dense nonaqueous phase liquids (DNAPLs) are relatively insoluble liquids that are more dense than water and tend to migrate vertically through aquifers to the top of the underlying confining layer. Wells containing light nonaqueous phase liquids will not be sampled for dissolved phases. Wells containing dense nonaqueous phase liquids will be sampled before purging the well for dissolved phase sampling. An interface probe will be lowered into the well to detect the existence and thickness of any immiscible layer(s), light and/or dense.

REFERENCE DOCUMENT

U.S. EPA, 1986, *RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD)*, OSWER-9950.1, September 1986

APPARATUS

- Photoionization detector, either an HNU, TIP II, or SIP 1000.
- Teflon bailer with bottom valve.
- Separatory funnel. (Laboratory funnel with a Teflon stopcock)
- Nylon line; disposed of after sampling.
- Waste containers.

PROCEDURE

1. Using a photoionization detector, scan the background area near the well to determine need for personnel protection. Scan inside the protective cover (flush mount lid or locking well cover) to determine if higher concentrations of organic vapors may be inside the well. Carefully remove the well riser cap and scan inside the casing to detect the presence of volatile organics. If the breathing zone has measurable volatile organic compounds, respiratory protection may be specified in Air Force Plant 4, Health and Safety Plan.

2. Lower the interface probe slowly into the well, following the procedure outlined in 6.2: Water-Level Measurements Using an Interface Probe. Note the depth to top of fluid and top of water. Continue lowering the interface probe to the bottom of the well to detect the presence of any immiscible layers below water. If a floating layer is detected disposable nylon line shall be used to lower the bailer.

3. a. To sample light nonaqueous phase liquids, lower a Teflon bailer until the bottom of the bailer is in contact with the top of the LNAPL layer. Continue to lower the bailer slowly, until the center of the bailer is centered on the water / phase interface. Smoothly raise bailer to the surface. This method will allow the collection of very thin floating layers.

   b. To sample dense nonaqueous phase liquids (after sampling any floating phase liquids), lower a Teflon bailer to the bottom of the well. Smoothly raise the bailer to the surface.

4. Carefully pour the bailer into a decontaminated separatory funnel. To sample LNAPLs use the separatory funnel to drain off the water phase and discard into a waste container. Fill sample container(s) from the separatory funnel. To sample DNAPLs use a clean separatory funnel to decant the immiscible fluid phase into the sample containers. Decant water phase into a waste container. Continue the process until adequate sample volume has been collected.

PHOTOVAC TIP II PHOTOIONIZATION ANALYZER

INTRODUCTION

This portable instrument is used to detect, measure, and provide a direct reading of chemicals in air that have an ionization potential of 10.2 eV or less. Most of the light permanent gases (such as air gases, hydrogen, or helium) have ionization potentials of 12 eV or more. Many organic chemicals have an ionization potential of less than 10.2 eV and can be detected by the TIP II.

The TIP II uses a small pump to continuously draw air into a small ionization chamber which is also flooded with ultraviolet light. This chamber has two electrodes; an electric voltage is applied across these electrodes and one of them is connected to a very sensitive current measuring circuit (electrometer). When ions are formed, and these will have both positive and negative charges, the negative ions will travel to the positive electrode and the positive ions will travel to the negative electrode. This will result in an electric current which is measured by the electrometer and can be used to express the "Total Ionizables Present".

The TIP II does not distinguish between different chemicals; the signal produced represents a composite of all different ionizable chemicals.

TIP II has four controls: a POWER switch, a SPAN control, a ZERO control, and a COURSE ZERO control. The Span and Zero controls are projecting knobs which can be locked into position and are provided with numerical position indicators. The Course Zero adjustment is made with a screwdriver through a hole in the front bulkhead of TIP II. A single electrical connector is located at the base of the handle and is used for battery recharging and for connection of external 12 Volt DC power. Two outputs are available at this same connector: an analog signal from the electrometer and an audio signal for connection to a headphone which is pulsed at a rate proportional to the concentration being measured.

The TIP II is powered by rechargeable Nickel Cadmium batteries. These batteries must be given proper care to insure long life performance. NiCad batteries will develop a "memory" if they are not run through complete discharge / recharge cycles on a regular basis. This means that if the TIP II is used for only one hour before recharging, the batteries will develop a "memory" for this duty cycle and will be unable to deliver adequate power for longer duty cycles. To avoid this condition, run the instrument until "LOBAT" appears on the display, then fully recharge for 16 hours as described in the TIP II manual.

WARNINGS

THIS DEVICE IS CLASSIFIED FOR USE IN CLASS 1, DIVISION 2, GROUPS A,B,C,D HAZARDOUS LOCATIONS. THIS DEVICE IS NOT INTENDED FOR CONSTANT USE WITH FLAMMABLE CONCENTRATIONS OF GASES. It complies with Underwriters Laboratories Inc. UL 1604 Standard for Electrical Equipment for use in Hazardous Locations Class 1, Division 2.

CAUTION

To reduce the risk of fire or injury to personnel, read and follow these instructions.

1. All calibration, maintenance, and servicing of this device, including battery charging, must be performed in a safe area away from hazardous locations.
2. Do not open or mutilate the battery cells. Released electrolyte is corrosive and may cause damage to the eyes or skin. It may be toxic if swallowed. Do not dispose of battery pack in a fire.

REFERENCE DOCUMENT

User's Manual, TIP II, Version 2.3 November 1988, Photovac Inc.

OPERATING PROCEDURES

The TIP II can be used in either a qualitative or quantitative mode. In the qualitative mode the instrument displays higher numbers as higher concentrations of ionizable gases are detected. It will not read out directly in parts per million. In quantitative mode the instrument is calibrated with a known concentration of gas and displays concentrations in parts per million. This procedure covers only the quantitative mode. See the TIP II Users Manual for a description of the qualitative mode.

SEMIQUANTITATIVE PROCEDURES TUTORIAL

1. When you press the POWER switch, the LCD of TIP II will turn on and the pump and yellow LEDs will come on briefly. Wait for them to come on continuously, indicating the ultraviolet lamp has started.

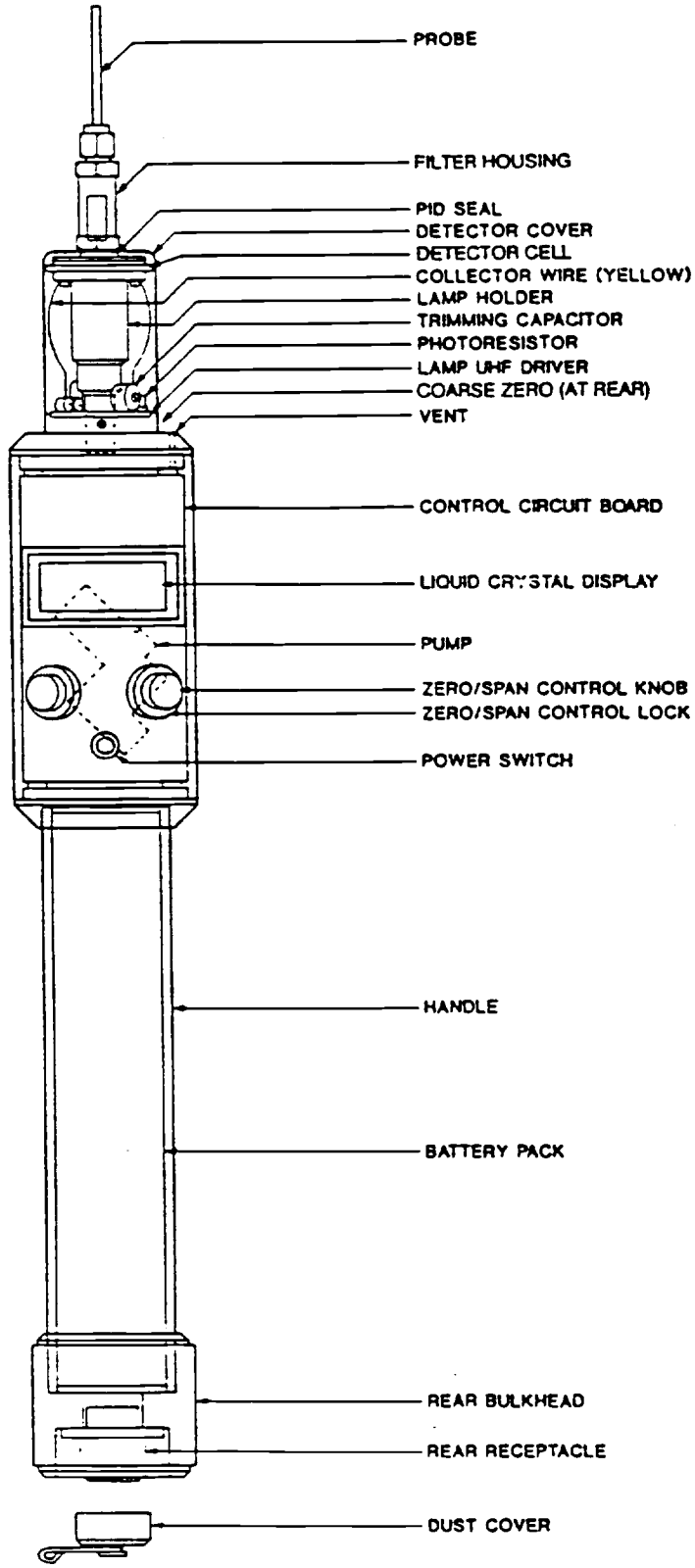
2. Turn the locking rings down to release the ZERO and SPAN controls.

3. A mid-range sensitivity (Span setting of 5) is a good place to start.

4. The cleanliness of the reference Zero air should match the application. Outdoor air away from chemical sources is usually suitable. Although background chemicals will not be canceled out as they are when TIP II is used qualitatively, the error they cause is usually insignificant. If the zero reference air contains 1 ppm equivalent of total ionizables, and TIP II is adjusted to read 100 when Span Gas is introduced, then in fact TIP II will read -1 when air with no ionizables is sampled. The error will decrease as concentration increases. If outdoor air is too heavily contaminated, bottled Zero Air should be used.

5. Turning the ZERO control clockwise will raise the LCD reading, turning it counterclockwise will lower it. Adjust the COARSE ZERO control with a small slotted screwdriver if TIP II always reads above or below zero with the ZERO control alone.
6. Hand tighten the gas bag adapter nut to TIP II inlet, and open the gas bag valve.

7. A clockwise turn of the SPAN control will raise the LCD reading, a



TIP Pictorial Diagram

counterclockwise turn will lower it.

8. Check the zero setting by sampling clean air again. Reset the ZERO control, if needed.

9. Turn the locking ring up against the SPAN control.

10. Check the SPAN setting by sampling Span Gas. Setting ZERO and SPAN controls is an iterative procedure. With experience, initial settings will be close to final settings.

11. Sample clean air while locking the ZERO control and sample Span Gas while locking the SPAN control, and hold the controls so that they don't shift when their locking rings are turned against them.

12. The LCD will now show concentrations of total ionizables in the sample in Span Gas equivalent units. Naturally, part per million readings taken with TIP II only have meaning when there is a single compound present in the sample. A mixture of two or more compounds will give a composite reading which, due to differences in response, will obviously NOT be the simple sum of the concentrations of each component. Nevertheless, there can often be a benefit to such a reading, for example, in studying the distribution of an accidental spill of gasoline. Calibration against the Span Gas gives a reasonably repeatable reference, which can then serve as a guide to the use and deployment of more sophisticated analyzers.

13. If TIP II aspirates some liquid, immediately turn to Maintenance, - If TIP II Draws in Water, and follow the instructions.

14. Switch off TIP II when finished taking readings or if the "LOBAT" sign appears at the top left of the LCD. Readings taken while "LOBAT" is on may not be reliable.

Calibrating TIP II with a known concentration of span gas provides a means of comparing readings from one day to another and compensates for film build-up on the detector lamp window.

The TIP II is calibrated at two points of concentration, 0 and 100 ppm. Its accuracy decreases when sampling concentrations away from these two points according to the following table:

Actual Concentration (ppm isobutylene)	TIP II Reading
1	1 ± 1.5
5	6 ± 2
10	12 ± 2
50	55 ± 5
100	100 ± 10
500	450 ± 10%
1000	850 ± 10%
1500	1250 ± 10%
2000	1500 ± 10%

Procedure

If it is known that only one chemical will be present in the air being sampled the TIP II can be calibrated with a standard of that compound. Note that the presence of other gases and vapors in the sample will change the results.

1. Press POWER switch to turn on TIP II.
2. Unlock ZERO and SPAN controls by turning locking rings clockwise.
3. Set SPAN control to 5.
4. Allow TIP II to sample clean air.
5. Adjust ZERO control until LCD reads zero.
6. Connect Kevlar bag of span gas to TIP II inlet.
7. Adjust SPAN control until LCD indicates the Span Gas concentration (nominally 100 ppm isobutylene, check label on Span Gas bottle). Disconnect gas bag.
8. Sample clean air again and readjust ZERO control if necessary.
9. Lock ZERO control by turning locking ring counterclockwise.
10. Sample Span Gas again and readjust SPAN control if necessary.
11. Lock SPAN control by turning locking ring counterclockwise. Disconnect gas bag.
12. Observe readings on LCD. Concentration of total ionizables is displayed in Span Gas equivalent units.
13. DO NOT ALLOW THE TIP II TO DRAW IN ANY LIQUIDS!
14. Press POWER switch after use to turn off TIP II.

Calibration Gas Procedure.

1. Hand tighten regulator onto Span Gas tank.
2. Turn gas bag valve counterclockwise to open.
3. Hand tighten gas bag adapter nut onto regulator.
4. Turn regulator knob counterclockwise about 1/2 turn to start gas flow.
5. Fill bag until bag material just begins to stretch.
6. Turn regulator knob fully clockwise to shut off the gas flow.
7. Turn gas bag valve fully clockwise to close.
8. Remove gas bag adapter nut from regulator.
9. Remove regulator from Span Gas tank.

NOTE: Before using the gas bag for the first time, and if it has not been used for four weeks, fill and flush gas bag with span gas two times before connecting it to TIP II.

MAINTENANCE

Keeping TIP II in top operating shape means charging the battery, cleaning the ultraviolet lamp window, and replacing the dust filter. The exterior of TIP II can be wiped clean with a damp cloth and mild detergent if necessary. Keep the cloth away from the sample inlet, however, and do not attempt to clean while TIP II is connected to the mains! Organic cleaning solvents might damage the finish.

BATTERY CHARGING

Charge TIP II battery when "LOBAT" appears at the top left of the LCD.

NOTE: DO NOT CHARGE TIP II IN A HAZARDOUS LOCATION.

TIP II handle and the charger may be warm to the touch during charging. This is normal.

By letting TIP II fully discharge until "LOBAT" appears, then charging for 16 hours, the operating time of TIP II is maximized. Occasional overcharging for up to two days will not be detrimental to the batteries. If TIP II is consistently put on charge before "LOBAT" appears, the operating time of TIP II will be diminished.

The TIP II Charger is one of two types, either a TIP Constant Current Battery Charger, or a TIP Dual Rate Charger.

To use the Constant Current Battery Charger:

1. Switch off TIP II.
2. Remove any external devices connected to the rear receptacle, or unscrew dust cover.
3. Set selector switch on back of charger to correct AC mains voltage.
4. Connect charger plug to TIP II rear receptacle. Turn knurled collar clockwise to secure plug.
5. Plug charger into AC mains.
6. Allow TIP II to charge for 16 hours.
7. Remove charger plug from TIP II and replace dust cover.

DO NOT LEAVE TIP II ON CHARGE CONTINUOUSLY WITH THE CONSTANT CURRENT BATTERY CHARGER.

To use the Dual Rate Charger:

1. Switch off TIP II.
2. Remove any external devices connected to the rear receptacle, or unscrew dust cover.
3. Connect charger plug to TIP II rear receptacle. Turn knurled collar clockwise to secure plug.
4. Plug the charger into AC mains. The indicator light will be green.
5. Press the HIGH CHRG button. The indicator light will turn red to show the charger is charging at the high rate.
6. TIP II will be fully charged in about 15 hours. After this time, the indicator light will turn green indicating the charger has returned to its low continuous charge rate. This maintains the battery at full charge. Do not press HIGH CHRG again as this may overcharge the battery.
7. To use TIP II, remove charger plug from TIP II and replace dust cover.

The low continuous charge rate can be used to charge TIP II when it has not been fully discharged, however, it is best to fully discharge TIP II before recharging to maintain the highest battery capacity.

Interrupting the AC power supply to the Dual Rate Charger will reset it to the low charge rate.

CLEANING THE LAMP WINDOW

As TIP II is used, a film of deposit will build up on the window of the ultraviolet lamp. The rate of film build-up depends on the chemicals and concentrations being sampled, and results from the action of ultraviolet light on the chemicals. Clean the lamp window when a span setting of 9 is insufficient to give a high enough LCD reading. Refer to TIP II Pictorial Diagram for parts location.

1. Switch off TIP II.
2. Grasp the black detector cover and unscrew it from TIP II. The detector cell, lamp holder and lamp UHF driver circuit board are now exposed. Be careful of the PID seal o-ring on top of detector cell.
3. Unplug red and yellow wires from UHF driver circuit board.
4. Grasp lamp holder so it will not rotate, and unscrew detector cell (with red and yellow wires attached) from lamp holder. Lamp will pop up.
5. Withdraw lamp from lampholder. Leave spring in lamp holder.
6. Moisten a lint-free tissue with methanol.
7. Rub lamp window with methanol-moistened tissue to remove film.
8. Dry lamp window with clean lint-free tissue.
9. Without touching window, slip lamp into lamp holder, window-end out.
10. Install detector cell onto lamp holder and tighten <u>until just snug.</u> Avoid cross threading.
11. Plug yellow wire onto gold pin and red wire onto tinned pin on UHF driver circuit board.
12. Install detector cover <u>hand-tight.</u>

When the detector cell is removed, be careful not to touch the fine wire mesh inside it. Any dirt in the detector cell may be blown out with a gentle jet of dry compressed air.

REPLACING THE DUST FILTER

TIP II is equipped with a dust filter to reduce detector contamination. As the filter becomes clogged, TIP II inlet flowrate and sensitivity will drop. If TIP II sensitivity increases by more than 10% when the filter is removed then install a new filter. Don't run TIP II without a filter for more than a minute or so.

1. Switch off TIP II.
2. Hold filter housing near detector cap with 9/16" wrench.
3. Unscrew top of housing with another 9/16" wrench. Be careful of the metal sealing washer.
4. Remove spring and filter.
5. Install new filter open end first.
6. Slip spring into top of housing and assemble housing. Tighten with two wrenches.

IF TIP II DRAWS IN WATER

Water drawn into TIP II will not cause permanent damage if the instrument is promptly disassembled and cleaned. The most important parts to clean are the lamp and the detector cell. To clean the pump, allow TIP II to run until no more water comes out of vent hole located in the front bulkhead.

1. Refer to maintenance instructions to remove detector cell and lamp.
2. Dry lamp with a clean lint-free tissue and clean the window.
3. Clean detector cell in clean water, preferably in an ultrasonic cleaner. Do not touch the fine wire mesh.
4. Dry detector cell overnight at 50 degrees C. (125° F).
5. Dry inside of lamp holder.
6. Remove filter following instructions above.
7. Dry inside of filter holder.
8. Install a new filter.
9. Assemble TIP II following instructions above.

SITE SPECIFIC PROCEDURE CHANGE or NOTICE

PROCEDURE Portable Photoionization Analyzer, Model ISPI 101 HNU

PROJECT or SITE Air Force Plant 4

CHANGE

Pressure and Humidity Calibration Corrections

Section 3 states "Connect the analyzer to the regulator and cylander with a short piece (butt connection) of tubing". Instead of directly connecting the HNU to the regulator, the HNU will be calibrated by filling a Tedlar bag with known concentration span gas (normally 100 ppm isobutylene) and attaching the HNU to the sampling valve of the gas bag. This method permits calibration at current atmospheric pressure.

After the Tedlar bag is full, attach the tygon tubing end of the calibration gas humidifier to the bag. Use of the calibration gas humidifier while calibrating will correct for water vapor effects on the photoionization readings. Water is a strong absorber of photons in the operating region of photoionization detectors and high humidity will cause lower readings unless humidity is accounted for while calibrating. The HNU must be recalibrated using the calibration gas humidifier whenever there is a significant change in ambient humidity.

Calibration Gas Procedure.

1. Hand tighten regulator onto Span Gas tank.
2. Turn gas bag valve counterclockwise to open.
3. Hand tighten gas bag adapter nut onto regulator.
4. Turn regulator knob counterclockwise about 1/2 turn to start gas flow.
5. Fill bag until bag material just begins to stretch.
6. Turn regulator knob fully clockwise to shut off the gas flow.
7. Turn gas bag valve fully clockwise to close.
8. Remove gas bag adapter nut from regulator.
9. Remove regulator from Span Gas tank.

NOTE: Before using the gas bag for the first time, and if it has not been used for four weeks or more, fill and flush gas bag with span gas two times before connecting it to the HNU.

Ambient Humidity Calibration

1. Turn on the HNU and adjust ZERO in the STANDBY MODE.

2. Turn the range switch to 0-200.

3. Connect the tygon tubing end of the humidifier to the span gas bag.

4. Connect the fitting end (white polypropylene) of the humidifier to the 10 probe extension.

5. When the reading stabilizes (15-30 seconds), adjust the SPAN POT until the meter reads the correct value for the calibration gas used.

6. The 101 is now calibrated for direct reading on the calibration gas.

7. The calibration can be adjusted for changes in humidity by repeating the process

PORTABLE PHOTOIONIZATION ANALYZER MODEL ISPI 101 HNU SYSTEMS, INC.

Introduction

This portable instrument is used to detect, measure, and provide a direct reading of the concentration of a variety of trace gases in many industrial or plant atmospheres. The analyzer employs the principle of photoionization. This process involves the absorption of ultraviolet light (a photon) by a gas molecule leading to ionization:

$$RH + h\nu \rightarrow RH^+ + e^-$$

in which

RH = trace gas
hv = Photon with an energy level equal to or greater than the ionization potential of RH

The sensor consists of a sealed ultraviolet (UV) light source that emits photons with an energy level high enough to ionize many trace species, particularly organics, but not high enough to ionize the major components of air, O_2, N_2, CO, CO_2, or H_2O.

A chamber exposed to the light source contains a pair of electrodes: one, a bias electrode, and the second, a collector electrode. When a positive potential is applied to the bias electrode a field is created in the chamber. Ions formed by the absorption of photons are driven to the collector electrode. The current produced is then measured, and the corresponding concentration is displayed on a meter directly in parts per million (ppm).

To minimize absorption or decomposition of sample gases, a rapid flow of sample gas is maintained through the ion chamber, which is small, made of inert material and located at the sampling point.

The analyzer consists of a probe, a read-out assembly, and a battery charger. The probe contains the sensing and amplifying circuitry; the read-out assembly contains the meter, controls, power supply, and rechargeable battery. The analyzer will operate from the battery for approximately 6-10 hours.

The ISPI 101 is designed for use with interchangeable probes containing lamps of different energies. The analyzer is ready for use simply by connecting the probe to the read-out assembly, calibrating, setting the proper SPAN pot value, and then zeroing the unit.

The standard probe provided with the analyzer contains a 10.2 eV lamp. Optional probes containing lamps of 9.5 and 11.7 eV permit selective determination or exclusion of special species having IP values lower than 9.5 eV in the presence of interfering species with IP values above 9.5 eV. The probe with the 11.7 eV lamp permits measurement of species with IP values up to approximately 11.7 eV. The probes with different lamps are interchangeable in use within individual read-out assemblies for different applications. The amplifier and ion chamber in the probe are selected for the specific eV lamp. Lamps of different eV ratings cannot be interchanged between probes.

Gases with ionization potentials near to or less than that of the lamp will be

ionized. These gases will thus be detected and measured by the analyzer. Gases with ionization potentials higher than that of the lamp will not be detected. The ionization potential of the major components of air, i.e., oxygen, nitrogen, and carbon dioxide, range from about 12.0 eV to about 15.6 eV and are not ionized by any of the three lamps. Gases with ionization potentials near to or slightly higher than the lamp are partially ionized, resulting in low response to the instrument. Ionization potentials for various atoms, molecules and compounds are given in Tables 8-1 through 8-13 in Section 8 of the HNU Instruction Manual.

The amount of ionization of a species of gas exposed to photons, its sensitivity, is a characteristic of that particular species. This is illustrated in Table 4-1 in the HNU Instruction Manual for a number of chemical groupings, and in Table 8-14 for a large number of individual species when exposed to photons from a 10.2 eV lamp.

The species with the higher values are more sensitive to the 10.2 eV photons than are those with lower values. Refer to Table 8-14 in the HNU Instruction Manual for further information.

WARNINGS

1. Do not look at the light source from closer than 6 inches with unprotected eyes. Observe the source only briefly. Continued exposure to ultraviolet energy generated by the light source can be harmful to eyesight. The lamp cannot be observed with the probe extension attached or when the instrument is in the stand-by mode.

2. Any obstruction of the probe extension or at the sample end of the probe will seriously impair ISPI 101 operation. The fan cannot draw a sample across a pressure drop. Efforts should be made to keep dirt, dust, grease (e.g., from pipe joints) and other matter from obstructing the flow.

3. The instrument measures gases in the vicinity of the operator and a high reading when measuring toxic or explosive gases is cause for immediate action for safety.

4. Never open the valve on a gas container without a regulator attached.

5. Turn the function switch on the control panel to the OFF position before disassembly. Otherwise, high voltage of 1000 V DC will be present in the probe assembly.

6. The ISPI 101 is suitable for uses in Class I Division 1 ABCD areas except when using the charger.

7. The Read-out Unit should NEVER be opened except by a service person trained and certified by HNU Systems, Inc.

8. Do not use the instrument in the rain or other precipitation, as it will not pick up volatiles under those conditions.

Precautions and Limitations

Environmental Sensitivities

Temperature, humidity and air particulates are factors in the proper operation

of this instrument.

Detection Range	0.1 to 2000 ppm
Minimum Detection Level	0.1 ppm
Maximum Sensitivity	0 to 20 ppm FSD at SPAN = 9.8 (full scale deflection) 0 to 2 ppm FSD at SPAN = 0.0
Repeatability	∓ 1% of FSD
Linear Range	0.1 to 400 ppm
Useful Range	0.1 to 2000 ppm
Response Time	Less than 3 seconds to 90% of FSD
Ambient Humidity	up to 90% RH (relative humidity)
Operating Temperature Ambient (10.2 and 9.5 eV lamps)	-10 to 40° C.
Operating Time on Battery (continuous use)	Approximately 6 - 10 hours: at lower temp. time is reduced due to effect of cold temp. on the battery
Recharge time from full discharge	Full recharge: 12 - 14 hours. Unit can be left on the charger and be continuously recharged whenever the unit is not in use (the analyzer will not operate while the unit is on the charger: an Intrinsically Safe feature).
Recharge current	Max. 0.4 amps at 15 V DC
Battery Charger Power	120 V AC, single phase, 50-60 Hz, 1.5 Amps 230 V AC, single phase, 50-60 Hz, .75 Amps

NOTE: The above specifications apply when the instrument is equipped with 10.2 eV Probe with SPAN set at 9.8 and measuring benzene. Values will vary for other compounds and conditions. The HNU is sensitive to interferences from the following physical/environmental conditions: overhead electrical powerlines, transmissions from some hand-held portable radios, temperature extremes, humidity, machinery emitting exhaust fumes, battery acid, and any other volatile organics that the HNU could detect. The lamp lens will need to be cleaned when working in dusty areas, or areas with heavy particulates in the air. Both the lamp lens and the ion chamber need to be cleaned when in areas of high humidity or precipitation. Water should not be sucked into the instrument.

Operating Procedures

The following procedures are to be used in operating the analyzer:

1. Unclamp the cover from the main read-out assembly.

2. Remove the inner lid from the cover by pulling out the two fasteners in order to access the charger, adapter, straps, and probe extension.

3. Connect the probe cable plug to the 12-pin keyed socket on the read-out assembly panel. Carefully match the alignment slot in the plug to the key in the connector. Screw down the probe connector until a distinct snap and lock is felt.

4. Screw the probe extension into the probe end cap. The probe may be used without the extension if desired.
5. Set the SPAN control for the probe being used (10.2, 9.5, or 11.7 eV) as specified by the initial factory calibration or by subsequent calibrations.

6. Turn the function switch to the BATT (battery check) position. The needle on the meter will go to the green zone if the battery is fully charged. If the needle is below the green arc or if the Low Battery Indicator comes on, the battery must be recharged before the analyzer is used. No measurements can be taken while charging.

   NOTE: To ensure accurate readings, the ISPI 101 is designed to operate ONLY when the battery voltage is greater than 11 V DC. A low battery will cause the analyzer to shut off automatically.

7. Set the SPAN pot to the desired value based on the gas to be used.

8. Turn the function switch to STANDBY position. Turn the zero adjustment until the meter needle is at zero.

9. Turn the function switch to the appropriate operating position. Start with the 0-2000 position and then switch to the more sensitive ranges. The UV light source should be on, confirmed by removing the probe extension and briefly looking into the probe to observe a purple glow from the lamp. Do not look at the light source closer than 6 inches.

10. The analyzer is now operational.

11. Hold the probe so that the extension is at the point where the measurement is to be made. Using a fan, the instrument measures the concentration by drawing the gas in at the end of the extension, through the ionization chamber, and out the handle end of the probe.

    NOTE: The fan will not operate against a pressure drop, i.e., it will not withdraw a sample from a duct with gas moving away from the probe. The ISPI 101 is designed for ambient (relatively still atmospheres) operation.

    WARNING: Stand up wind from the source whenever sampling. The instrument measures gases in the vicinity of the operator and a high reading when measuring toxic or explosive gases is cause for action for operator safety.

12. Take the reading or readings as desired, taking into account that air currents or drafts, equipment, vehicles, or environmental interferences in the vicinity of the probe tip may cause fluctuations in readings. Change the ranges as required. Check that the probe you are using will measure the ionization potential of the chemical/source that you are sampling for.

13. Check the battery condition as required. If the Low Battery Indicator comes on. turn the analyzer off and recharge. Measurements cannot be taken while charging.

14. After completion of use, check the battery condition as described in #6.

15. Turn the function switch to the OFF position.

16. When not operating the analyzer, leave it in its assembled condition and connected to the battery charger,

17. When transporting the unit, disassemble the probe and its extension from the read-out assembly and return the equipment to its stored position.

18. In case of emergency, turn the function switch to the OFF position.

Battery Charge

Check the battery charge as described above in # 6, during each period of operation. If the battery is low, as indicated by the meter reading, it is necessary to recharge it.

To charge the battery, locate the Battery Charge Adapter Cable, (which is comprised of a 1/4-inch phone plug on one end and a mini phone jack on the other). Press the 1/4-inch phone plug onto the mating read-out assembly jack installed on top of the ISPI 101 battery charger case. Attach the charger cable with the mini-plug into the mini-jack of the battery charger adapter cable. The charger can then be plugged into a 120 VAC or 230 VAC (as specified by charger) single phase, 50-60 Hz outlet. Recharge the unit in a non-hazardous atmosphere.

The analyzer cannot be operated during this recharging period. Leave the function switch in the OFF position during charging. After the charging period, the battery charger can be detached from the analyzer and reassembled in the reverse order as described above.

Rechecking the battery's newly charged condition can be accomplished with the analyzer assembled, the probe attached and the function switch set to the BATT position. The meter should deflect to the green region.

> ***NOTE 1:*** The probe assembly must be attached to the analyzer during the battery check. Without following this procedure, the instrument will not indicate the correct battery condition.
>
> ***NOTE 2:*** The instruction on the cover of the battery charger instruct the user to *"place output plug into jack on the left side of bezel."*. This is incorrect. The output plug should be attached to the charger adapter cable as explained above.

Calibration

The ISPI 101 Analyzer is designed for trace gas analyzer in ambient air and is calibrated at HNU with certified standards of benzene, vinyl chloride and iso-butylene. Good instrumentation practice calls for calibration on the species to be measured in the concentration range to be used. This procedure assures the operator that the analyzer is operating properly and will generate reliable data.

Some general points to consider when calibrating the ISPI 101 are that the

analyzer is designed for operation at ambient conditions and therefore the gas standards used for calibration should be delivered to the analyzer at ambient temperatures and pressure and at the proper flow rates.

The instrument shall be internally calibrated with benzene on an annual basis. This shall be accomplished by the Industrial Hygienist and/or designee. Calibrations with benzene of any other toxic or hazardous gases must be done under a hood. Reference will be made to calibration checking with isobutylene. This shall also be referred to as a calibration. Isobutylene is used as a reference gas and the instrument is calibrated externally by adjusting the external span control knobs. Isobutylene is a non-toxic gas, therefore these calibrations do not have to be done under a hood.

The frequency of calibration should be dictated by the usage of the analyzer and the toxicity of the species measured. If the analyzer has been serviced or repaired, calibration should be done to verify operation and performance. When using the instrument at possible hazardous waste sites or in situations involving unknown chemicals, the instrument should be calibrated daily in a "clean" non-hazardous area.

The calibration results, along with instrument field readings must be recorded in the orange health & safety log book.

Best operation of the analyzer is accomplished by its calibration for the gas to be measured. In cases where it becomes necessary to operate with a gas for which it has not been calibrated and recalibration is not possible, correction can be made to the meter reading. One method is to multiply the meter reading by a correction factor. This equation and accompanying photoionization sensitivities can be found in section 8.4 and Table 8-14 respectively in the HNU Instruction Manual. This is to be used only when measuring a <u>known</u> solitary gas. It cannot be used with gas mixtures. Consult sections 8.1 and 8.3 of the HNU Instruction Manual for calibration with a special mixture or with an alternate gas.

<u>Probe</u>

1. Identify the lamp by the probe label. If a question exists, disassemble the probe and inspect the lamp. The energy of the lamp is etched into the glass envelope. If the lamp appears to need cleaning, see the Section titled, "*UV Lamp and Ion Chamber Cleaning*".

2. Connect the probe to the read-out assembly. A small "click" will indicate that the probe is fitted securely into the instrument.

3. The calibration cylinder should be consulted for the proper value (ppm) for the probe being calibrated. Refer to the following Section titled, "*Calibration Checking with Isobutylene*".

4. Check the Ionization Potential (IP) of the calibration gas to be used. <u>The IP of the calibration gas must be at or below the IP of the lamp.</u>

5. Proceed with the calibration as described below.

<u>Calibration Checking with Isobutylene</u>

The calibration of the analyzer can be rapidly checked by the use of an HNU

small disposable cylinder containing isobutylene and a regulator. Consult Section 3.4 of the HNU Instruction Manual for internal calibrations with benzene.

1. Battery check - with the probe attached, turn the function switch to BATT. The needle should be in the green region. If not, recharge the battery.

2. Zero set - with the probe attached, turn the function switch to STANDBY. In this position the lamp is OFF and no signal is generated. Set the zero point with the ZERO set control.

3. Connect the analyzer to the regulator and cylinder with a short piece (butt connection) of tubing. The calibration gas in the cylinder consists of a mixture of isobutylene and zero air. Isobutylene is nontoxic and safe to use in confined areas. There are no listed exposure levels at any concentration.

   The regulator sets and controls the flow rate of gas at a value preset at the factory. This will be about 100 - 200 cc/min.

   It is important that the tubing be clean since contaminated tubing will effect the calibration reading. Do not use the cylinder below about 30 psig as readings below that level can deviate up to 10% from the rated value. Notify the instrument technician when a cylinder is at 30 psig so additional gas cylinders can be ordered. Safely discard the disposable cylinder when empty.

4. Open the valve on the cylinder until a steady reading is obtained. This should take 30-60 seconds.

5. Turn the function switch to the range position and note the meter reading. Adjust the SPAN control setting as required to read the ppm concentration of the standard for the probe being used. The span should not have to be adjusted below 3.0. Notify the instrument technician if this is the case. This indicates that either the lamp is dirty, the lamp needs to be replaced, or the instrument needs to be calibrated internally with benzene.

6. Shut off the cylinder as soon as the reading is established.

7. Record and maintain this new SPAN setting.

Maintenance

Introduction

User maintenance of the analyzer consists of cleaning the lamp and ion chamber, and replacing the lamp or ion chamber. Other component parts or subassemblies may be serviced only by a service person trained and authorized by HNU Systems, Inc. HNU Systems has made this policy to maintain the Intrinsically Safe properties of the ISPI 101.

> ***WARNING:** Turn off the function switch on the control panel to the OFF position before probe disassembly. Otherwise, high voltage of 1000 VDC will be present in the probe assembly.*
>
> ***Do not look at the light source from closer than 6 inches with unprotected eyes. Observe the source only briefly. Continued***

exposure to ultraviolet energy generated by the light source can be harmful to eyesight. The lamp cannot be observed with the probe extension attached.

Do not interchange lamps of different eV ratings in a probe. Amplifier and other components are selected for a specific eV lamp. A probe with the wrong lamp will not operate properly.

Cleaning Procedure for ISPI 101 Lamps and Ion Chamber

During periods of operation of the analyzer, dust or other foreign matter could be drawn into the probe, forming deposits on the surface of the UV lamp or the ion chamber. This condition is indicated by meter readings that are low, erratic, unstable, non-repeatable, or drifting, or apparently due to moisture sensitivity. These deposits interfere with the ionization process and cause erroneous readings. Check for this condition monthly or more often as required. Cleaning can be accomplished as follows:

Lamp Removal

1. Remove 5/32" hex screw (exhaust screw) with Allen wrench provided. Slide the innards out of the probe shell.

2. Remove the probe from the unit. Hold the probe upright, cable down. Remove the two cross-headed screws that hold the black end cap. Carefully remove the end cap. Remove the two screws holding the ion chamber on, and lift the chamber off of the probe.

3. Loosen the small set screw in the side of the lamp housing, place your hand over the end of the probe and tilt. The lamp will fall into your hand. Notice the eV number etched on the lamp.

Lamp Cleaning: 10.2 and 9.5 eV

1. Put a small drop of HNU Cleaning Compound (Part #80-PA 101534-A1) (or GLEEM™ toothpaste on the lens of the lamp (the small glass circle on the metal end).

2. Using a nonlinting tissue, rub in a circular motion until all residue is removed.

3. Rinse with hot, clean tap water, and dry with nonlinting tissue.

4. If the lens is still not clean, repeat Steps 1, 2, and 3.

Lamp Cleaning: 11.7 eV

1. Clean the lens only (the small glass circle on the metal end) with Freon™ or any chlorinated organic solvent to remove any deposits, using a non-linting tissue.

2. Do **NOT** use HNU Cleaning Compound, water, or any water-miscible solvent on these lamps.

Ion Chamber Cleaning

1. Remove the "O" Ring from the side opposite the wire mesh and save.

2. Agitate the whole assembly in a beaker of methanol or acetone, or place the beaker and contents in an ultrasonic bath for ten minutes.

3. Remove the beaker and shake out the surplus solvent. Dry overnight at room temperature or bake for two hours in a drying oven at 100°C. Do not dry at temperatures over 100°C. Allow chamber to cool completely before reinstalling.

4. In an emergency, careful use of a hair dryer is permissible.

Reassembly

1. Hold the probe upright, cable down, and replace the lamp with the lens uppermost. Tighten the set screw in the lamp housing after insertion.

2. Replace the "O" Ring in the groove in the ion chamber (side opposite the wire mesh).

3. Place the ion chamber over the lamp with the wire mesh side on top. Make sure all the connection pins, screw holes, and the vent hole in the ion chamber are correctly aligned. (The small vent hole in the ion chamber lines up with the vent hold in the probe, which has a small black "O" Ring around it). Secure the chamber with the two screws.

4. Replace the probe cap, noting the alignment of screw holes. Replace the two screws and tighten evenly.

5. Replace the lamp housing in the probe shell, aligning the exhaust ports and the amplifier board connector. Secure with the hex exhaust screw.

6. Reattach the probe to the analyzer and check the analyzer operation.

7. If performance is still not satisfactory, replace the lamp.

The unit is now ready to be used.

Lamp Replacement

> ***CAUTION: Do not interchange lamps of different eV ratings in a probe. Amplifier and other components are selected for a specific eV lamp. A probe with the wring lamp will not operate properly.***

To replace the lamp, disassemble the probe, remove the old lamp, install a new one of the same eV rating and reassemble. Record this on the HNU's Data Sheet which is located in the top drawer Equipment Files in Room 212.

> ***WARNING: Turn off the function switch on the control panel to the OFF position before probe disassembly. Otherwise, high voltage of 1000 VDC will be present in the probe assembly.***

Lamp eV Power Change

If different applications for the analyzer would require lamps of different eV power, then separate probes, each with its own eV lamp must be used. A single read-out assembly will serve for any of the probes. A change in probe will require resetting of the ZERO control and the SPAN control. Calibration should be checked to verify proper operation.

Probe Assembly/Disassembly

> ***WARNING: Turn off the function switch on the control panel to the OFF position before probe disassembly. Otherwise, high voltage of 1000 VDC will be present in the probe assembly.***

Disassemble the probe by first removing the exhaust screw at the base of the probe adjacent to the handle using the 5/32" hex key (Allen wrench). Disconnect the probe cable connector at the read-out assembly. Grasp the end cap in one hand and the probe shell in the other, gently pull to separate the end cap and the lamp housing from the shell.

Hold the lamp housing with the black end cap upright. Loosen the screws on the top of the end cap, separate the end cap from the lamp housing. Remove the two screws on the ion chamber and separate the chamber from the lamp housing. To remove the lamp, locate the lamp retaining screw on the side of the lamp housing and remove.

> ***CAUTION: Care must be taken so that the lamp does not fall out of the lamp housing when the retaining screw is removed.***

Place one hand over the top of the lamp housing and tilt slightly. The light source will slide out of the housing.

Reassemble the probe by first sliding the lamp back into the lamp housing and aligning the screw hole in the lamp retaining ring with the aperture on the side of the lamp housing, then install the lamp retaining screw and tighten.

> ***CAUTION: Overtightening this screw may break the lamp. DO NOT OVERTIGHTEN.***

Place the ion chamber on top of the lamp housing, making sure that the contacts and the vent hold are properly aligned. The ion chamber fits only one way; secure it with the two screws.

If the ion chamber is to be replaced, always use one identical to the one being removed. Check the aperture (small: 3.0 mm, used with the 10.2 eV lamp; large: 6.0 mm, used with the 9.5 and 11.7 eV lamps) at the top of the ion chamber and materials of construction (gold-plated or Teflon™) to ensure proper replacement. See Parts List.

Check the ion chamber electrodes (on the side with NO mesh): the collecting electrode (a disk about 1" in diameter) must not touch the polarizing electrode (the central pin). If they do, call HNU Systems, Inc.

Place the end cap on top of the ion chamber and replace the two screws. Tighten the screws only enough to seal the "O" Ring.

CAUTION: DO NOT OVERTIGHTEN THESE SCREWS

Line up the pins (pogo contacts) on the base of the lamp housing with the pins inside the probe shell. Gently slide the housing assembly into the probe shell.

The end cap should meet the probe shell evenly after final assembly. If not, the ion chamber may be installed wrongly.

CAUTION: DO NOT FORCE the assembly into the shell. It fits only one way.

If the probe does not reassemble readily, remove it from the shell and check pin alignment. Check to ensure pogo contacts are not bent. Refasten the exhaust screw at the base of the probe.

Align the 12-pin probe connector to the read-out assembly and reconnect with a twisting motion until a click occurs. The lamp should light if the function switch is turned to any position except **STANDBY**.

Read-out Unit

WARNING: The read-out Unit should NEVER be opened except by a service person certified and authorized by HNU Systems, Inc. Leave the case on the Read-out Unit, which is fitted with a tamper-proof seal.

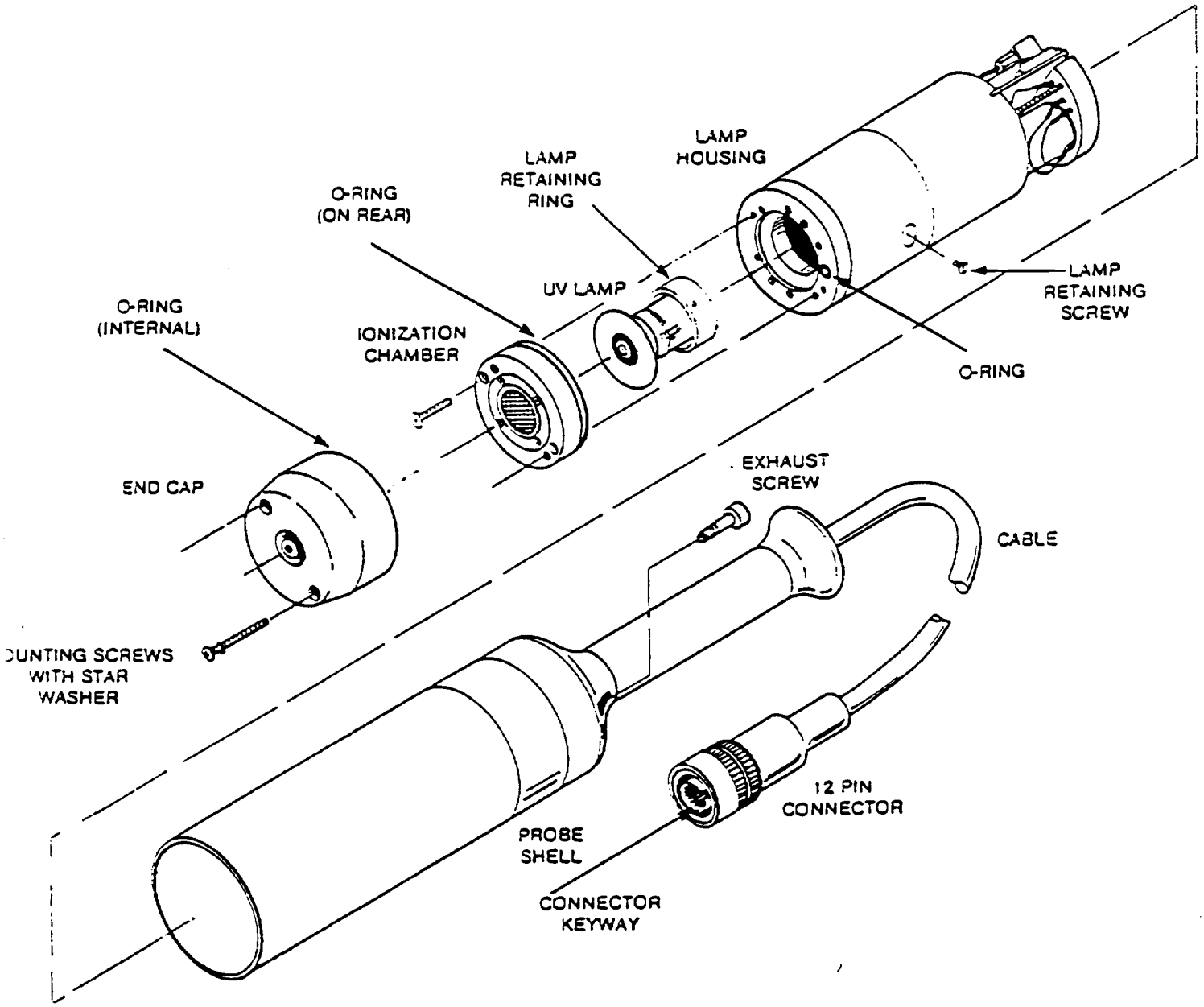


FIGURE
PROBE ASSEMBLY

SIP 1000 ORGANIC VAPOR ANALYZER

Purpose

The SIP 1000 Organic Vapor Analyzer is for the detection of organic vapors in the work environment. The unit is to be operated only by personnel signed off by the Industrial Hygienist as qualified to operate this instrument.

Charge/Discharge Characteristics (Refer to Figures 1(a) and 1(b))

The battery is a 12-volt, 1.9 ampere-hour sealed lead-acid type that can be operated in any orientation. Since any battery loses capacity through self-discharge, it is recommended that a "top charge" be applied to any battery which has been stored prior to putting it in service. With the power and pump switches off (not depressed), connect the battery and charger as indicated on the back of the SIP 1000. Plug the battery charger into the appropriate AC power source, as indicated on the charger, and let the battery charge for 16 hours.

Connections

1. Fasten the 1/4-inch x 6-inch long probe to the probe hand grip (1/4" fitting).

2. Connect the probe hand grip to the sample inlet fitting on the back of the unit with the 1/8" coiled teflon tubing provided.

3. Turn off the hydrogen cylinder after the hydride has been charged, and unplug the quick connect by grasping the hydride container and pulling the knurled portion of the connector toward you. Unfasten the tubing from the hydrogen cylinder and connect it to the carrier inlet fitting (1/8") on the back of the SIP-1000. CAUTION: Never disconnect the tubing from the hydrogen cylinder or carrier inlet with the hydride connected as this will discharge the stored hydrogen.

4. Check the battery and charger to see that they are properly connected.

5. Connect the cable between the signal jack and any appropriate accessory recording instrument.

Operation

Turn On

Remove the reaction chamber cap, grasp the reaction module by the "O" ring and firmly pull it out of the chamber.

Electrical Shock

Depress the PWR switch and note the display will read [E E E E], indicating the program has been erased. Depress the MODE switch once. The display will read between [0 0 0 0] and [0 0 0 5] within a few seconds, indicating that the electronics are functioning properly.

FIGURE 1(a). DISCHARGE CHARACTERISTICS

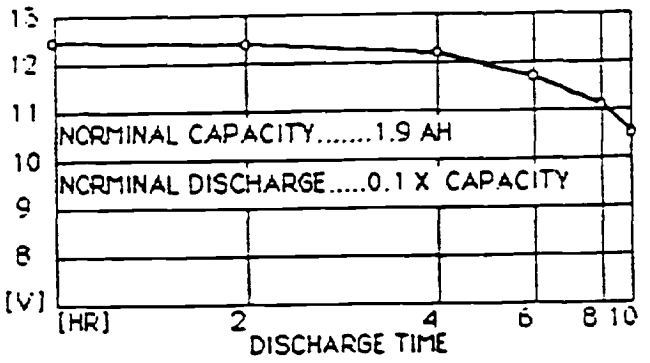
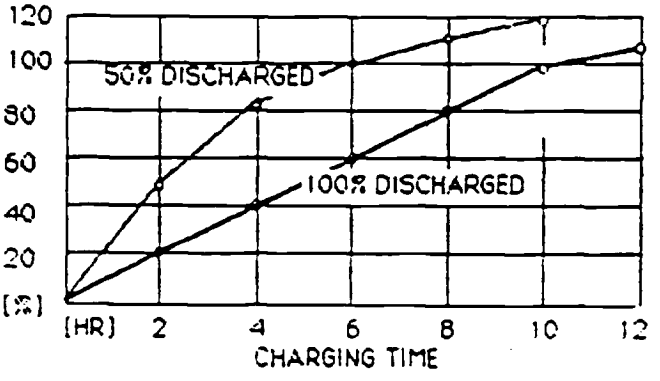


FIGURE 1(b). CHARGING CHARACTERISTICS



A7.3-2

Pump Check

Depress the PUMP switch, and you will hear the pump operate. Place your finger over the sample probe inlet and note the pump will "load down," indicating no major leaks in the sampling system. Turn off the POWER switch before proceeding.

Photoionization Detector (PID) Check

NOTE: Refer to the appropriate section for checking the specific detector options you have purchased. Insert the PID reaction module, (the one with the lamp window visible through the base), observe the keyway when inserting. Replace the reaction chamber cap. CAUTION: do not overtighten. The module is properly sealed as soon as some resistance is felt. Turn on the POWER switch, and note through the hole in the chamber cap that the ultra violet lamp is on. The display again reads [E E E E] until you depress the MODE switch once, at which time it will display background ionization counts. If the display reads [H I], wait a few minutes for the sampling system to flush and the count rate to drop. If it does not, place the sample probe in an area where it will sample uncontaminated air. The standard lamp will ionize most gases with an ionization potential at or below 10.6 electron volts. Turn off the power switch and remove the PID reaction module before proceeding to the "Flame Ionization Detector Check."

Flame Ionization Detector (FID) Check

Insert the FID reaction module, (the one with the black anodized base), again observing the keyway. Replace the cap and again do not overtighten. Plug the quick connect into the hydride container or other hydrogen source such as a compressed gas cylinder or hydrogen generator. Set the SIP 1000 regulator at 15 to 20 psi; this corresponds to a flow rate of approximately 50 cc/min. Turn on the POWER and PUMP, and wait about 30 seconds for the hydrogen to flush the column and reach the flame jet. The display will again read [E E E E]. Depress the MODE switch, and the display will read between [0 0 0 0] to [0 0 0 5]. Depress the IGNITE switch, and listen for the FID to ignite. You will hear a slight "pop," and the display will indicate background count. Reduce the pressure to between 5 and 7 psi for normal operation. CAUTION: Excessive hydrogen flow will cause the flame to burn too hot; this causes high background noise and may result in damage to the reaction chamber or module.

NOTE: Turn off the power and insert the reaction module you wish to calibrate before proceeding.

Thermal Conductivity Detector (TCD)

The TCD reaction module is only used in the gas chromatograph configuration and will be discussed in specific application notes.

NOTE: Turn off the POWER and insert the reaction module you wish to calibrate before proceeding.

Calibration

As with any analytical instrument, the accuracy of your results will directly relate to the calibration method, accuracy of the standards and technique. It is outside the scope of this manual to discuss the details of the many calibration methods. It is up to the user to select the method, calibration standards and technique best suited to the application. Basically, CALIBRATION is divided into two categories, ZERO and SPAN.

NOTE: Always observe the following for the most accurate results regardless of the method used:

1. Always sample the zero and span gases at ambient pressure to assure the same flow rate as the instrument normally pumps through the system, i.e., never pressurize the inlet or allow the pump to create a partial vacuum by impeding pump flow.

2. Always select the zero gas and the majority component in the span gas to be the same as the atmosphere to be sampled, i.e., use pure air as the zero gas and an air calibration mixture if you intend to look for contaminants in air. Conversely use nitrogen and nitrogen mixtures if you intend to monitor contaminants in a nitrogen atmosphere.

3. Always select a calibration mixture that is reasonably close in concentration to the average levels you would expect to find in the atmosphere to be monitored.

Zero

1. Turn the POWER and PUMP switches on and depress the MODE switch once so that you are monitoring background count. Allow the SIP 1000 to warm up for approximately 15 minutes.

2. Sample a pure gas source as described above. When the count rate has stabilized at its lowest value, depress MODE once more to zero the unit. If there is any down-scale drift, as indicated by a negative reading on the display, depress the set switch to re-zero. There is no limit on how many times you can re-zero during this process. What the unit is doing is storing the sum of both the zero and re-zero readings for subtraction from subsequent readings. This updates the "zero."

Span (Refer to Figure 2)

1. Sample an appropriate calibration standard as previously discussed and wait for the count rate to increase and stabilize.

2. Depress the MODE switch and note that the least significant digit (LSD) on the display is now blank. Enter the value of your calibration standard as follows: EXAMPLE, 14.5 ppm of Benzene, balance air,

   a) Select 5 for LSD with the SET switch and depress MODE once to enter. The third digit is then blank.

   b) Select 4 with the SET switch and depress MODE to enter. The second digit is then blank.

c) Select 1 with the SET switch and depress MODE to enter. The first digit is then blank.

d) Select 0 with the SET switch and depress MODE to enter. CALIBRATION IS NOW COMPLETE.

Recall (Refer to Figure 3)

After calibration has been completed, the instrument is ready to use in the monitoring mode. However, it is suggested that you recall and record the values you have entered and stored for background counts, span counts, and calibration value. You will note that the background counts stored is the sum of the counts zeroed and any rezero counts.

Recalibrate

The frequency with which you should recalibrate the SIP-1000 is a function of operator judgment and is dictated by the desired accuracy, environmental conditions and monitoring requirements. To reduce recalibration frequency, the unit has been designed to minimize long-term drift with changes in environmental conditions. Because it is many times difficult or even impossible to have the necessary equipment available for accurate on-site calibration, the following are available options:

1. An operator programmable microprocessor that stores the program for up to 10 years with the power off.

2. An electronic calibrator to dial in the values recorded as suggested previously. This device replaces the reaction module to simulate detector response and can also be used to change response factors as may be required. In addition, it is a very useful diagnostic tool.

Maintenance

General Information

The unit should be periodically cleaned to avoid the build-up of particulates, moisture, and other foreign materials that may affect operation. Dust, moisture, or other liquids allowed to accumulate in the plumbing lines, probe or detector elements could seriously damage the unit, or at a minimum, cause restriction and/or coat surfaces that would degrade accuracy. Always clean and perform routine maintenance before storage. Carefully pack the unit in the carrying case with all accessories and store in a dry, clean area. Avoid locations that may be exposed to severe environmental conditions such as the trunk of your vehicle.

FIGURE 2. PROGRAMMING

DESCRIPTION	MODE	DISPLAY	SET
PROGRAM ERASED	☐	E E E E	☐
BACKGROUND COUNT (SAMPLING ZERO GAS)	■	0 1 5 2	☐
ZERO BACKGROUND	■	0 0 0 0	☐
BACKGROUND DRIFT (IF ANY)	☐	- 0 0 3	☐
REZERO	☐	0 0 0 0	■
SPAN COUNTS (SAMPLING CAL.GAS)	☐	0 6 8 4	☐
ENTER CAL. VALUE	■	0 0 0.	☐
REPEAT FOUR TIMES TO ENTER ALL DIGITS	☐	0 0 0.5	▒
	■	0 0 .5	☐
READING CAL. UNITS (PPB,PPM OR %)	☐	1 4.5 0	☐

NOTES: 1. ■ MOMENTARILY DEPRESS

2. ▒ SELECT 0 THROUGH 9

3. ☐ DO NOT DEPRESS

4. ALTHOUGH THE FRONT PANEL READS PPM, THE UNIT CAN BE CALIBATED IN: PPB, PPM OR % FROM (000.1 TO 999.9)

FIGURE 3. RECALL

DESCRIPTION	MODE	DISPLAY	SET
BACKGROUND COUNT STORED	■	0149	□
SPAN COUNTS STORED	■	0684	□
CAL. VALUE STORED IN PPB, PPM OR %	■	014.5	□
SAMPLING MODE	■	27.31	□
RECALLS HIGHEST READING	□	68.42	▨
SAMPLING MODE	□	5.208	□
BELOW THE ZERO VALUE STORED	□	LO	□
EXCEEDED THE DYNAMIC RANGE	□	HI	□
HOLD FOR 3 SEC. TO ERASE PROGRAM	▨	----	□

NOTES: 1. ■ MOMENTARILY DEPRESS

2. ▨ (SET) RESETS WHEN HELD 3 SEC.
(MODE) HOLD TO ERASE PROGRAM

3. □ DO NOT DEPRESS

4. ALTHOUGH THE FRONT PANEL READS PPM, THE UNIT CAN BE CALIBATED IN: PPB, PPM OR % FROM (000.1 TO 999.9)

Routine Maintenance

1. CHARGING: Always "top" charge the battery and hydride when not in use and before storage.

2. CLEANING: Remove all items from the carrying case. Remove the partitions, if necessary, and wipe out the inside of the case with a damp cloth. Clean the outside with a lint roller, use a brush, soap and water, if required. Wipe down the unit and all accessories with a damp cloth. NEVER use solvents as they may damage the case, but more important, they will be detected during operation. Avoid getting any moisture in open fittings, tubing, connectors or reaction chamber. Inventory all items and repack in the carrying case.

3. PROBE FILTER: The inlet end of the probe is loosely packed with glass wool to prevent particulates from entering the system. Periodically, push it out with a fine wire from the tip end and replace.

4. INJECTION PORT: When injecting samples in the chromatograph mode, always use a syringe with a minimum needle length of 2 inches. Periodically, remove the needle guide and check the condition of the septa. Replace as required to avoid leaks.

5. REACTION MODULES: A decrease in sensitivity, excessive drift or noisy signal are indicators that the PID or FID modules require cleaning. Clean the base of the FID or window on the PID with a Q-tip soaked in Ethanol. Rinse with de-ionized water and bake at 100°C until dry.

6. LEAKS: Whenever the column is changed or fittings reconnected, there is always the possibility for leaks. To avoid leaks, NEVER overtighten fittings. To check for leaks, disconnect the column from the regulator output and plug the fitting. Connect the hydride and set the pressure regulator at 30 psi. Disconnect the hydride from the quick connect. The pressure gauge should remain at 30 psi. If not, check all fittings and injection port with a leak test soap solution. Take corrective measures and reconnect the column.

ASTM PROCEDURES USED FOR AREA AIR SAMPLING

ASTM Standard Practices will be followed to collect both airborne particulates and organic vapors. These procedures will not be reproduced in this Appendix due to copyright laws. A working copy will be available in the field for use as a reference.

One sample location will be set upwind and one station downwind of Air Force Plant 4. Particulate filters and organic vapor tubes will be set to sample for a 24 hour period, once per week for a period of four months. After the 24 hour sample period is complete the samples will be retrieved. New particulate filters and organic sample tubes will be prepared and placed prior to the next sampling event as per the ASTM methods.

D-4096-82 Standard Practice for
Application of the Hi-VOL (High-Volume) Sampler Method for Collection and Mass Determination of Airborne Particulate Matter

D-3686-84 Standard Practice for
Sampling Atmospheres to Collect Organic Compound Vapors (Activated Charcoal Tube Adsorption Method)

Protocol for Measuring Vapor Surface-Flux and Soil-Gas Concentrations From Volatile Organic Compounds

INTRODUCTION

Organic compounds contaminating the groundwater or the soil and which are sufficiently volatile to migrate through the soil, may escape at the soil/air interface. Measurements of the rate of which volatile organic compounds escape at the soil surface and the concentration of the compounds in the soil atmosphere may be used to assess population and occupational health effects, delineate areas of contamination, and evaluate the effectiveness of a remedial action process at hazardous waste sites.

1. SCOPE

1.1 This document is intended to provide the user with a protocol for the measurement of organic vapor flux at the soil/air interface and the concentration of organic compounds in the soil atmosphere. Considerations for performing surface-flux measurements using a passive accumulator device and an adsorption canister, and active soil-gas sampling methods are emphasized.

1.2 Accumulator devices are used to determine the instantaneous flux based on short term measurements. Analytical measurements can be performed in the field using the Photovac TIP total organic vapor analyzer or a Photovac portable gas chromatograph. Measurements obtained using the Photovac TIP should be designated a nonreferee method while measurements obtained by the gas chromatograph may be designated as a referee method.

1.3 Adsorption canisters are used to measure the average flux over periods up to seven days. Samples collected with the adsorption device are returned to the UNC Analytical Laboratory for analysis by gas chromatography. This method is designated as a referee method.

1.4 Soil gas concentrations may be determined in the field by analyzing the soil gas directly from the sample probe using the Photovac TIP or a specific indicating detector. Samples may also be collected in an evacuated 125 ml glass bulb and analyzing with the Photovac portable gas chromatograph at a field laboratory. Samples submitted to UNC Analytical Laboratory for analyses are collected on a sorbent and analyzed by gas chromatography. Procedures using the Photovac TIP should be designated a nonreferee method while procedures performed using the Photovac gas chromatograph and laboratory analytical procedures may be designated as referee methods.

2. REFERENCED DOCUMENTS

2.1 Karp, K., 1988. FY-1988 Annual Report on Volatile Organic Compounds Vapor Surface-Flux Measurements, WM-M-88-2, Internal Technical Report, UNC Geotech, Grand Junction, Colorado.

2.2 Karp, K., 1989. FY-1989 Annual Report on Volatile Organic Compounds Vapor Surface-Flux Measurements, EC-R-89-2, Internal Technical Report, UNC Geotech, Grand Junction, Colorado.

2.3 Karp, K., 1989. Rapid Groundwater and Soil-Gas Sampling, EC-R-89-1, Internal Technical Report. UNC Geotech, Grand Junction, Colorado.

3. SIGNIFICANCE AND USE

3.1 Proper use of the surface-flux and soil-gas approach requires an understanding of the site hydrogeologic environment, chemical and physical properties of the organic compounds, meteorologic conditions, and limitations of the analytical instrumentation and sampling equipment. Total organic analyzers (i.e. TIP) are non-specific can cannot be used alone to distinguish a response from a non-target compound. However, these instruments can be used by personnel less skilled than required to perform quantitative measurements by gas chromatography. Conversely, the ease of performing the analytical measurement with a total organic analyzer tends to oversimplify the method and may lead to misinterpretation of the results by those unfamiliar with the limitations of the method.

3.2 Temporal surface vapor flux can be determined by sealing the open end of a 3.1 L chamber to the surface of contaminated soil and monitoring the concentration build-up. The time rate of change in concentration accumulated inside the chamber is related to the flux. Advantages to this approach are that a large number of screening measurements can be performed in the field, relatively fast and inexpensively, without disturbing the site. Because of the extreme variations that can occur in the temporal surface-flux, values obtained over different time periods are generally not comparable. Use of a base station to normalize data sets is not recommended. Measurements of this type should be performed under the same sampling conditions to optimize results.

3.3 Adsorption canister devices are sealed to the surface of the soil several days before returning the sample to the laboratory for analysis. Absolute surface flux values are calculated from measurements of the mass of volatile organic compounds (VOCs) collected on the sorbent, collection efficiency, sampling area of the collector, and exposure time. A major advantage to this approach is that quantitative measurements can be conducted for most of the VOCs on the EPA's priority pollutants list. Canisters are simple, rugged, and can be deployed and collected by non-technical personnel. Temporal variations in the surface-flux can be averaged out to some degree using this method.

3.4 Small diameter hollow probes inserted several feet below the surface of the ground are used to collect soil-gas samples. Probes can be inserted by manually driving the probe with a slide hammer or pressing the probe into the soil with a hydraulically powered mechanical system. For shallow sampling (4 feet or less) manual probing is preferred because of the ease and speed of obtaining samples. Difficult topographic access and areas restricting the use of power equipment (i.e. close to petroleum storage tanks) preclude the use of the hydraulic system. Deep sampling (over 4 feet) or when it is necessary to first penetrate a cover (i.e. asphalt, concrete) the hydraulically powered system should generally be used.

The user should be aware that a greater potential for cross-contamination exists when using the hydraulic system. Contamination can result from exhaust

fumes and, oil and grease used to lubricate the hydraulics. In addition, use of the hydraulic system has greater potential for creating a lose seal between the probe and the soil, resulting in a sample diluted with atmospheric air.

When the probe is at the desired depth, soil-gas may be analyzed directly for a quick and qualitative indication of the presence of potential contaminants by use of a total organic analyzer or a specific detector tube, attached to the sample probe. For quantitative measurements samples are collected in a glass bulb or on a sorbent bed and analyzed by gas chromatography.

4. HAZARD ANALYSIS

4.1 No hazards requiring controls have been identified with this protocol. Controls associated with the use of hazardous material for the calibration and decontamination of analytical instrumentation and the use of power equipment for collecting samples may be found in the specific procedure. It is the responsibility of the user of a specific procedure to establish appropriate safety, health, and shipping practices and to determine the applicability of regulatory limitations prior to its use.

5. LIMITATIONS

5.1 Interpretation of the measurement results, determining appropriate sampling locations, and selecting the appropriate measurement and sampling method to employ is dependent on the chemical and physical properties of the organic compound, vadose zone characteristics, hydrogeologic parameters, meteorologic conditions, and limitations of the analytical instrument.

5.1.1 Chemical and Physical Properties.

5.1.1.1 Organic compounds contaminating the groundwater or the soil are more likely to be detected using either a surface-flux or a soil-gas method if the compounds have relatively high vapor pressures and low aqueous solubilities. The ratio of the partial pressure in the vapor to the concentration in the liquid is expressed as Henry's law constant. Thus organic compounds having relatively high Henry's law constants are more conducive for partitioning from the aqueous phase into the soil gas. Compounds having high vapor pressures and high solubilities may be detected if the contamination results from a surface or vadose zone spill.

5.1.1.2 The rate of which a volatile organic compound escapes at the soil/air boundary is governed by the concentration gradient of the compound in the soil. A gradient established between the source of contamination and the ground surface is dependent on the vapor concentration at the source and the path length the compound has to diffuse to reach the surface. Contamination occurring in relatively low concentration from a relatively deep zone will be more difficult to detect by the surface-flux method. Conversely, relatively high concentrations of a contaminant occurring near the surface of the ground may not be detected by deep soil-gas sampling.

5.1.1.3 Organic compounds diffusing through the soil may be adsorbed by organic carbon matter (i.e. vegetation) which will tend to reduce soil gas concentrations and the surface flux. The organic carbon distribution

coefficient which relates the affinity for a compound to adsorb onto organic carbon can be used to evaluate this potential effect.

5.1.1.4 The density of a compound occurring in the groundwater will have an important influence on the success of a particular soil-gas or surface flux measurement method. Compounds with specific gravities greater than one may sink through the saturated zone. Organic compound with specific gravities less than one and having a high Henry's constant would be considered more favorable for being detectable.

5.1.1.5 Melting points of particular organic compounds and the soil temperature should be considered when evaluating if a particular compound has potential to be present in the vapor phase. Compounds with melting points above ambient soil temperature will remain mostly in the solid phase.

5.1.1.6 Biodegradation of some organic compounds can occur if soil temperature, pH, oxygen concentrations, and nutrient conditions are optimum. Organic compounds may degrade at a faster rate than they can migrate away from the area of contamination, greatly reducing the efficiency of the soil gas or surface flux measurement methods.

5.1.2 Vadose Zone Characteristics.

5.1.2.1 The porosity and moisture content of the soil will determine the extent of migration of a particular organic vapor. Diffusion coefficients for organic vapors are approximately 10,000 times lower in water than they are in air. Increasing the moisture content of a soil will therefore decrease the diffusivity of the organic vapor. Increasing the moisture content reduces the air filled porosity, while at the same time tends to increase the soil-gas concentrations and decrease the surface-flux.

5.1.2.2 Site lithology will effect the soil-gas vapor concentrations, surface-flux, and diffusion distance. Vapor fluxes through unconsolidated and dry lithology such as course sand or gravel may be relatively high, while finer and more dense material such as clay, can be effective diffusional barriers. Both lateral and vertical changes in lithology and the thickness of the vadose zone (diffusion path length) overlying the contaminant source should be considered a factor in deciding the appropriate sampling depth for soil gas analyses.

5.1.3 Hydrogeologic Parameters.

5.1.3.1 Groundwater flow direction and velocity should be considered when deciding on where to locate soil-gas or surface-flux sample locations to define a boundary of a groundwater contaminant plume. Groundwater flow direction will influence the areal extent of contaminant transport while the velocity will determine the degree of contaminant dilution.

5.1.3.2 Fluctuations in the ground-water level may effect the lateral or horizontal vapor migration pattern. For example, organic contaminants floating on the surface of a rising water table may be exposed to more permeable lithology allowing greater vapor migration.

5.1.4 Meteorological Conditions.

5.1.4.1 Surface-flux measurement results can be affected by temporal meteorological changes. Decreasing barometric pressure combined with windy conditions may deplete the near surface soil gas concentrations to levels that are below detection limit. Precipitation may increase the moisture content in the vadose zone to significantly attenuate the surface flux. One way to reduce temporal meteorological effects would be to perform surface-flux measurements only after a 48 hour period of stable weather conditions. Increasing the depth soil-gas samples are obtained will also tend to dampen the effect. Seasonal variations in meteorological conditions can also effect soil-gas concentrations and surface-flux. During the winter and summer nights, soil temperature gradients may exist and thermal diffusion of organic vapors to the surface will by induced. When ambient temperatures freeze the soil surface, a capping effect is produced which tends to increase soil-gas concentrations and decrease the surface-flux.

6. INTERFERENCES

6.1 The Photovac TIP total organic vapor analyzer is non-specific and cannot be used alone to distinguish a response from a non-target organic vapor. Interference can occur from man made or naturally occurring non-target compounds which have an ionization potential in the energy range of the ultraviolet lamp used in the TIP. Interference will also occur when the soil gas atmosphere has a reduce oxygen content which may lead to a false indication of contamination. Temperature and humidity can effect the linearity of the instrument.

6.2 Interference using the Photovac portable gas chromatograph will result from lower boiling point compounds that will elute through an ambient temperature chromatographic column and having an ionization potential in the energy range of the ultraviolet lamp used in the 10S70. The degree of interference is greater for those compounds having similar retention times to the compounds of interest.

6.3 Specific indicator tubes relate the length of a stain produced by a colorimetric reaction on a sorbent to the concentration in the atmosphere sampled. However since a common chemical reaction is used for detecting organic compounds most tubes are not all that specific. Evaluating a potential interference from non-target organic compounds requires a specific knowledge of the reagent and the corrections to the tubes calibration scale.

6.4 Interference can result due to cross-contamination from sampling equipment. Visible contamination on soil-gas sample probes can usually be removed by a wire brush followed by a chemical wash. Flushing the sample probes with an ultra pure chromatographic grade air after each sample has been collected is mandatory. Routine method and trip banks should always be collected even if cross-contamination is not suspected.

7. PRECISION AND BIAS

7.1 Using the accumulator can for an accumulation period of 2 minutes will result in a reported flux biased 1 percent low. The bias will increases to approximately 11 percent for a 20 minute accumulation period. The precision, expressed as the coefficient of variation (s/x), for flux measurements performed on a controlled laboratory model having a relatively high and constant organic vapor surface flux, is less than 20 percent. Precision for field measurements can be over 60 percent in some instances, since a true duplicate measurement can not be obtained.

7.2 Similarly the precision of the adsorption canister was also determined by replicate measurements on a controlled laboratory model. The precision, expressed as the coefficient of variation (s/x), is approximately 18 percent, but can also increase up to 40 to 60 percent for field measurements.

7.3 The reproducibility of soil-gas analyses performed at the same sample location from the same sample probe is generally less than 10 percent [coefficient of variation (s/x)] for the Photovac gas chromatograph. A coefficient of variation of 20 to 30 percent is typical for replicate soil-gas analyses performed using the Photovac TIP or a colorimetric specific indicator tube.

8. PATENTS

8.1 Invention disclosures for the accumulator device and the adsorption canister were submitted to the U. S. Department of Energy, Office of Patent Counsel.

Standard Practice for Installation of Soil-Gas Sampling Probes

INTRODUCTION

Soil-gas surveys are often performed to delineate areas of potential contamination and to evaluate the effectiveness of a remedial action process at hazardous waste sites. Samples are collected from hollow probes inserted into the soil at a predetermined sampling depth. For screening areas of potential contamination sample probes can be rapidly installed up to 20 feet in ideal soils. Sample probes can also be left in place for subsequent sample collecting if long-term monitoring is required.

1. SCOPE

1.1 This document is intended to provide the user with a procedure to install soil-gas sample probes. Procedures are outlined to install probes either manually or with a hydraulically powered system.

2. REFERENCED DOCUMENTS

2.1 Karp, K. E. 1989. Rapid Groundwater and Soil-Gas Sampling, EC-R-89-1, Internal Technical Report. UNC Geotech, Grand Junction, Colorado.

2.2 Geoprobe Model 8-A Operator and Maintenance Manual, Geoprobe Systems, 607 Barney, Salina, Kansas, 67401, April 7, 1989.

2.3 Karp, K. E. 1990. Standard Procedure for Collecting Volatile Organic Compounds in Soil-Gas, Technical Procedure, UNC Geotech, Grand Junction, Colorado.

3. SIGNIFICANCE AND USE

3.4 Small diameter hollow probes inserted several feet below the surface of the ground are used to collect soil-gas samples. Probes can be inserted by manually driving the probe with a slide hammer or pressing the probe into the soil with a hydraulically powered mechanical system. For shallow sampling (4 feet or less) manual probing is preferred because of the ease and speed of obtaining samples. Difficult topographic access and areas restricting the use of power equipment (i.e. petroleum storage tanks) preclude the use of the hydraulic system. Deep sampling (over 4 feet) or when it is necessary to first penetrate a cover (i.e. asphalt, concrete) the hydraulically powered system should generally be used.

4. HAZARD ANALYSIS

4.1 Procedures discussed in this practice may involve the use of hazardous material for the calibration and decontamination of analytical instrumentation and the use of power equipment for installation of sample probes. It is the responsibility of the user of this practice to establish appropriate safety, health, and shipping practices and to determine the applicability of regulatory limitations prior to its use.

4.2 A major safety concern installing sample probes manually or hydraulically is the possibility of encountering buried utilities. Safe-

guards are provided by requiring proper work permits to be secured and a UNC utility survey completed prior to any probing.

4.3 The major safety concern using the manual probe is the possibility that the hammer may separate from the probe. A retaining ring has been incorporated into the design to reduce this possibility.

4.4 The hydraulically powered sample probe is relatively easy to operate and safe when used properly. Proper use of this equipment is maximized by providing training to the operators. No one shall operate this equipment unless orientation, qualification, and relevant job training has been documented. In addition it is the responsibility of all operators using the practice to read and become familiar with section 11 of this document titled Operation Safety Cautions.

5. EQUIPMENT AND SUPPLIES

5.1 Manual Probe

5.1.1 Six-foot long, hollow, steel sample probes.
5.1.2 Three pound slide hammer.
5.1.3 Expendable drive points, plastic or metal depending on the nature of the investigation.
5.1.4 Retainer disk.
5.1.5 Sample manifold.
5.1.6 Cylinder of ultra-pure ambient monitoring air.
5.1.7 Regulator to fit ultra-pure ambient monitoring air cylinder.
5.1.8 Steel-toed shoes.
5.1.9 Ear protection.
5.1.10 Cloth or leather gloves.

5.2 Hydraulic Powered Probe

5.2.1 Geoprobe model 8A Hydraulic Hammer-Drill mounted in the rear of a cargo van or 4 wheel drive vehicle.
5.2.2 Wire brush.
5.2.3 Grease gun.
5.2.4 Fuses.
5.2.5 Three-foot long sections of drill rods with conventional threads.
5.2.6 Drive and pull caps.
5.2.7 Hammer anvil and drive point holder.
5.2.8 Carbide tipped drill bit to penetrate asphalt.
5.2.9 Expendable drive points, plastic or metal depending on the nature of the investigation.
5.2.10 Retractable sample point.
5.2.11 Soil-gas sampling cap.
5.2.12 Hydraulic fluid, filters, and wrench set.
5.2.13 Cylinder of ultra-pure ambient monitoring air.
5.2.14 Regulator to fit ultra-pure ambient monitoring air cylinder.
5.2.15 Steel-toed shoes.
5.2.16 Safety glasses with side shields or goggles.
5.2.17 Ear protection.
5.2.18 Heavy leather gloves.

5.2.19 Fire extinguisher.
5.2.20 Wheel chocks for all four wheels.
5.2.21 Exhaust pipe extension.

6. INSTALLATION PROCEDURES

6.1 Manual Sample Probe

6.1.1 Obtain proper engineering work permits. This usually involves written permission from the organization responsible for the administration of civil engineering activities stating that the proposed area to be surveyed has been checked and cleared for utilities. Other site specific permits may also be appropriate.

6.1.2 Identify specific sample locations by marking each location with a survey flag or equivalent method of identification.

6.1.3 Obtain a utility survey at each specific sample location as per standard UNC procedure.

6.1.4 Place an expendable drive point into the nonthreaded end of the sample probe.

6.1.2 Place the end of the probe containing the drive point at the sample location.

6.1.3 Slide the 3-pound hammer over the top of the probe.

6.1.4 Thread the retaining disk on the top of the probe. This is a safety measure to insure that the 3-pound hammer does not separate from the probe during installation. Separation could result in serious injury to the user.

6.1.5 Slowly slide the hammer to the top of the probe and with one quick smooth and even motion quickly bring the hammer down to the lower retaining ring. This ring is a permanent part of the sample probe. Repeat this motion until the probe is at the desired depth.

6.1.6 Reverse step 6.1.5 so that the probe is pulled up out of the hole to a distance of 4-inches. This allows the expendable drive point to disengage from the probe and allows a cavity to draw a sample from.

6.1.7 Remove the upper retaining ring.

6.1.8 Thread the sampling manifold to the top of the probe.

6.1.9 Collect the sample as described by a specific sampling procedure or a work plan.

6.1.10 Remove the sampling manifold.

6.1.11 Thread the upper retaining disk to the top of the probe.

6.1.12 Reverse step 6.1.5 so the probe is pulled out of the sample hole.

6.1.13 Flush the sample probe with ultra pure air at a rate of 2 Lpm for 30 seconds.

6.2 Hydraulically Powered Sample Probe

6.2.1 Obtain proper engineering work permits. This usually involves written permission from the organization responsible for the administration of civil engineering activities stating that the proposed area to be surveyed has been checked and cleared for utilities. Other site specific permits may also be appropriate.

6.2.2 Identify specific sample locations by marking each location with a survey flag or equivalent method of identification.

6.2.3 Obtain utility survey at each specific sample location as per UNC procedure.

6.2.4 Position the vehicle so that the rear bumper is centered approximately 2 feet from the sample location.

6.2.5 Set the truck's parking brake.

6.2.6 Place chocks around all four tires.

6.2.7 Install the exhaust extension so that the engines fumes are directed away from the rear of the vehicle.

6.2.8 Ensure that the hydraulic switch is in the OFF position.

6.2.9 Secure the rear doors in an open position and turn the oil cooling fan switch to ON.

6.2.10 Check the hydraulic fluid level. Fluid should be within 1/2 inch of the mark on the dipstick.

6.2.11 Request all personnel to move at least 6 feet from the vehicle.

6.2.12 Turn the hydraulic switch to the middle position (low throttle with the hydraulic system engaged).

6.2.13 Extend the hydraulic ram horizontally out through the rear of the vehicle by pushing the EXTEND and the FOOT controls in the down position. The ram should be extended to maximum length to clear the top of the vehicle when rotated in the vertical position.

6.2.14 Rotate the ram into a vertical position by pushing the FOLD lever in the down position.

6.2.15 Retract the horizontal ram 6-12 inches back into the vehicle by pushing the EXTEND control in the up position.

6.2.16 Lower the foot to the ground surface by pressing the FOOT lever.

6.2.17 Turn the hydraulics off by placing the switch to the DOWN position.

6.2.18 Insert the hammer anvil into the drill and secure with the hammer latch. Make sure that the hammer rotation control is in the middle position indicating no rotation.

6.2.19 Prepare the first probe by inserting an expendable tip into the lower end and screwing a drive cap on the top of the probe.

6.2.20 Turn the hydraulic switch to the middle position and raise the ram far enough to stand the probe in a vertical position under the hammer anvil.

6.2.21 Holding the prepared probe in a vertical position under the hammer anvil, carefully lower the ram, guiding the probe into the recess in the hammer anvil.

6.2.21 Pull the PROBE lever back to slowly and carefully lower the ram a few inches into the soil while maintaining the probe in a near vertical position as possible.

6.2.22 Press the probe slowly to the desired depth using the PROBE lever. Hammer only if necessary to avoid enlarging the hole and abusing the equipment. This will require that the hydraulic switch be in the up, high throttle position. If hammering is required to penetrate more difficult material, raise the foot, turn the hammer rotation switch to the left, and hold the HAMMER lever all the way down while controlling the pressure on the drill stem with the PROBE lever.

6.2.23 If additional depth is required raise the ram using the PROBE control lever to allow attachment of another probe. If not go to step 6.2.27.

6.2.24 Turn the hydraulic switch to the OFF position.

6.2.25 Unscrew the drive cap from the driven probe and screw on the next probe section. Attach the drive cap to the top of the new probe section.

6.2.26 Turn the hydraulic switch to the middle position and lower the ram carefully while guiding the drive cap into the recess in the hammer anvil. The ram can be realigned with the probe if necessary by raising the foot and retracting the ram.

6.2.27 At the desired depth, raise the ram 4 inches from the bottom of the hole, using the PROBE control lever.

6.2.28 Turn the hydraulic switch to the OFF position (down position). Relieve the hydraulic pressure on the hammer anvil by pressing the HAMMER lever down. Release the hammer latch and remove the anvil.

6.2.29 Remove the drive cap from the probe.

6.2.30 Thread on the soil-gas sampling cap on the drive probe.

6.2.31 Obtain the proper soil-gas sample according to a specific sampling procedure (TBD) or a project work plan.

6.2.32 Remove the soil-gas sampling cap.

6.2.33 Thread on the pull cap.

6.2.34 Turn the hydraulic switch to ON (middle position) and lower the ram until the hammer latch can be rotated over the pull cap.

6.2.35 Pull the probe sections out of the hole by pressing the PROBE control up. The high throttle may be engaged during this step by temporarily placing the hydraulic switch in the up position.

6.2.36 Flush each section of sample probe with ultra pure air at a rate of 2 Lpm for 30 seconds.

6.2.37 Remove dirt from the outside of the probe with a wire brush and cloth before storing it in the rack next to the Geoprobe.

6.2.38 Verify that the hammer anvil or other tool has been removed from the machine before folding down the ram to the horizontal position.

6.2.39 Adjust the FOOT ram so that the top is about 5 inches below the probe cylinder shaft. Extend the horizontal ram away from the truck and then carefully fold the vertical ram to the horizontal storage position. Retract the ram into the vehicle for transportation.

6.3 Operation Safety Cautions

6.3.1 Always set the vehicle parking break before starting probing operations.

6.3.2 Always extend the probe unit out from the vehicle before folding the probe unit out.

6.3.3 Assembly and disassembly of probe sections beneath the machine shall always be performed by the person operating the hydraulic controls. Never put your hand on top of a probe section while is under the machine. Always turn the hydraulic system off when assembling or disassembling probe sections.

6.3.4 Operators shall always wear OSHA approved steel toed shoes. Keep your feet clear of the machine FOOT.

6.3.5 Turn off the hydraulic system while inserting the HAMMER anvil for driving.

6.3.6 Wear safety glasses at all times during the operation of this equipment.

6.3.7 Never exert down pressure on a probe section so as to lift the machine FOOT over six inches off the ground.

6.3.8 Never exert down pressure on a probe section so as to lift the rear tires of the vehicle off the ground.

6.3.9 Always remove the HAMMER anvil or other tool from the machine before folding the machine to the horizontal position.

6.3.10 Use caution when operating over dry grass since the vehicle catalytic converter is hot and may present a fire hazard.

6.3.11 Operators shall wear ear protection. OSHA approved ear protection for sound levels exceeding 85 dBA is recommended.

6.3.12 Know the location of buried or covered utilities or services before you start to drill or probe.

6.3.13 Shut down the hydraulic system before attempting to clean or service the equipment. Accidental engagement of the machine may cause injury.

6.4 Maintenance

6.4.1 The Geoprobe Operator and Maintenance Manual contains the necessary information and procedures for servicing this machine. A permanent record book of repairs and periodic maintenance shall be kept in the vehicle.

6.4.2 Check the hydraulic fluid reservoir level at the beginning of each operating day. Maintain the oil level within one-half inch of the cold fill level on the dip stick. Appropriate oil for filling are listed in the operator and maintenance manual.

6.4.3 Grease should be applied to the derrick slide (two fittings on each side), and the derrick end of the fold cylinder (one fitting) on a weekly basis.

6.4.4 Check the oil cooling fan each day and make sure that it is operating properly.

6.4.5 This machine vibrates. Tighten bolts and hydraulic fittings at least monthly.

6.4.6 Keep the tool threads clean. Wire brush them to remove dirt after every use.

6.5 Training and Qualifications

6.5.1 The Geoprobe is fairly simple and safe to operate. However, to further minimize the possibility of injury or damage to the equipment, training in the proper use of the Geoprobe is required of all Geoprobe operators. All operators shall be trained through actual use by a Geoprobe Systems factory representative or a qualified UNC Geoprobe operator.

6.5.2 Qualification as a UNC Geoprobe operator will not be granted, however, to either experienced heavy equipment operators or to those who have completed the above orientation until a satisfactory level of proficiency is

demonstrated to a Geoprobe Systems factory representative, a qualified UNC Geoprobe operator, the ECRA manager, or the UNC drilling supervisor. Orientation, qualification, and relevant job training shall be documented by the operators organization.

Standard Procedure for Collecting Volatile Organic Compounds in Soil-Gas

INTRODUCTION

Soil-gas surveys are often performed to delineate areas of potential contamination, evaluate the effectiveness of a remedial action process, or assess population and occupational health effects at hazardous waste sites.

1. SCOPE

1.1 This document is intended to provide the user with a procedure to collect volatile organic compounds in soil-gas from a previously installed sample probe. Soil-gas concentrations may then be determined in the field by analyzing the soil gas directly from the sample probe using a Photovac TIP total organic analyzer or with a specific indicating detector. Samples may also be collected in an evacuated 125 mL glass sample bulb for analysis in the field with a portable gas chromatograph or collected on a sorbent and submitted to the UNC Chemistry Laboratory for analysis by gas chromotography.

2. REFERENCED DOCUMENTS

2.1 Photovac. 1986. TIP1 User's Manual. Photovac International Incorporated, 741 Park Avenue, Huntington, New York 11743, 34 p.

2.4 Karp, K. E. 1990. Protocol for Measuring Vapor Surface-Flux and Soil-Gas Concentrations from Volatile Organic Compounds, Technical Procedure, UNC Geotech, Grand Junction, Colorado.

2.5 Karp, K. E. 1990. Standard Practice for Installation of Soil-Gas Sampling Probes, Technical Procedure, UNC Geotech, Grand Junction, Colorado.

2.6 Spangler, R. R. 1990. Technical procedure for calibrating low volume sample pumps, UNC Geotech, Grand Junction, Colorado.

3. SIGNIFICANCE AND USE

3.1 Soil-gas samples may be analyzed directly in the field for a quick and qualitative indication of the presence of potential contaminants by use of a total organic analyzer or a specific indicating detector. For quantitative measurements samples are collected in a glass sample bulb and analyzed in the field using a portable gas chromatograph or collected on a sorbent bed and returned to the UNC Chemistry Laboratory for analysis by GC/MS.

4. HAZARD ANALYSIS

4.1 It is the responsibility of the user of this procedure to establish appropriate safety, health, and shipping practices and to determine the applicability of regulatory limitations prior to its use.

5. PRECISION AND BIAS

5.1 The coefficient of variation (s/x), for soil-gas measurements performed by methods described in this procedure are typically in the order of 25 percent.

6. EQUIPMENT AND SUPPLIES

6.1 Total Organic Vapor Method.

6.1.1 Photovac TIP.
6.1.2 Portable battery pack, 12 V.
6.1.3 Tedlar sample bags, 0.5 to 2.0 L volumes.
6.1.4 Calibration gas standard for analyte of interest.
6.1.5 Single stage gas regulator for calibration gas cylinder.

6.2 Specific Indicating Detector Method.

6.2.1 Specific indicator detector for analyte of interest.
6.2.2 Tygon tubing to connect the detector to the sample probe.
6.2.3 Hand vacuum pump.

6.3 Glass Sample Bulb Method.
6.3.1 125 mL glass sample bulb equipped with Teflon stopcocks and sample septum.
6.3.2 Hand vacuum pump.
6.3.3 Tygon tubing to connect the bulb to the sample probe.

6.4 Sorbent Tube Method.

6.4.1 Supleco Carbotrap 300 sorbent tube.
6.4.2 Low volume battery operated vacuum pump.
6.4.3 Tygon tubing to connect sorbent tube, vacuum pump, and sample probe.

7. PROCEDURES

7.1 Sample Collection Using A Total Organic Vapor Analyzer.

7.1.1 Calibrate the TIP (Photovac, 1986) to analyte of interest and record results in field record book or on field information data sheet according to project needs and requirements.
7.1.2 Connect the TIP to the top of previously installed sample probe manifold with Tygon tubing.
7.1.3 Subjectively determine the average and maximum response over a 60 minute measurement period.
7.1.4 Record the results in a field notebook or on a field data form as dictated by the project needs and requirements.

7.2 Sample Collection using colorimetric indicator tubes and pumps.

This procedure specifies the requirements and methods for using colorimetric tubes and pumps.

Colorimetric indicator tubes are used to indicate a specific chemical. Tubes are available in different detector concentrations. While in storage they should be refrigerated. Tubes should not be used that have exceeded their stamped expiration date.

FIELD CHECK

All colorimetric indicator tubes and pumps should be field checked prior to use. This field check tests for leaks in the following manner:

7.2.1. Insert unbroken tube into pumps tube holder.

7.2.2. If using a bellows-type pump, squeeze the bellows. After 60 seconds, bellows should not regain its original shape or chain should not be taut. If a pump fails this test, it should be serviced according to manufacturer's instructions.

OPERATION

The following steps are used for device operation:

7.2.3. Break off both tips of a fresh colorimetric indicator tube in break-off eyelet on front cover plate or in break-off husk (an accessory).

7.2.4. Insert tube into pump head with arrow on tube pointing towards pump.

7.2.5. Hold pump between thumb and the base of index finger with front cover plate contacting finger.

7.2.6. Insert end of tube into sample atmosphere or connect the intake end of the specific detector to the top of the previously installed sample probe manifold using Tygon tubing.

7.2.7. Compress the bellows completely with a squeezing motion assuring that the total volume of the bellows is used.

7.2.8. Release grip and allow chain to become taut, signifying that 100cc of air have been pulled through the tube. Be sure to keep the tube end in the sample atmosphere during the specified time.

7.2.9. Complete steps 5 and 6 as many times as the tube's instructions state.

7.2.10. Read concentration of material in air at stained / unstained interface.

7.2.11. If chemical concentration in air is very high compared to the sampling tube detection limits, the entire tube may change color instantly; colors should be verified by comparison with an unopened indicator tube.

7.3 Sample Collection Using Glass Bulbs.

7.3.1 Close the stopcocks on the 125 mL glass sample bulb.
7.3.2 Connect the hand vacuum pump to one of the stopcocks on the glass sample bulb with Tygon tubing.
7.3.3 Open the stopcock that is connected to the vacuum pump.
7.3.4 Pump the air out of the bulb using the hand vacuum pump.
7.3.5 Close the stopcock.
7.3.6 Connect the glass sample bulb to the top of a previously installed sample probe manifold.
7.3.7 Open the stopcock on the glass sample bulb to draw vapor from the accumulator.
7.3.8 Close the stopcock.
7.3.9 Repeat steps 7.3.2 to 7.3.8.
7.3.10 Record the sample date, time, and location in a field notebook or on a data information sheet as dictated by project needs and requirements.
7.3.11 Immediately return the sample bulb to a field laboratory for analysis by gas chromatography.

7.4 Sample Collection Using A Sorbent.

7.4.1 Connect the intake end of the Supelco Carbotrap 300 sorbent tube to the top of a previously installed sample probe manifold using Tygon tubing.
7.4.2 Connect the other end of the sorbent tube to the intake end of the low volume vacuum pump using Tygon tubing.
7.4.3 Turn on the vacuum pump.
7.4.4 Obtain a predetermined volume of sample. This volume shall not exceed 10 liters to prevent breakthrough and shall be based on the laboratory detection limit and expected soil-gas concentrations.
7.4.5 Place the sorbent tube inside its glass shipping container.
7.4.6 Label the shipping container with the sample collection date, time, and location.
7.4.7 Return the sample to the UNC Chemistry Laboratory for analysis.

COLORIMETRIC INDICATOR TUBES AND PUMPS - Dräger

This procedure specifies the requirements and methods for using Dräger tubes and pumps.

Dräger indicator tubes are used to indicate a specific chemical. Tubes are available in different detector concentrations. While in storage they should be refrigerated. Tubes will not be used that have exceeded their stamped expiration date.

FIELD CHECK

All colorimetric indicator tubes and pumps should be field checked prior to use. This field check tests for leaks in the following manner:

1. Insert unbroken tube into pump tube holder.

2. If using a bellows-type pump, squeeze the bellows. After 60 seconds, bellows should not regain its original shape or chain should not be taut. If a pump fails this test, it should be serviced according to manufacturer's instructions.

OPERATION

The following steps are used for instrument operation:

1. Break off both tips of a fresh colorimetric indicator tube in break-off eyelet on front cover plate or in break-off husk (an accessory).

2. Insert tube into pump head with arrow on tube pointing towards pump.

3. Hold pump between thumb and the base of index finger with front cover plate contacting finger.

4. Insert end of tube into sample atmosphere.

5. Compress the bellows completely with a squeezing motion assuring that the total volume of the bellows is used.

6. Release grip and allow chain to become taut, signifying that 100cc of air have been pulled through the tube. Be sure to keep the tube end in the sample atmosphere during the specified time.

7. Complete steps 5 and 6 as many times as the tube's instructions state.

8. Read concentration of material in air at stained / unstained interface.

9. If chemical concentration in air is very high compared to the sampling tube detection limits, the entire tube may change color instantly; colors should be verified by comparison with an unopened indicator tube.

WELL-LOCATION SURVEY

INTRODUCTION

This procedure describes the equipment and methodology used in the performance of a well-location survey. Both the location and elevation will be determined for all permanent monitoring wells installed at AFP 4.

REFERENCE DOCUMENTS

AGA Geotronics AB. *Geodimeter 12A Operating Manual*, Sweden, 40 p.

Asahi Precision Co., Ltd. *Pentax PX-06D/PX-10D EDM Theodolite Instruction Manual*, Tokyo, Japan, 40 p.

Carl Zeiss. *Th2 Theodolite-Instructions for Use and Adjustment*, Oberkochen, West Germany, 26 p.

Davis, R. E., and F. S. Foote, 1940. *Surveying-Theory and Practice*, McGraw-Hill Book Company, Inc., New York, N.Y., 1032 p.

Tokyo Optical Co., Ltd. *Topcon EDM Theodolite Geodetic Total Station GTS-2B Instruction Manual*, Tokyo, Japan, 75 p.

SIGNIFICANCE AND USE

Accurate coordinate locations are required for a permanent record of where samples were collected, accurate plotting of data, and computer modeling of data. The elevation data is used for determining not only the elevation of the ground surface at the well, but for also for determining an accurate elevation of the water table based on a known measuring-point elevation (which is usually the top of the surface casing).

APPARATUS

- Tripod
- Brunton Compass
- Optical Reading Compass
- Philadelphia Level Rod
- Range Pole
- Fargo Level Rod
- Steel Tapes
- Cloth Measuring Tapes
- Total Station (combined theodolite and electronic distance meter)
- Theodolite

- Geodimeter
- Portable Drawing Board
- Survey Stakes
- Other Survey Markers

PROCEDURES

Calibration

1. Although the theodolite does not generally need to be calibrated, it is possible that the tubular level, the circular level, or the line of sight may require adjustment. The theodolite is in adjustment if the tubular plate level will center on the midpoint, irrespective of the position in which the adjustment is rotated. The circular-level bubble should be centered through two right-angle turns of the theodolite. The line of sight is in adjustment if readings of a bearing on both faces differ by exactly 180 degrees.

2. The geodimeter is in adjustment when there is no deviation in measurement between a known standard distance and the distance as measured by the instrument. A deviation of several tenths of a foot or less does not require adjustment, but a correction factor should be noted and applied in those cases where extreme accuracy is required. When instrument readings become very erratic, the instrument must be serviced by a qualified technician.

3. The total station is adjusted using the methodologies described in the previous two steps. Each step pertains to its own function within the instrument.

Survey

1. Locate existing survey control points from previous investigations (brass caps, fence corners, building corners, existing monitoring wells).

2. Check the accuracy of the existing control-point locations by measuring the distance between two known locations via the total station or geodimeter (for measurements up to a maximum of 2 miles).

3. If necessary, establish new survey control points to be used for subsequent distance measurements to soil boring sites or monitoring wells. These points will be established and marked using a 2-foot piece of #5 rebar located within 0.5 foot.

4. All borehole locations will be located from existing or new control points using the AFP 4 northing and easting coordinate system previously established for the site. These will be established using the total station or geodimeter by:

   a. Mount and level the instrument over a bench mark, section corner, or other control station.

b. A backsight point, whose bearing and measured distance from the control station are known, shall be located and sighted with the instrument. The horizontal vernier shall be set to zero while sighting the backsight point.

c. Rotate the instrument to sight the well location and read the horizontal angle with the vertical crosshair set on the well. Obtain the vertical angle with the horizontal crosshair centered on the target.

d. Determine the horizontal distance between the two stations using the total station or geodimeter while sighting on the reflecting prism located at the well.

BOREHOLE ELEVATIONS

Elevations of the boreholes will be established by differential leveling between two or more points using the following procedure.

1. Start at a benchmark or other point of known elevation.

2. Set up the level at a convenient point between the benchmark and the next benchmark or turning point.

3. Observe and record the level rod reading at the backsight benchmark, add the reading to the known elevation of the benchmark and record the total as the height of the instrument.

4. Obtain a level rod reading at a new station and record. Subtract this reading from the height of the instrument to determine the elevation of the new station. Rod readings for a number of stations may be read from one setup location and the elevations determined using the same height-of-instrument measurement.

5. Once the elevation of the borehole or well is established, take a rod reading to a known benchmark to close the circuit and determine the error of closure to verify the accuracy of the circuit closure. Elevations will be determined to within 0.1 foot.

6. All measurements will be recorded in a bound survey notebook. The coordinates and elevations will be input later into the project computer data base along with the well or boring identification number.

SITE SPECIFIC PROCEDURE CHANGE or NOTICE

PROCEDURE: Ground Water Monitoring Wells - Design and Installation

PROJECT or SITE: Air Force Plant 4

VARIANCE

General Comments:

This practice may involve hazardous materials, operations, and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this practice to establish and follow appropriate safety and health practices, as defined by the site specific Health and Safety Plan.

The UNC project manager, project hydrologist, or their qualified designee **must** be present to supervise the installation of monitoring wells and is responsible for following procedures, making field decisions regarding specific details such as selecting the screened internal, and approving variations, such as a change in monitoring well locations. All variances must be documented in the bound field notebook. The project manager (or designee) is responsible for establishing decontamination procedures to prevent cross contamination between boreholes and between different zones within the same borehole. It is their responsibility to ensure that all samples, wastes and hazardous materials are handled, stored, disposed of, and transported in compliance with all applicable requirements.

The field crew is responsible for following the procedures, making lithologic logs and completion diagrams in the field, measuring the depth to the top of each type of fill material, developing the wells, collecting water samples, and collecting and disposing of borehole fluids in compliance with all applicable requirements.

All employees and subcontractor personnel are required to follow the procedures in the Air Force Plant 4 Health and Safety Plan and must be familiar with it before work begins. All personnel are further required to follow the direction of General Dynamics or Air Force security and fire officials. Monitor well installations will be in accord with all Federal, State, and Local regulations.

Specific Changes:

4.5.2 A sediment sump may have questionable value for some monitoring wells and may be desirable for others. The decision whether or not to install a sediment sump should be made by the project hydrologist. This decision will be based on site specific lithology.

5.3.3 <u>Groundwater Flow Direction</u> -- Note that a potentiometric surface map is only rigorously valid for horizontal flow in horizontal confined aquifers. If these conditions are not met, a potentiometric surface

map can be misleading (Freeze and Cherry, 1979). The project hydrologist will determine whether a potentiometric surface map should be prepared.

6.1 NOTE 1.5 -- If Material Safety Data Sheets (MSDS) exist for materials used in well construction, they shall be obtained and made available on site. Because of the hazards associated with airborne particulates, respiratory protection may be required when placing some of these materials, such as silica sand, in the borehole annulus.

6.2 A potable water source will be selected on site to use for decontamination wash water and also for monitor well installation. This source will be sampled and the results must verify the lack of contaminants before use. All water used will be from this clean source.

6.5.3 Note that joints on the riser pipe must be threaded. No glued or solvent welded joints will be permissible at Air Force Plant 4.

8.6 Monitoring Well Installation, Installation of the Bentonite Seal. Bentonite seals placed above the water table will be hydrated by adding at least 10 gallons of potable water to the bentonite pellets. The pellets will be allowed to hydrate before grouting the remaining annulus.

8.8.2 Specific Procedures for Single Cased Wells.
All conventional monitor wells installed at Air Force Plant 4 will be single completion monitor wells. Placement of the grout will be done by injecting the grout through a side discharging tremie pipe, so as to not disturb the bentonite seal.

8.9.3 Additional Protection.
Some monitor wells installed at Plant 4 may require flush mounts due to traffic considerations. Monitor wells with above ground installations will be protected by placing concrete filled steel guard pipes 2 feet into the ground 3 to 5 feet from the well riser. The pipes will be painted for high visibility in traffic areas.

9.1 Well Development at Air Force Plant 4 will conducted by using a vented surge block followed by pumping with either a submersible pump or a hand / mechanically operated "momentum pump" which operates on the principle of imparting an upward velocity to groundwater by rapidly raising and lowering a discharge pipe equipped with a foot valve at its bottom end. The surging / pumping cycle will continue until the water is free of any sand, silt, or clay. Development will be considered complete when sand is not observed in discharge water pumped from the very bottom of the well, and the turbidity of the water is less than five nephelometric turbidity units (NTU's). If this criteria cannot be met, development will continue until three bore volumes have been pumped without a detectable reduction in turbidity as measured in NTU's.

9.2 All waste water generated during well development at Air Force Plant 4 must be assumed to be contaminated (unless shown to be otherwise) and will be collected. Waste water will be disposed of in compliance with all applicable requirements.

Figures 2 and 3 -- The word "extent" should be changed to "extend". Note that a sediment sump is optional.

GROUND WATER MONITORING WELLS - DESIGN AND INSTALLATION

INTRODUCTION

This recommended practice for the design and installation of ground water monitoring wells in aquifers will promote (a) durable and reliable construction, (b) extraction of representative ground water quality samples, and (c) efficient and complete site hydrogeological characterizations. The guidelines established herein are affected by governmental regulations and by site specific geological, hydrogeological, climatological, topographical, and subsurface chemistry conditions. To meet these geoenvironmental challenges, this guidance promotes the development of a conceptual hydrogeologic model prior to monitoring well design and installation.

1. Scope

1.1 This recommended practice considers the selection and characterization (i.e., defining soil, rock types, and hydraulic gradients) of the target monitoring zone as an integral component of monitoring well design and installation. Hence, the development of a conceptual hydrogeologic model for the intended monitoring zone(s) is recommended prior to the design and installation of a monitoring well.

1.2 These guidelines are based on recognized methods by which monitoring wells may be designed and installed for the purpose of detecting the presence or absence of a contaminant, and collecting representative ground water quality data. The design standards and installation procedures herein are applicable to both detection and assessment monitoring programs for facilities.

1.3 The recommended monitoring well design, as presented in these guidelines, is based on the assumption that the objective of the program is to obtain representative ground water information and water quality samples from aquifers. Monitoring wells constructed following this recommended practice should produce relatively turbidity-free samples for granular aquifer materials ranging from gravels to silty sand and sufficiently permeable consolidated and fractured strata. Strata having grain sizes smaller than the recommended design for the smallest diameter filter pack materials should be monitored by alternative monitoring well designs which are not addressed in this recommended practice.

2. Applicable Documents

2.1 Proposed Standard Guide for the Use of:

Casing Advancement Drilling Methods in Geoenvironmental Site Characterization and the Installa tion of Subsurface Water Quality Monitoring Devices

Direct Air Rotary Drilling in Geoenvironmental Site Characterization and Installation of SubsurfaceWater Quality Monitoring Devices

Hollow-Stem Augers for Geoenvironmental Site Characterization and the Installation of Subsurface Water Quality Monitoring Devices

Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Site Characterization and Installation of Subsurface Water Quality Monitoring Device

2.2 ASTM Standards

C150 Standard Specification for Portland Cement

C 294 Descriptive Nomenclature of Constituents of Natural Mineral Aggregates

D1452 Practice for Soil Investigation and Sampling by Auger Borings

D1586 Method for Penetration Test and Split-Barrel Sampling of Soils

D1587 Practice for Thin-Walled Tube Sampling of Soils

D2113 Practice for Diamond Core Drilling for Site Investigation

D2487 Test Method for Classification of Soils for Engineering Purposes

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D 3282 Practice for Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes

3. Significance and Use

3.1 An adequately designed and installed ground water monitoring well system for aqueousphase liquids provides essential information for decisions pertaining to one or more of the following subjects:

3.1.1 Aquifer and aquitard properties, both geologic and hydraulic;

3.1.2 Potentiometric surface of a particular hydrologic unit (s);

3.1.3 Water quality with respect to various indicator parameters;

3.1.4 Migration characteristics of a contaminant release;

3.1.5 Additional installations and/or decommissioning of installations no longer needed.

4 Definitions

4.1 Annular Space: Annulus – The space between two concentric tubes or casings, or between the casing and the borehole wall. This would include the space(s) between multiple strings of tubing/casings in a borehole installed either concentrically or multi-cased adjacent to each other.

4.2 Aquifer – A geologic formation, group of formations, or part of a formation that is saturated, and is capable of providing a significant quantity of water.

4.3 Aquitard – A lithologic unit that impedes ground water movement and does not yield water freely to wells or springs but that may transmit appreciable water to or from adjacent aquifers. Where sufficiently thick, may act as a ground water storage zone. Synonymous with confining unit.

4.4 Assessment Monitoring – An investigative monitoring program that is initiated after the presence of a contaminant in ground water has been detected. The objective of this program is to determine the concentration of constituents that have contaminated the ground water and to quantify the rate and extent of migration of these constituents.

4.5 ASTM Cement Types – Portland cements meeting the requirements of ASTM C 150 (Standard Specifications for Portland Cement). Cement types have slightly different formulations that result in various characteristics which address different construction conditions and different physical and chemical environments. They are as follows:

4.5.1 ASTM Type I (Portland) – A general-purpose construction cement with no special properties.

4.5.2 ASTM Type II (Portland) – A construction cement that is moderately resistant to sulfates and generates a lower heat of hydration at a slower rate than ASTM Type I.

4.5.3 ASTM Type III (Portland: high early strength) – A construction cement that produces a high early strength. This cement reduces the curing time required when used in cold environments, and produces a higher heat of hydration than ASTM Type I.

4.5.4 ASTM Type IV (Portland) – A construction cement that produces a low heat of hydration (lower than ASTM Types I and II) and develops strength at a slower rate.

4.5.5 ASTM Type V (Portland) – A construction cement that is a high sulfate resistant formulation. Used when there is severe sulfate action from soils and ground water.

4.6 Bailer – A hollow tubular receptacle used to facilitate withdrawal of fluid from a well or borehole.

4.7 Ballast – Materials used to provide stability to a buoyant object (such as casing within a borehole filled with water).

4.8 Bentonite Clay – An altered deposit of volcanic ash usually consisting of sodium montmorillonite clay.

4.9 Blow-In – The inflow of ground water and unconsolidated material into a borehole or casing caused by differential hydraulic heads; that is, caused by the presence of a greater hydraulic head outside of a borehole/casing than inside.

4.10 Borehole – A circular open or uncased subsurface hole created by drilling.

4.11 Borehole Log – The record of geologic units penetrated, drilling progress, depth, water level, sample recovery, volumes and types of materials used, and other significant facts regarding the drilling of an exploratory borehole or well.

4.12 Bridge – An obstruction within the annulus which may prevent circulation or proper emplacement of annular material.

4.13 Casing – Pipe, finished in sections with either threaded connections or beveled edges to be field welded, which installed temporarily or permanently to counteract caving, to advance the borehole, and/or to isolate the zone being monitored.

4.14 Casing, Protective – A section of larger diameter pipe that is emplaced over the upper end of a smaller diameter monitoring well riser or casing to provide structural protection to the well and restrict unauthorized access into the well.

4.15 Casing, Surface – Pipe used to stabilize a borehole near the surface during the drilling of a borehole that may be left in place or removed once drilling is completed.

4.16 Caving; Sloughing – The inflow of unconsolidated material into a borehole which occurs when the borehole walls lose their cohesive strength.

4.17 Cement: Portland Cement – Commonly known as Portland cement. A mixture that consists of calcareous, argillaceous, or other silica-, alumina-, and iron-oxide-bearing materials that is manufactured and formulated to produce various types which are defined in ASTM C 150. Portland cement is also considered a hydraulic cement because it must be mixed with water to form a cement-water paste that has the ability to harden and develop strength even if cured under water (see ASTM Cement Types).

4.18 Centralizer – A device that assists in the centering of a casing or riser within a borehole or another casing.

4.19 Circulation – Applies to the fluid rotary drilling method; drilling fluid movement from the mud pit, through the pump, hose and swivel, drill pipe, annular space in the hole and returning to the mud pit.

4.20 Conductance (Specific) – A measure of the ability of the water to conduct an electric current at 77° F (25°C). It is related to the total concentration of ionizable solids in the water. It is inversely proportional to electrical resistance.

4.21 Confining Unit – A term that is synonymous with "aquiclude," "aquitard," and "aquifuge"; defined as a body of relatively low permeable material stratigraphically adjacent to one or more aquifers.

4.22 Contaminant – An undesirable substance not normally present or an unusually high concentration of a naturally occurring substance in water or soil.

4.23 Detection Monitoring – A program of monitoring for the express purpose of determining whether or not there has been a contaminant release to ground water.

4.24 Drill Cuttings – Fragments or particles of soil or rock, with or without free water, created by the drilling process.

4.25 Drilling Fluid – A fluid (liquid or gas) that may be used in drilling operations to remove cuttings from the borehole, to clean and cool the drill bit, and to maintain the integrity of the borehole during drilling.

4.26 d-10 – The diameter of a soil particle (usually in millimeters) at which 10% by weight of the particles of a particular sample are finer. Synonymous with the effective size or effective grain size.

4.27 d-60 – The diameter of a soil particle (usually in millimeters) at which 60% by weight of the particles of a particular

sample are finer.

4.28 Flow Path – Represents the area between two flow lines along which ground water can flow.

4.29 Flush Joint or Flush Coupled – Casing or riser with ends threaded such that a consistent inside and outside diameter is maintained across the threaded joints or couplings.

4.30 Gravel Pack – Common nomenclature for the preferred terminology, primary filter of a well (see primary filter pack).

4.31 Ground Water – That part of subsurface water that is in the saturated zone.

4.32 Grout – A low permeability material placed in the annulus between the well casing or riser pipe and the borehole wall (i.e., in a single cased monitoring well), or between the riser and casing (i.e., in a multi-cased monitoring well), to maintain the alignment of the casing and riser and to prevent movement of ground water or surface water within the annular space.

4.33 Grout Shoe – A "plug" fabricated of relatively inert materials that is positioned within the lowermost section of a permanent casing and fitted with a passageway, often with a flow check device, through which grout is injected under pressure to fill the annular space. After the grout has set, the grout shoe is usually drilled out.

4.34 Head (Static) – The height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point. The static head is the sum of the elevation head and the pressure head.

4.35 Head (Total) – The sum of three components at a point: (1) elevation head, h_e, which is equal to the elevation of the point above a datum; (2) pressure head, hp, which is the height of a column of static water that can be supported by the static pressure at the point; and (3) velocity head, hv, which is the height the kinetic energy of the liquid is capable of lifting the liquid.

4.36 Hydraulic Conductivity – The volume of water at the existing kinematic viscosity and density that will move in unit time under unit gradient through a unit area measured at right angles to the direction of flow.

4.37 Hydrologic Unit – Geologic strata that can be distinguished on the basis of capacity to yield and transmit fluids. Aquifers and confining units are types of hydrologic units. Boundaries of a hydrologic unit may not necessarily correspond either laterally or vertically to lithostratigraphic formations.

4.38 Jetting – When applied as a drilling method, water is forced down through the drill rods or casing and out through the end aperture. The jetting water then transports the generated cuttings to the ground surface in the annulus of the drill rods or casing and the borehole. The term jetting may also refer to a development technique (see well screen jetting).

4.39 Loss of Circulation – The loss of drilling fluid into strata to the extent that circulation does not return to the surface.

4.40 Mud Pit – Usually a shallow, rectangular, open, portable container with baffles into which drilling fluid and cuttings are discharged from a borehole and that serves as a reservoir and settling tank during recirculation of the drilling fluids. Under some circumstances, an excavated pit with a lining material may be used.

4.41 Multi-Cased Well – A well constructed by using successively smaller diameter casings with depth.

4.42 Neat Cement – A mixture of Portland cement (AST 150) and water.

4.43 Observation Well – Typically, a small diameter well used to measure changes in hydraulic heads, usually in respon to a nearby pumping well.

4.44 Oil Air Filter – A filter or series of filters placed in the air flow line from an air compressor to reduce the oil content the air.

4.45 Oil Trap – A device used to remove oil from the compressed air discharged from an air compressor.

4.46 Packer – A transient or dedicated device placed in well that isolates or seals a portion of the well, well annulus, borehole at a specific level.

4.47 Potentiometric Surface – An imaginary surface representing the static head of ground water. The water table is a pa ticular potentiometric surface. NOTE: Where the head varies with depth in the aquifer, a potentiometric surface is meaningful only if it describes the static head along a particular specific surface or stratum in that aquifer. More than one potentiometr surface is required to describe the distribution of head in this case.

4.48 Primary Filter Pack – A clean silica sand or sand a gravel mixture of selected grain size and gradation that is installed in the annular space between the borehole wall and the well screen, extending an appropriate distance above the scree for the purpose of retaining and stabilizing the particles from t adjacent strata. The term is used in place of "gravel pack."

4.49 PTFE Tape – Joint sealing tape composed of polytetr fluoroethylene.

4.50 Riser – The pipe extending from the well screen to or above the ground surface.

4.51 Secondary Filter Pack – A clean, uniformly grad sand that is placed in the annulus between the primary filter pa and the over-lying seal, or between the seal and overlying grout backfill or both, to prevent movement of seal, or grout, or bo into the primary filter pack.

4.52 Sediment Sump – A blank extension beneath the well screen used to collect fine-grained material from the filter pac and adjacent strata. The term is synonymous with rat trap or pipe.

4.53 Shear Strength – A measure of the shear or gel properties of a drilling fluid or grout; also, the maximum resistance o soil or rock to shearing stresses.

4.54 Single-Cased Well – A monitoring well constructed with a riser but without an exterior casing.

4.55 Static Water Level – The elevation of the top of a c umn of water in a monitoring well or piezometer that is not fluenced by pumping or conditions related to well installation, hydrologic testing, or nearby pumpage.

4.56 Tamper – A heavy cylindrical metal section of tubi that is operated on a wire rope or cable. It slips over the riser and fits inside the casing or borehole annulus. It is generally used to tamp annular sealants or filter pack materials into pl and prevent bridging.

4.57 Target Monitoring Zone – The ground water flow path from a particular area or facility into which monitoring wells will be screened. The target monitoring zone should be a stratum (strata) in which there is a reasonable expectation that a vertically placed well will intercept migrating contaminants.

4.58 Test Pit – A shallow excavation made to characterize the subsurface.

4.59 Transmissivity – The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient. NOTE: It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths.

4.60 Tremie Pipe – A pipe or tube that is used to transport filter pack materials and annular sealant materials from the ground surface into the borehole annulus or between casings and casings or riser pipe of a monitoring well.

4.61 Uniformity Coefficient – The size ratio of the 60% finer (d-60) grain size to the 10% (d-10) finer grain size of a sample of granular material (refer to ASTM Standard Test Method D 2487).

4.62 Uniformly Graded – A quantitative definition of the particle size distribution of a soil which consists of the majority of particles being of the same approximate diameter. A granular material is considered uniformly graded when the uniformity coefficient is less than about 5 (refer to ASTM Standard Test Method D 2487). Analogous with the geologic term well sorted.

4.63 Vented Cap – A cap with a small hole that is installed on top of the riser.

4.64 Washout Nozzle – A tubular extension with a check valve utilized at the end of a string of casing through which water can be injected to displace drilling fluids and cuttings from the annular space of a borehole.

4.65 Water-Cement Ratio – The amount of mixing water in gallons used per sack of cement.

4.66 Water Table – The ground water surface in an unconfined aquifer at which the pressure is equal to that of the atmosphere; the surface between the zone of saturation and the zone of aeration.

4.67 Weep Hole – A small diameter hole (usually 1/4 in.) drilled into the protective casing above the ground surface that serves as a drain hole for water that may enter the protective casing annulus.

4.68 Well Completion Diagram – A record that illustrates the details of a well installation.

4.69 Well Screen – A filtering device used to retain the primary or natural filter pack; usually a cylindrical pipe with openings of a uniform width, orientation, and spacing.

4.70 Well Screen Jetting (Hydraulic Jetting) – When jetting is used for development, a jetting tool with nozzles and a high pressure pump is used to force water outwardly through the screen, the filter pack, and sometimes into the adjacent geologic unit.

4.71 Zone of Saturation – A hydrologic zone in which all the interstices between particles of geologic material or all of the joints, fractures, or solution channels in a consolidated rock unit are filled with water under pressure greater than that of the atmosphere.

5. Site Characterization

53 272

5.1 General – Soil mechanics, geomorphological concepts, stratigraphy, and sedimentary concepts, as well as the natur behavior of the solutes of interest, must be combined knowledge of ground water movement to make a complete application of the results of the monitoring well design and installation guidance. Therefore, development of a conceptual hydrogeologic model that identifies potential flow paths and the target monitoring zone(s) is recommended prior to monitoring well design and installation. Development of the conceptual model is accomplished in two phases—an initial reconnaissance and a field investigation. When the hydrogeology of a project area is relatively uncomplicated and well documented in the literature, the initial reconnaissance may provide sufficient information to identify flow paths and the target monitoring zone(s). However, where little background data is available or the geology is complicated, a field investigation will generally be necessary to completely develop a conceptual hydrogeologic model.

5.2 Initial Reconnaissance of Project Area – The goal of the initial reconnaissance of the project area is to identify and locate those zones with the greatest potential to transmit a fluid from the project area. Identifying these flow paths is the first step in selecting the target ground water monitoring zone(s).

5.2.1 Literature Search – Every effort should be made to collect and review all applicable field and laboratory data from previous investigations of the project area. Data such as, but not limited to, topographic maps, aerial imagery, site ownership and utilization records, geologic and hydrogeologic maps and reports, mineral resource surveys, water well logs, personal information from local well drillers, agricultural soil reports, ge nical engineering reports, and other engineering maps reports related to the project area should be reviewed.

5.2.2 Field Reconnaissance – Early in the investigation, the soil and rocks in open cut areas in the vicinity of the project should be studied, and various soil and rock profiles noted. Special consideration should be given to soil color and textural changes, landslides, seeps, and springs within or near the project area.

5.2.3 Preliminary Conceptual Model – The distribution of the predominant soil and rock units likely to be found during subsurface exploration may be hypothesized at this time in a preliminary hydrogeologic conceptual model using data obtained in the literature search and field reconnaissance. In areas where the geology is relatively uniform, well documented in the literature, and substantiated by the field reconnaissance, further refinement of the conceptual model may not be necessary unless anomalies are discovered in the well drilling stage.

5.3 Field Investigation – The goal of the field investigation is to refine the preliminary conceptual hydrogeologic model so that the target monitoring zone(s) is selected prior to monitoring well installation.

5.3.1 Exploratory Borings and Test Pits – Characterization of the flow paths conceptualized in the initial reconnaissance involves defining the porosity, hydraulic conductivity, gradation, stratigraphy, lithology, and structure of each hydrologic unit. The characteristics are defined by conducting an explor-

boring program which may include test pits. Exploratory borings and test pits should be deep enough to develop the required engineering and hydrogeologic data for determining the flow path(s), target monitoring zone, or both.

5.3.1.1 Sampling – Soil and rock properties should not be predicted wholly on field identification or classification, but should be checked by laboratory and field tests made on samples. Representative soil or rock samples, or both, of each material that is significant to the analysis and design of the monitoring system should be obtained and evaluated by a geologist, hydrogeologist, or engineer trained and experienced in soil and rock analysis. Soil sample extraction should be conducted according to American Society of Testing and Methods (ASTM) Standards D 1452, D 1586, or D 1587, whichever is appropriate given the anticipated characteristics of the soil samples. Rock samples should be extracted according to ASTM D 2113. Soil samples obtained for evaluation of hydraulic properties should be containerized and identified for shipment to a laboratory. Special measures to preserve either the continuity of the sample or the natural moisture are not usually required. However, soil and rock samples obtained for evaluation of chemical properties often require special field preparation and preservation to prevent significant alteration of the chemical constituents during transportation to a laboratory (see ASTM D 4220-83). Rock samples for evaluation of hydraulic properties are usually obtained using a split-inner-tube core barrel. Evaluation and logging of the core samples is usually made in the field before the core is removed from half of the split inner tube core barrel.

5.3.1.2 Boring Logs – Care should be taken to prepare and retain a complete boring log and sampling record for each exploratory borehole and test pit. Boring logs should include the location, geotechnical (i.e., penetration rates or blow counts), and sampling information for each material identified in the borehole either by symbol or word description or both. Identification of all soils should be according to ASTM Standard Practice D 2488 or D 3282. Identification of rock material should be based on ASTM Descriptive Nomenclature C 294 or by an appropriate geologic classification system. Observations of seepage, free water, and water levels should also be noted. The boring logs should be accompanied by a report that includes a description of the area investigated; a map illustrating the vertical and horizontal location (with reference to nearest National Geodetic Vertical Datum [NGVD] and to a standardized survey grid, respectively) of each exploratory borehole or test pit or both; and color photographs of rock cores, soil samples, and exposed strata labeled with a date and identification.

5.3.2 Geophysical Exploration – Geophysical surveys may be used to supplement borehole and outcrop data and to aid in interpretation between boreholes. Surface geophysical methods such as seismic surveys, and electrical-resistivity and electromagnetic conductance surveys can be particularly valuable when distinct differences in the properties of contiguous subsurface materials are indicated. Borehole methods such as resistivity, gamma, gamma-gamma, neutron, and caliper logs can be useful to confirm specific subsurface geologic conditions. Gamma logs are particularly useful in existing cased wells.

5.3.3 Ground Water Flow Direction – Ground water flow direction is generally determined by measuring the vertical and horizontal hydraulic gradient within each conceptualized flo path. However, because water will flow along the path of lea resistance, flow direction may be oblique to the hydraulic grad ent (buried stream channels or glacial valleys, for example). Flow direction is determined by first installing piezometers the exploratory boreholes. The depth and location of the pi zometers will depend upon anticipated hydraulic connections between conceptualized flow paths and their respective lateral di rection of flow. Following careful evaluation, it may be possib to utilize existing private or public wells to obtain water lev data. The construction integrity of such wells should be verified to ensure that the water levels obtained from the wells are repr sentative only of the zones of interest. Following water lev data acquisition, a potentiometric surface map should be prepared. Flow paths are ordinarily determined to be at right an gles, or nearly so, to the equipotential lines.

5.4 Completing the Conceptual Model – A series of hydro geologic cross-sections should be developed to refine the conceptual model. This is accomplished by first plotting logs of so and rock observed in the exploratory borings or test pits, and i terpreting between these logs using the geologic and engineering interrelatin ships between other soil and rock data observed i the initial reconnaissance or with geophysical techniques. E trapolation of data into adjacent areas should be done only when geologically uniform subsurface conditions are known to exist. The next step is to integrate the profile data with the piezomet data for both vertical and horizontal hydraulic gradients. Pla view and cross-sectional flow nets may need to be constructed. Following the analysis of these data, conclusions can be made a to which flow path(s) is the appropriate target monitoring zo (s).

NOTE 1 – Ground water monitoring is difficult and may not be a reliable technology in fine-grain, low hydraulic conductiv ty, primary porosity strata because of a) the disproportionate i fluence that microstratigraphy has on ground water flow in fine grain strata; b) flow lines proportionally higher for the vertic flow component in low hydraulic conductivity strata; and c) t presence of indigenous metallic and inorganic constituents tha make water quality data evaluation difficult.

6. Monitoring Well Construction Materials

6.1 General – The materials that are used in the construction of a monitoring well and that come in contact with the water sample should not alter the chemical quality of the sample f the constituents being examined using the appropriate sampling protocols. Furthermore, the riser, well screen, and annular sealant injection equipment should be steam or high pressure wat cleaned (if appropriate for the selected riser material) immediat ly prior to well installation or certified clean from the manufacturer and delivered to site in a protective wrapping. Samples of the cleaning water, filter pack, annular seal, and mixed gro should be retained to serve as quality control until the completion of at least one round of ground water quality sampling and analysis.

6.2 Water – Water used in the drilling process, to prepa grout mixtures and to decontaminate the well screen, riser, and

Table 1. Recommended (Achievable) Filter Pack Characteristics for Common Screen Slot Sizes.

Size of Screen Opening mm(in.)	Slot No.	Sand Pack Mesh Size Name(s)	1% Passing Size (D-1) mm	Effective Size (D-10) mm	30% Passing Size (D-30) mm	Range of Uniformity Coefficient	Roundness (Power Scale)
0.125 (0.005)	5	100	0.09 - 0.12	0.14 - 0.17	0.17 - 0.21	1.3 - 2.0	2 - 5
0.25 (0.010)	10	20 - 40	0.25 - 0.35	0.4 - 0.5	0.5 - 0.6	1.1 - 1.6	3 - 5
0.50 (0.020)	20	10 - 20	0.7 - 0.9	1.0 - 1.2	1.2 - 1.5	1.1 - 1.6	3 - 6
0.75 (0.030)	30	10 - 20	0.7 - 0.9	1.0 - 1.2	1.2 - 1.5	1.1 - 1.6	3 - 6
1.0 (0.040)	40	8 - 12	1.2 - 1.4	1.6 - 1.8	1.7 - 2.0	1.1 - 1.6	4 - 6
1.5 (0.060)	60	6 - 9	1.5 - 1.8	2.3 - 2.8	2.5 - 3.0	1.1 - 1.7	4 - 6
2.0 (0.080)	80	4 - 8	2.0 - 2.4	2.4 - 3.0	2.6 - 3.1	1.1 - 1.7	4 - 6

annular sealant injection equipment, should be obtained from a source of known chemistry that does not contain constituents that could compromise the integrity of the well installation.

6.3 Primary Filter Pack:

6.3.1 Materials -- The primary filter pack (gravel pack) consists of a granular material of known chemistry and selected grain size and gradation that is installed in the annulus between the screen and the borehole wall. The filter pack is usually selected to have a 30% finer (d-30) grain size that is about 4 to 10 times greater than the 30% finer (d-30) grain size of the hydrologic unit being filtered(see figure 1). Usually, the filter is selected to have a low (i.e., less than 2.5) uniformity coefficient. The grain size and gradation of the filter are selected to stabilize the hydrologic unit adjacent to the screen and permit only the finest soil grains to enter the screen during development. Thus, after development, a correctly filtered monitoring well is relatively turbid-free.

NOTE 2 -- When installing a monitoring well in Ka

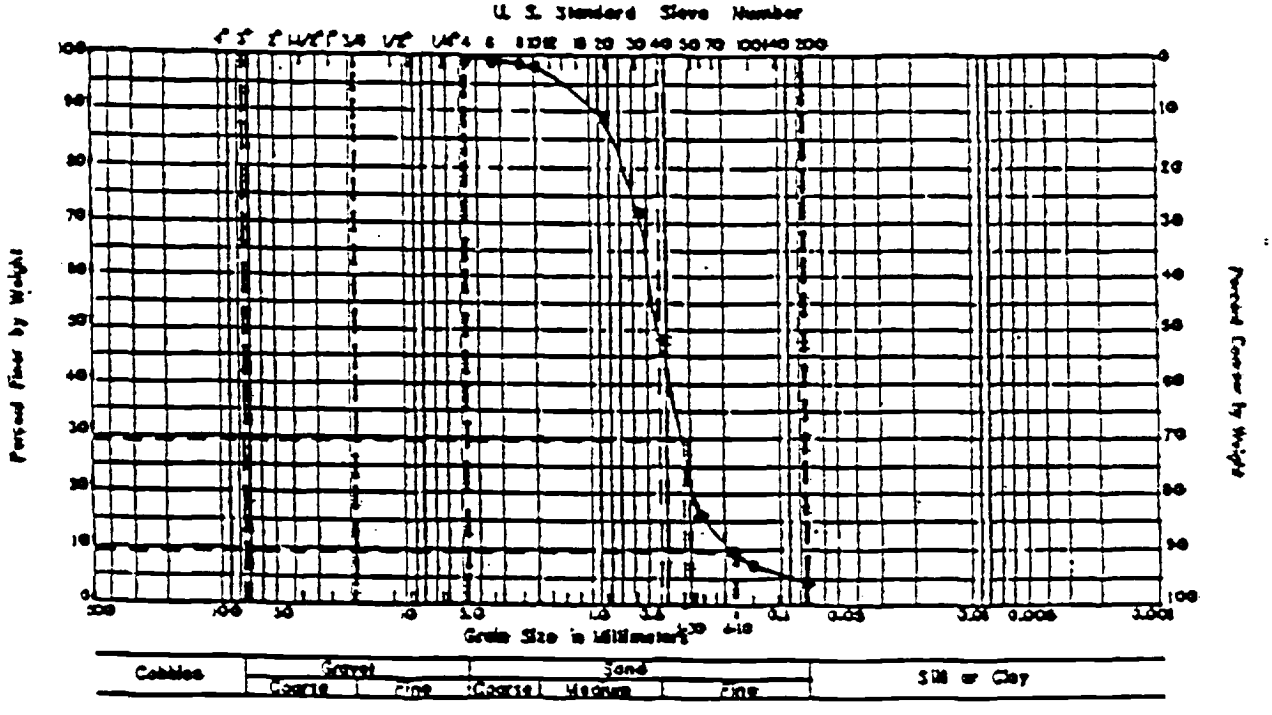


Fig. 1 Example Grading Curve For Design Of Monitoring Well Screens

highly fractured bedrock; the borehole configuration of void spaces within the formation surrounding the borehole is often unknown. Therefore, the installation of a filter pack becomes difficult and may not be possible.

6.3.2 Gradation – The filter pack should be uniformly graded and comprised of hard durable siliceous particles washed and screened with a particle size distribution derived by multiplying the d-30 size of the finest-grained screened stratum by a factor between 4 and 10. Use a number between four and six as the multiplier if the stratum is fine and uniform; use a factor between six and ten where the material has highly nonuniform gradation and includes silt-sized particles. The grain-size distribution of the filter pack is then plotted using the d-30 size as the control point on the graph. The selected filter pack should have a uniformity coefficient of approximately 2.5 or less.

NOTE 3 – Because the well screen slots have uniform openings, the filter pack should be composed of particles that are as uniform in size as is practical. Ideally, the uniformity coefficient (the quotient of the 60% passing, D-60 size divided by the 10% passing D-10 size [effective size]) of the filter pack should be 1.0 (i.e., the D-60 percent and the D-10 percent sizes should be identical). However, a more practical and consistently achievable uniformity coefficient for all ranges of filter pack sizes is 2.5. This value of 2.5 should represent a maximum value not an ideal.

NOTE 4 – Although not recommended as standard practice, often a project requires drilling and installing the well in one phase of work. Therefore, the filter pack materials must be ordered and delivered to the drill site before soil samples can be collected. In these cases, the suggested well screen slot size and filter pack materials are presented in Table 1.

6.4 Well Screen:

6.4.1 Materials – The well screen should be new, machine-slotted or continuous wrapped wire-wound and composed of materials most suited for the monitoring environment and site characterization findings. The screen should be plugged at the bottom. The plug should be of the same material as the well screen. This assembly must have the capability to withstand installation and development stresses without becoming dislodged or damaged. The length of the slotted area should reflect the interval to be monitored. Immediately prior to installation, the well screen should be steam or high pressure water cleaned (if appropriate for the selected well screen materials) with water from a source of known chemistry if not certified by the manufacturer, delivered, and maintained clean at the site.

NOTE 5 – Well screens are most commonly composed of PVC, stainless steel, fiberglass, or fluoropolymer materials.

6.4.2 Diameter – The minimum nominal internal diameter of the well screen should be chosen based on the particular application. However, in most instances, a minimum of 2 in. (50 mm) is needed to allow for the introduction and withdrawal of sampling devices.

6.4.3 Slot Size – The slot size of the well screen should be determined relative to the grain size analysis of the stratum interval to be monitored and the gradation of the filter pack material. In granular non-cohesive strata that will fall in easily around the screen, filter packs are not necessary. In these cases of natural development, the slot size of the well screen is to be determined using the grain size of the materials in the surrounding strata. The slot size and arrangement should retain at least 90% and preferably 99% of the filter pack. The method for determining the correct gradation of filter pack material is described in Section 6.3.2.

6.5 Riser:

6.5.1 Materials – The riser should be new and composed of materials that will not alter the quality of water samples for the constituents of concern and that are appropriate for the monitoring environment. The riser should have adequate wall thickness and coupling strength to withstand installation and development stresses. Each section of riser should be steam or high pressure water cleaned (if appropriate for the selected material) using water from a source of known chemistry immediately prior to installation.

NOTE 6 – Risers are generally constructed of PVC, stainless steel, fiberglass, or fluoropolymer materials.

6.5.2 Diameter – The minimum nominal internal diameter of the riser should be chosen based on the particular application. However, in most instances, a minimum of 2 in. (50 mm) is needed to accommodate sampling devices.

6.5.3 Joints (Couplings) – Threaded joints are recommended. Glued or solvent welded joints of any type are not recommended since glues and solvents may alter the chemistry of the water samples. In most cases, threaded joints should be PTFE taped to prevent leakage of water into the riser. Alternatively, O-rings composed of materials that would not impact the water sample for the constituents of concern may be selected for use on flush joint threads.

6.6 Casing – Where conditions warrant, the use of permanent casing installed to prevent communication between water-bearing zones is encouraged. The following subsections address both temporary and permanent casings.

6.6.1 Materials – The material type and minimum wall thickness of the casing should be adequate to withstand the forces of installation. All casing that is to remain as a permanent part of the installation (i.e., multi-cased wells) should be new and cleaned to be free of interior and exterior protective coatings.

NOTE 7 – The exterior casing (temporary or permanent multi-cased) is generally composed of steel, although other appropriate materials may be used.

6.6.2 Diameter – Several different casing sizes may be required depending on the subsurface geologic conditions penetrated. The diameter of the casing for filter packed wells should be selected so that a minimum annular space of 2 in. (50 mm) is maintained between the inside diameter of the casing and outside diameter of the riser. In addition, the diameter of the casings in multi-cased wells should be selected so that a minimum annular space of 2 in. is maintained between the casing and the borehole (i.e., a 2 in. diameter screen will require first setting a 6 in. (152 mm) diameter casing in a 10 in. (254 mm) diameter boring).

NOTE 8 – Under difficult drilling conditions (collapsing soils, rock or cobbles), it may be necessary to advance temporary

casing, under these conditions a smaller annular space may be maintained.

6.6.3 Joints (Couplings) – The ends of each casing section should be either flush-threaded or bevelled for welding.

6.7 Protective Casing:

6.7.1 Materials – Protective casings may be made of aluminum, steel, stainless steel, cast iron, or a structural plastic. The protective casing should have a lid capable of being locked shut by a locking device.

6.7.2 Diameter – The inside dimensions of the protective casing should be a minimum of 2 in. (50 mm) and preferably 4 in. (101 mm) larger than the nominal diameter of the riser to facilitate the installation and operation of sampling equipment.

6.8 Annular Sealants – The materials used to seal the annulus may be prepared as a slurry or used un-mixed in a dry pellet, granular, or chip form. Sealants should be selected to be compatible with ambient geologic, hydrogeologic, and climatic conditions and any man-induced conditions anticipated to occur during the life of the well.

6.8.1 Bentonite – Bentonite should be powdered, granular, pelletized, or chipped sodium montmorillonite furnished in sacks or buckets from a commercial source and free of impurities which adversely impact the water quality in the well. Pellets consist of roughly spherical or disk shaped units of compressed bentonite powder. Chips are large, irregularly shaped, and coarse granular units of bentonite free of additives. The diameter of pellets or chips selected for monitoring well construction should be less than one-fifth the width of the annular space into which they are placed to reduce the potential for bridging. Granules consist of coarse particles of unaltered bentonite, typically smaller than 0.2 in. (50 mm).

6.8.2 Cement – Each type of cement has slightly different characteristics that may be appropriate under various physical and chemical conditions. Cement should be one of the five Portland cement types that are specified in ASTM C 150. The use of quick-setting cements containing additives is not recommended for use in monitoring well installation. Additives may leach from the cement and influence the chemistry of the water samples.

6.8.3 Grout – The grout backfill that is placed above the bentonite annular seal and secondary filters (see Fig. 1) is ordinarily a liquid slurry consisting of either a bentonite (powder and/or granules) base and water, or a Portland cement base and water. Often, bentonite-based grouts are used when it is desired that the grout remain flexible (i.e., to accommodate freeze-thaw) during the life of the installation. Cement or bentonite-based grouts are often used when the filling in of cracks in the surrounding geologic material, adherence to rock units, or a rigid setting is desired.

6.8.3.1 Mixing – The mixing (and placing) of a grout backfill should be performed with precisely recorded weights and volumes of materials, and according to procedures stipulated by the manufacturer that often include the order of component mixing. The grout should be thoroughly mixed with a paddle type mechanical mixer or by recirculating the mix through a pump until all lumps are disintegrated. Lumpy grout should not be used in the construction of a monitoring well to prevent bridging within the tremie.

NOTE 9 – Lumps do not include lost circulation materials that may be added to the grout if excessive grout losses occur.

6.8.3.2 Typical Bentonite Base Grout – When a ben' base grout is used, bentonite, usually unaltered, must be the additive placed in the water through a venturi device. A typical unbenificiated bentonite base grout consists of about 1 lb to 1.25 lb (0.57 kg) of unaltered bentonite to each 1 gal (3.8 L) of water. After the bentonite is mixed and allowed to "yield," up to 2 lb (0.9 kg) of Type I Portland cement (per gallon of water) is often added to stiffen the mix. Bentonite grouts should not be used in the vadose zone of arid regions because of their propensity to desiccate. This could result in non-representative waters affecting the target monitoring zone.

NOTE 10 – High solids bentonite grouts (minimum 20% by weight with water) and other bentonite-based grouts may contain granular bentonite to increase the solids content and other components added under manufacturer's directions to either stiffen or retard stiffening of the mix. All additives to grouts should be evaluated for their effects on subsequent water samples.

6.8.3.3 Typical Cement Base Grout – When a cement-based grout is used, cement is usually the first additive placed in the water. A typical cement-based grout consists of about 6.0 gal to 7.0 gal (23 L to 26 L) of water per 94 lb (43 kg) bag of Type I Portland cement. From 0 to 10% (by weight of cement) of unaltered bentonite powder is often added after the initial mixing of cement and water to retard shrinkage and provide plasticity. The bentonite is added "dry" to the cement-water slurry without first mixing it with water.

6.9 Secondary Filter Packs:

6.9.1 Materials – A secondary filter pack is a layer of rial placed in the annulus between the primary filter pack an bentonite seal, and between the bentonite seal and the grout backfill (see Figs. 2 and 3).

6.9.2 Gradation – The secondary filter pack should be uniformly graded fine sand with a 100% by weight passing the No. 30 U.S. Standard sieve, and less than 2% by weight passing the 200 U.S. Standard sieve.

6.10 Annular Seal Equipment – The equipment used to inject the annular seals and filter pack should be steam or high pressure water cleaned (if appropriate for the selected material) using water from a source or known quality prior to use. This procedure is performed to prevent the introduction of materials that may ultimately alter the water sample quality.

7. Drilling Methods

7.1 The type of equipment required to create a stable, open, vertical borehole for installation of a monitoring well depends upon the site geology, hydrology, and the intended use of the data. Engineering and geological judgment is required for the selection of the drilling methods utilized for drilling the exploratory boreholes and monitoring wells. Whenever feasible, drilling procedures should be utilized that do not require the introduction of water or liquid fluids into the borehole, and that optimize cuttings control at ground surface. Where the use of drilling fluid is unavoidable, the selected fluid should have as little impact as possible on the water samples for the constituents c

terest. In addition, care should be taken to remove as much drilling fluid as possible from the well and the aquifer during the well development process. It is recommended that if an air compressor is used, it is equipped with an oil air filter or oil trap.

8. Monitoring Well Installation

8.1 Stable Borehole – A stable borehole must be constructed prior to attempting to install the monitoring well screen and riser. Steps must be taken to stabilize the borehole before attempting installation if the borehole tends to cave or blow-in or both. Boreholes that are not straight or are partially obstructed should be corrected prior to attempting the installations described herein.

8.2 Assembly of Well Screen and Riser:

8.2.1 Handling – The well screen, bottom plug, riser, should be either certified clean from the manufacturer or steam or high pressure water cleaned (if appropriate for the selected material) using water from a source of known chemistry immediately prior to assembly. Personnel should take precautions to assure that grease, oil, or other contaminants that may ultimately alter the water sample do not contact any portion of the well screen and riser assembly. As one precaution, personnel should wear a clean pair of cotton or surgical (or equivalent) gloves while handling the assembly.

8.2.2 Riser Joints (Couplings) – The male threaded part of each required riser coupling should be wrapped with PTFE tape. Alternatively, O-rings of known chemistry, selected on the basis of prevailing environmental or physical conditions, may be used to assure a tight seal of flush-joint couplings. Couplings are often tightened by hand; however, if necessary, steam or high pressure water cleaned wrenches may be utilized. Precautions should be taken to prevent damage to the threaded joints during installation.

8.3 Setting the Well Screen and Riser Assembly – When the well screen and riser assembly is lowered to the predetermined level and held into position, the assembly may require ballast to counteract the tendency to float in the borehole. Ballasting may be accomplished by continuously filling the riser with water from a source of known chemistry or, preferably, water which was previously removed from the borehole. Alternatively, the riser may be slowly pushed into the fluid in the borehole with the aid of hydraulic rams on the drill rig and held in place as additional sections of riser are added to the column. Care must be taken to secure the riser assembly so that personnel safety is assured during the installation. The assembly must be installed straight with the appropriate centralizers to allow for the introduction and withdrawal of sampling devices. Difficulty in maintaining a straight installation may be encountered where the weight of the well screen and riser assembly is significantly less than the buoyant force of the fluid in the borehole. The riser should extend above grade and be capped temporarily to deter entrance of foreign materials during completion operations.

8.4 Installation of the Primary Filter Pack:

8.4.1 Volume of Filter Pack – The volume of filter pack required to fill the annular space between the well screen and borehole should be computed, measured, and recorded on the well completion diagram during installation. To be effective, the filter pack should extend above the screen for a distance of about 20% of the length of the well screen but not less than 2 ft (600 mm) (see Figs. 2 and 3). Where there is hydraulic connection between the zone to be monitored and the overlying strata, this upward extension should be gauged to prevent seepage from overlying hydrologic units into the filter pack. Seepage from other units may alter the water sample.

8.4.2 Placement of Primary Filter Pack – Placement of the well screen is preceded by placing no less than 2% and no more than 10% of the primary filter pack into the bottom of the borehole using a decontaminated, flush threaded, 1 in. (25 mm) minimum internal diameter tremie pipe. Alternatively, the filter pack may be added directly between the riser pipe and the auger or borehole or casing and the top of the filter pack located using a tamper or a weighted line. The well screen and riser assembly is then centered in the borehole using a centralizer located not more than 10 ft (300 mm) above the bottom of the well screen (see Figs. 2 and 3). The centralizer should not be located in the bentonite seal. The remaining primary filter pack is then placed in increments as the tremie is gradually raised. As primary filter pack material is poured into the tremie pipe, water from a source of known chemistry may be added to help move the filter pack. The tremie pipe or a weighted line inserted through the tremie pipe can be used to measure the top of the primary filter pack as work progresses. If bridging of the primary filter pack occurs, the bridged material should be broken mechanically prior to proceeding with the addition of more filter pack material. The elevation, volume, and gradation of primary filter pack is recorded on the well completion diagram.

8.4.3 Withdrawal of the Temporary Casing/Augers – If used, the temporary casing or hollow stem auger is withdrawn, usually in stipulated increments. Care should be taken to minimize lifting the riser with the withdrawal of the temporary casing/augers. To limit borehole collapse, the temporary casing or hollow stem auger is usually withdrawn until the lower most point on the temporary casing or hollow stem auger is at least 2 ft (608 mm), but no more than 5 ft (1.5 m), above the filter pack for unconsolidated materials; or at least 5 ft, but no more than 10 ft (3.0 m), for consolidated materials. In highly unstable formations, withdrawal intervals may be much less. After each increment, it should be ascertained that the primary filter pack has not been displaced during the withdrawal operation (i.e., a weighted measuring device).

8.5 Placement of First Secondary Filter – A secondary filter pack may be installed above the primary filter pack to prevent the intrusion of the bentonite grout seal into the primary filter pack (see Figs. 2 and 3). To be effective, measured and recorded volume of secondary filter material should be added to extend 1 ft to 2 ft (304 mm to 608 mm) above the primary filter pack. As with the primary filter, a secondary filter must not extend into an overlying hydrologic unit (see Section 3.4.1). The well designer should evaluate the need for this filter pack by considering the gradation of the primary filter pack, the hydraulic heads between adjacent units, and the potential for grout intrusion into the primary filter pack. The secondary filter material is poured into the annular space through a decontaminated, flush threaded, 1 in. (25 mm) minimum internal diameter tremie pipe lowered to

within 3 ft (1.0 m) of the placement interval. Water from a source of known chemistry may be added to help move the filter pack into its proper location. The tremie pipe or weighted line inserted through the tremie pipe can be used to measure the top of the secondary filter pack as work progresses. The elevation, volume, and gradation of the secondary filter pack is recorded on the well completion diagram.

3.6 Installation of the Bentonite Seal – A bentonite pellet or a slurry seal is placed in the annulus between the borehole and the riser pipe on top of the secondary or primary filter pack (see Figs. 2 and 3). This seal retards the movement of cement-based grout backfill into the primary or secondary filter packs. To be effective, the bentonite seal should extend above the filter packs approximately 3 ft to 5 ft (1.0 m to 1.5 m)—depending on local conditions. The bentonite seal should be installed using a tremie pipe lowered to the top of the filter packs and slowly raised as the bentonite pellets or the slurry fill the annular space. Bentonite pellets may bridge and block the tremie pipe in deep wells. In these cases, pellets may be allowed to free-fall into the borehole. As a bentonite pellet seal is poured into the tremie pipe or allowed to free-fall into the borehole, a tamper or weighted line may be necessary to tamp pellets into place. If the seal is installed above the water level, water from a source of known chemistry would be added to allow proper hydration of the annular seal. The tremie pipe or a weighted line inserted through the tremie pipe can be used to measure the top of the bentonite seal as the work progresses. If a bentonite pellet seal is being constructed above the water level, approximately 5 gal (20 L) of water from a source of known chemistry can be poured into the annulus to ensure that the pellets hydrate. Sufficient time should be allowed for the bentonite pellet seal to hydrate or the slurry annular seal to expand prior to grouting the remaining annulus. The volume and elevation of the bentonite seal material should be measured and recorded on the well completion diagram.

3.7 Final Secondary Filter Pack – A 6 in. to 1 ft (152 mm to 304 mm) secondary filter may be placed above the bentonite seal in the same manner described in Section 3.5 (see Figs. 2 and 3). This secondary filter pack will provide a confining layer over the bentonite seal to limit the downward movement of cement-based grout backfill into the bentonite seal. The volume, elevation, and gradation of this final secondary filter pack should be documented on the well completion diagram.

3.8 Grouting the Annular Space:

3.8.1 General – Grouting procedures vary with the type of well design. The following procedures will apply to both single- and multi-cased monitoring wells. Sections 3.8.2 and 3.8.3 detail those procedures unique to single- and multi-cased installations, respectively.

3.8.1.1 Volume of Grout – The volume and location of grout used to backfill the remaining annular space is recorded on the well completion diagram. An ample volume of grout should be premixed on site to compensate for unexpected losses. The use of alternate grout materials, including grouts containing gravel, may be necessary to control zones of high grout loss.

3.8.1.2 Injection Procedures – The grout backfill should be injected under pressure to reduce the chance of leaving voids in the grout, and to displace any liquids and drill cuttings that may remain in the annulus. Depending upon the well design, grouting may be accomplished using a pressure grouting technique or by gravity feed through a tremie pipe. With either method, grout is introduced in one continuous operation until full strength grout flows out at the ground surface without evidence of drill cuttings or fluid. The grout should slope away from the riser or casing at the surface, but care should be taken not to create a grout mushroom that would be subject to frost heave.

3.8.1.3 Grout Setting and Curing – The riser and/or casing should not be disturbed until the grout sets and cures for the amount of time necessary to prevent a break in the seal between the grout and riser or grout and casing or both. The amount of time required will vary with grout content and climatic conditions and should be documented on the well completion diagram.

3.8.2 Specific Procedures for Single Cased Wells - Grouting should begin at a level directly above the final secondary filter pack (see Fig. 2). Grout should be injected using a tremie pipe equipped with a side discharge; this dissipates the fluid-pumping energy against the borehole wall and riser, reducing the potential for infiltration of grout into the primary filter pack. The tremie pipe should be kept full of grout from start to finish with the discharge end of the pipe completely submerged as it is slowly and continuously lifted. Approximately 5 ft to 10 ft (1.5 m to 3.0 m) of tremie pipe should remain submerged until grouting is complete. For deep installations or where the joints or couplings of the selected riser cannot withstand the shear or collapse stress exerted by a full column of grout as it sets, a staged grouting procedure may be considered. If used, the temporary casing or hollow stem auger should be removed in increments immediately following each increment of grout installation and in advance of the time when the grout begins to set. If casing removal does not commence until grout injection is complete, then, after the casing is removed, additional grout may be periodically injected into the annular space to maintain a continuous column of grout up to the ground surface.

3.8.3 Specific Procedures for Multi-Cased Wells – If the outer casing of a multi-cased well cannot be driven to form a tight seal between the surrounding stratum (strata) and the casing, it should be installed in a predrilled borehole. After the borehole has penetrated not less than 2 ft (608 mm) of the first targeted confining stratum, the outer casing is lowered to the bottom of the boring and the annular space is filled with grout. Grouting may be accomplished using a pressure grouting method or gravity feed through a tremie pipe. Pressure grouting will require the use of a grout shoe or packer installed at the end of the outer casing to prevent grout from moving up into the casing. If a tremie pipe is used to inject grout into the annular space, it should be equipped with a side discharge. With each alternative, the grout must be allowed to cure and form a seal between the casing and the grout prior to advancing the hole to the next hydrologic unit. This procedure is repeated as necessary to advance the borehole to the desired depth. Upon reaching the final target depth, the riser and screen is set through the inner casing. Subsequent to the placement of the filter packs and bentonite seal, the remaining annular space is grouted as described in Section 3.8.2 (see Fig. 3).

NOTE 11 – When using a packer, pressure may build up during grout injection and force grout up the sides of the packer and into the casing.

8.9 Well Protection – Well protection refers specifically to installations made at the ground surface to deter unauthorized entry to the monitoring well and to prevent surface water from entering the annulus.

8.9.1 Protective Casing – The protective casing should extend from below the frost line (3 ft to 5 ft [1.0 m to 1.5 m] below the grade depending on local conditions) to slightly above the well casing top. The protective casing should be initially placed before final set of the grout backfill. The protective casing should be sealed and immobilized in concrete placed around the outside of the protective casing above the set grout backfill. The casing should be positioned and stabilized in a position concentric with the riser (see Figs. 1 and 2). Sufficient clearance, usually 6 in. (15.2 cm) should be maintained between the lid of the protective casing and the top of the riser to accommodate sampling equipment. A 1/4 in. (6.3 mm) diameter weep hole should be drilled in the casing 6 in. above the ground surface to permit water to drain out of the annular space. In cold climates, this hole will also prevent water freezing between the well protector and the well casing. Dry bentonite pellets, granules, or chips should then be placed in the annular space below ground level within the protective casing. Coarse sand or pea gravel or both is placed in the annular space above the dry bentonite pellets and above the weep hole to prevent entry of insects. All materials chosen should be documented on the well completion diagram. The monitoring well identification number should be clearly visible on the inside and outside of the lid of the protective casing.

8.9.2 Completion of Surface Installation – The well protection installation may be completed in one of three ways:

8.9.2.1 In areas subject to frost heave, place a soil or bentonite/sand layer adjacent to the protective casing sloped to direct water drainage away from the well.

8.9.2.2 In regions not subject to frost heave, a 4 in. (101 mm) thick concrete pad sloped to provide water drainage away from the well may be placed around the installation. Care must be taken not to lock the concrete pad onto the protective casing if subsidence of the surface may occur in the future.

8.9.2.3 Where monitoring well protection must be flush with the ground, an internal cap should be fitted on top of the riser within the manhole or vault. This cap should be leak-proof so that if the vault or manhole should fill with water, the water will not enter the well casing. Ideally, the manhole cover cap should also be leak-proof.

8.9.3 Additional Protection – In areas where there is a high probability of damaging the well (high traffic, heavy equipment, poor visibility), it may be necessary to enhance the normal protection of the monitoring well through the use of posts, markers, signs, etc. The level of protection should meet the damage threat posed by the location of the well.

9. Well Development

9.1 General – Well development serves to remove the finer grained material from the well screen and filter pack that may otherwise interfere with water quality analyses, and to improve the hydraulic characteristics of the filter pack and hydrologic unit adjacent to the well screen. Methods of well developmen vary with the physical characteristics of hydrologic units in which the monitoring well is screened and with the drillin method used.

9.2 Development Methods – Methods of development mos. often used include mechanical surging and bailing or pumpin over-pumping, air-lift pumping, and jetting. An important fact in any method is that the development work be started slowl and gently and be increased in vigor as the well is developed. Most methods of well development require the application c sufficient energy to disturb the filter pack, thereby freeing th fines and allowing them to be drawn into the well. The coarse fractions then settle around and stabilize the screen. The well development method chosen should be documented on the we completion diagram.

NOTE 12 – Any time an air compressor is used, it should be equipped with an oil air filter or oil trap to minimize the introduction of oil into the screen area. The presence of oil woul impact the organic constituent concentrations of the water samples.

NOTE 13 – Development procedures for wells completed fine sand and silt strata should involve methods that are relativ ly gentle so that the strata material will not be incorporated into the filter pack. Vigorous surging for development can produc mixing of the fine strata and filter pack and produce turbid sam ples from the installation. Also, development methods should be carefully selected based upon the potential contaminant(s) present, quality of waste water generated, and requirements f containerization or treatment of waste water.

9.2.1 Mechanical Surging – In this method, water is forced to flow into and out of the well screen by operating a plunger (or surge block) or bailer up and down in the riser. A pump or ba er should then be used to remove the dislodged sediments following surging.

9.2.2 Over Pumping – With this method, the monitori well is pumped at a rate considerably higher than it would during normal operation. The fine-grain materials would be dislodged from the filter pack and surrounding strata influenced the higher pumping rate. This method is usually conducted conjunction with mechanical surging.

9.2.3 Air Lift Pumping – In this method, an air lift pump i operated by cycling the air pressure on and off for short perio of time. This operation will provide a surging action that w dislodge fine-grained particles. Applying a steady, low pressure will remove the fines that have been drawn into the well by t surging action. Efforts should be made to avoid pumping into the filter pack and adjacent hydrologic unit because the air may lodge there and inhibit future sampling efforts and may alter ambient water chemistry. Furthermore, application of hi air pressures should be avoided to prevent damage to small ameter PVC risers, screens, and filter packs.

9.2.4 Well Jetting – Another method of development volves jetting the well screen area with water while simultan ously air-lift pumping the well. However, the water added during this development procedure will alter the natural, ambient water quality and may be difficult to remove. Therefore, the w ter added should be obtained from a source of known chemistr Water from the monitoring well being developed may also be

used if the suspended sediments are first removed.

9.3 Duration of Well Development – Well development should begin after the monitoring well is completely installed and prior to water sampling. Development should be continued until representative water, free of the drilling fluids, cuttings, or other materials introduced during well construction is obtained. Representative water is assumed to have been obtained when pH, temperature, and specific conductivity readings stabilize and the water is visually clear of suspended solids. The minimum duration of well development should vary in accordance with the method used to develop the well. For example, surging and pumping the well may provide a stable, sediment free sample in a matter of minutes; whereas, bailing the well may require several hours of continuous effort to obtain a clear sample. The duration of well development and the pH, temperature, and specific conductivity readings should be recorded on the well completion diagram.

9.4 Well Recovery Test – A well recovery test should be performed immediately after and in conjunction with well development. The well recovery test not only provides an indication of well performance but also provides data for determining the transmissivity of the screened hydrologic unit. Estimates of the hydraulic conductivity of the unit can then be determined. Readings should be taken at intervals suggested in the table below until the well has recovered to 90% of its static water level.

Table 2. Suggested Recording Intervals for Well Recovery Tests

Time Since Starting Test	Time Interval
0-15 min	1 min.
15-50 min	5 min.
50-100 min	10 min.
100 min - 5 h	30 min.
5 h - 24 h	60 min.

NOTE 14 – If a monitoring well does not recover sufficiently for sampling within a 24 h period and the well has been properly developed, the installation should not generally be used as a monitoring well for detecting or assessing low level organic constituents. The installation may, however, be used for long-term water level monitoring if measurements of shorter frequency water level changes are not required.

10. Installation Survey

10.1 General – The vertical and horizontal position of each monitoring well in the monitoring system should be surveyed and subsequently mapped by a licensed surveyor. The well location map should include the location of all monitoring wells in the system and their respective identification numbers, elevations of the top of riser position to be used as the reference point for water level measurements, and the elevations of the ground surface protective installations. The locations and elevations of all permanent benchmark(s) and pertinent boundary marker(s) located on-site or used in the survey should also be noted on the map.

10.2 Water Level Measurement Reference – The water level measurement reference point should be permanently marked by cutting a V-notch into the top edge of the riser pipe. This reference point should be surveyed in reference to the nearest NGVD reference point.

10.3 Location Coordinates – The horizontal location of all monitoring wells (active or decommissioned) should be surveyed by reference to a standardized survey grid or by metes and bounds.

11. Monitoring Well Network Report

11.1 To demonstrate that the goals as set forth in Section 1 have been met, a monitoring well network report should be prepared. This report should:

11.1.1 Locate the area investigated in terms pertinent to the project. This should include sketch maps or aerial photos on which the exploratory borings, piezometers, sample areas, and monitoring wells are located, as well as topographic items relevant to the determination of the various soil and rock types, such as contours, streambeds, etc. Where feasible, include a geologic map and geologic cross-sections of the area being investigated.

11.1.2 Include copies of all well boring test pits and exploratory borehole logs, initial and post-completion water levels, all laboratory test results, and all well completion diagrams.

11.1.3 Include the well installation survey.

11.1.4 Describe and relate the findings obtained in the initial reconnaissance and field investigation (Section 5) to the design and installation procedures selected (Sections 7-9) and the surveyed locations (Section 10).

11.1.5 This report should include a recommended decommission procedure that is consistent with the well construction and local regulatory requirements.

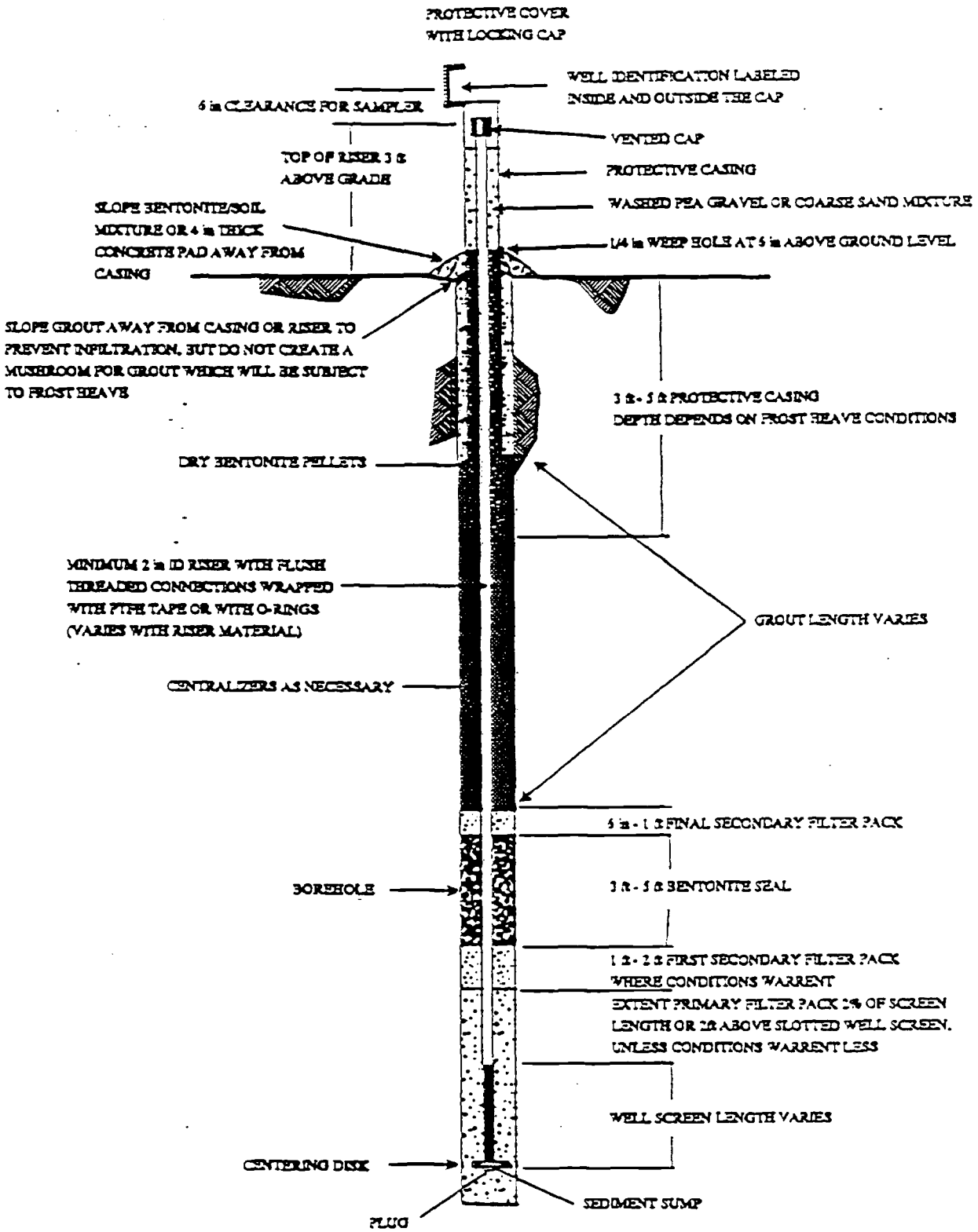


FIG. 2 Typical Monitoring Well Design - Single Cased Well

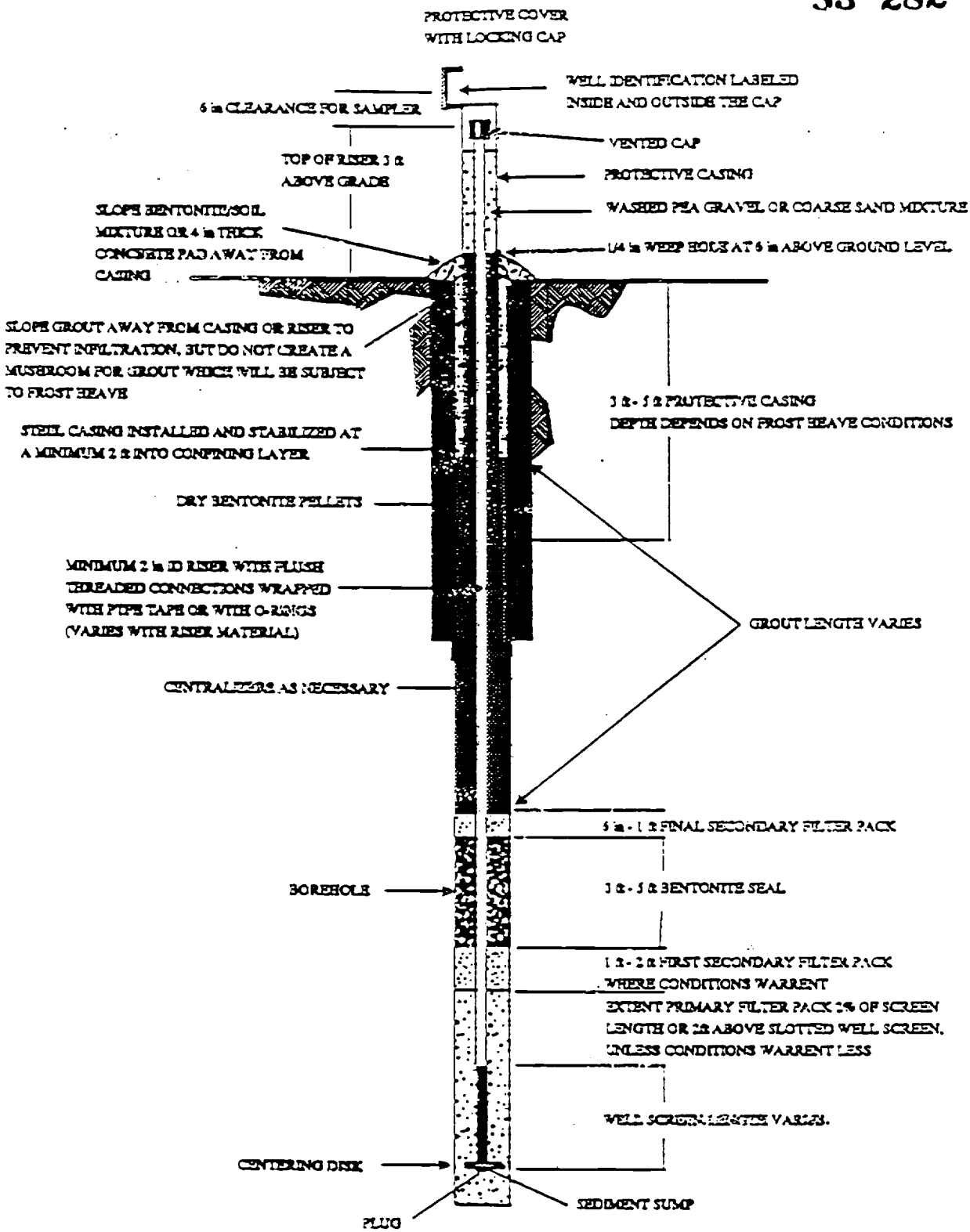


FIG. 3 Typical Monitoring Well Design - Multi Cased Well

Recommended Practice for Borehole and Monitoring Well Abandonment

1. Scope

1.1 This procedure is designed for the purpose of proper abandonment of boreholes, including monitor wells, water wells, soil borings and other types of boreholes where a potential may exist for downward migration of surface waters or contaminants, or intermingling of water-bearing zones which may have been penetrated during the drilling of the borehole.

1.2 For the purposes of this procedure, *abandonment* is synonymous with *decommissioning*.

1.3 This procedure will be used for well and borehole abandonment work where Federal, State, or local abandonment regulations or guidelines may not exist. However, when other abandonment regulations exist for a specific locality, the more stringent regulations will take precedence. It is the responsibility of the user to determine the most applicable procedure(s) or guideline(s) to be used.

1.4 This practice may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this practice to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 UNC Geotech Publications

UNC Geotech, Environmental, Safety and Health Procedures
UNC Geotech, Environmental Procedures Catalog, Decontamination Procedures
UNC Geotech, Utilities Location Procedures

2.2 Other Publications

American Petroleum Institute, Standard Practice Procedures for Testing Drilling Fluids.

Driscoll, F.G., *Groundwater and Wells*, 2nd edition, Johnson Division, St. Paul, MN, 1987.

Hix, G.L., "Decommissioning Monitoring Wells", *Ground Water Monitoring Review*, Vol 10, No. 2, Spring, 1990, pp. 63-65.

3. Terminology

3.1 Description of Terms Specific to this Procedure

3.1.1 *abandonment material* -- materials used for the permanent sealing of a borehole, monitor well, prospect hole, or other similar borings.

3.1.2 *approved materials* -- materials that are accepted as being environmentally safe and will not produce any adverse effects on the subsurface environment when used as per manufacturer's recommendations.

3.1.3 *casing hammer* -- a drive-weight assembly consisting of a 300 lbs (136.4 kg) or heavier impact weight which is successively lifted and dropped to provide the energy for driving casing downward or upward.

3.1.4 *casing perforator* -- a device to puncture, cut, or penetrate casing for the purpose of gaining access to the formation.

3.1.5 *downhole tools* -- this term is usually synonymous with 3.1.6.

3.1.6 *drill string* -- the assembly of drill pipe, augers, drill rod, bits or other tools which are powered or driven by the drill rig to perform a drilling function. This term is usually synonymous with "downhole tools."

3.1.7 *grout pipe* -- synonymous with 3.1.9.

3.1.8 *Marsh Funnel* -- funnel specifically designed for measuring viscosity of fluids pertinent to the drilling industry. The measurement is expressed in seconds per quart of flow through the funnel.

3.1.9 *tremmie pipe* -- a pipe inserted into a borehole for the purpose of placing material at a selected interval and in a manner so as to prevent voids or cavities. This term is synonymous with the term "grout pipe".

4. Significance and Use

4.1 This procedure shall be used whenever boreholes or monitoring wells are to be abandoned, unless Federal, State, or local abandonment procedures are more stringent. The proper abandonment procedures for boreholes will:

1) Eliminate physical and health hazards
2) Prevent vertical migration of contaminants
3) Prevent spread of contaminants to uncontaminated zones and aquifers
4) Reduce liability.

4.2 This procedure will be used to ensure that all casing and other well construction materials are permanently removed where possible and that the borehole(s) are sufficiently and permanently sealed to prevent any possible vertical migration of contaminants.

4.3 In addition, this procedure is designed to ensure that borehole(s) will be sealed so as to prevent any possible communication between contaminated zones, aquifers, or other subsurface geological features.

4.4 The project manager, or designee, is responsible for proper abandonment of boreholes and monitoring wells. It is also their responsibility to determine whether the wells have been registered with local, State, or Federal authorities and obtain permission to abandon the wells when necessary. Any required abandonment documentation will be forwarded to the

responsible agency(s) within the time constraints defined by the governing agency(s).

5. Hazard Analysis

5.1 This practice involves hazardous operations and equipment inherent to drill rigs. Hazards include, but are not limited to, those associated with moving and rotating equipment, and heavy equipment. Occupational hazards associated with noise, and lifting heavy objects also exist. Site-specific hazards may exist depending on the type of contaminants present in the subsurface. Site-specific hazards are addressed in the Health and Safety Plan for each site and are not discussed further. Personnel following the procedure outlined here are responsible for becoming familiar, and complying with, the site-specific Health and Safety Plan, the Drilling Health and Safety Plan, and other applicable health and safety requirements.

5.2 In order to minimize the hazards associated with this procedure, an exclusion area will be established around the drill rig that extends 25 feet in all directions and at least as far as the height of the mast. To the extent possible, all work will be performed outside this exclusion area and access will be limited to personnel performing essential tasks. While the drill string is rotating, Health and Safety personnel, technical personnel, and the drilling supervisor will have access to the exclusion area only when necessary to perform their work assignments.

5.3 The health and safety procedures for all personnel will be addressed in the UNC Health and Safety Plan (HASP) and are not discussed in detail. All project personnel are responsible for complying with the site-specific Health and Safety Plan, the Drilling Health and Safety Plan, and any terms of the subcontract. Personnel must have current training and medical requirements for fieldwork at the site.. Within the exclusion zone, all personnel must wear a hard hat, steel-toed boots, safety glasses, and any other personal protective equipment required for work in the exclusion zone.

6. Procedure(s)

6.1 Obtain the necessary permits and/or approvals to abandon the well. Contact other organizations that might have plans to monitor the well to be sure that there are no valid objections to abandonment.

6.2 Collect historical well data that will be useful in planning for abandonment. This should include borehole diameters and depths, well depth, casing diameters and depths, screen intervals, casing and screen materials, maximum groundwater contaminant concentrations, lithologic logs, and completion diagrams.

6.3 If an existing well or borehole to be abandoned has not been surveyed, it shall be surveyed prior to abandonment. New boreholes that must be abandoned will be marked temporarily and surveyed as soon as possible after abandonment.

6.4 Remove surface covers and/or other unnecessary installation(s) by dismantling, excavating, or other accepted means.

6.5 Remove all pumps, recorders, and other downhole apparatus where possible.

6.6 Remove all steel casing and well screens where possible. Removal may be accomplished by pulling, cutting, using jacks, or similar methods. Any casing and screen that cannot be removed by these methods shall be cut off at the maximum depth possible and retrieved. Any steel casing remaining in the borehole which is not cemented in the annular area will be perforated at minimum twenty foot intervals so as to provide a conduit for abandonment materials. If conditions warrant, perforation intervals shall be reduced to assure complete borehole sealing.

6.7. Remove all PVC and other synthetic casing and screens where possible. Removal may be effected as outlined in 6.6. Any PVC casing, screen, or other drillable materials that cannot be removed by methods as outlined in 6.6 shall be removed by drilling out the remaining material by rotary or auger drilling methods. Bit diameter shall be equivalent in size to the original borehole diameter and the borehole will be drilled to the original depth.

6.8 Materials and Methods for Filling the Borehole

6.8.1 The borehole shall be filled from total depth to within five feet of the surface with an approved abandonment material, e.g., neat cement grout, bentonite slurry, concrete or other approved abandonment material. In all cases, a tremmie (or grout) pipe will be used to place the abandonment fluid/material down the borehole. Drill pipe, drill rod, or other conductive materials may be used as the tremmie pipe. In all cases, the bottom of the tremmie or grout pipe shall be placed at the total depth of the borehole and the material pumped, under pressure, as the tremmie pipe is removed. No voids or air pockets are acceptable.

6.8.2 The manufacturer's recommended mix ratio shall be used for all pre-packaged abandonment material, e.g., SureGel™, Volclay™ and similar products. If other materials are used, they shall be prepared using the *minimum water volume necessary to allow pumping*. Minimum material/water mix ratios for common abandonment fluids are:

6.8.2.1 neat cement slurry -- in a ratio not to exceed seven (7) gallons of water per 94 pound sack of cement. The neat cement slurry shall have a minimum density of 13.5 lbs per gallon as measured by using a mud balance or scale.

6.8.2.2 bentonite clay slurry -- will have a minimum uniform density of 9.4 pounds per gallon. In addition, the bentonite clay slurry shall have a Marsh Funnel viscosity of at least 50 seconds per quart of fluid and a ten minute gel strength of 20 lbs/sq ft. Density and funnel viscosity shall be measured as outlined in the most recent "American Petroleum Institute, Standard Practice Procedures for Testing Drilling Fluids" publication.

6.8.2.3 Cement/Sand grout -- a slurry of cement. sand and water. The amount of sand added shall not exceed 140 pounds for each 94 pounds of cement. Not more than seven (7) gallons of water per 94-pound sack of cement shall be used in preparation of these slurries. These slurries are normally

used where extra strength or bulk is required.

6.8.2.4 Concrete -- a slurry of cement, sand and gravel aggregate. The amount of aggregate added shall not exceed 400 pounds for each 94-pound sack of cement. Not more than seven (7) gallons of water per 94-pound sack of cement shall be used in preparation of these slurries. These slurries should be used where extra strength and bulk is required and the annular space allows the placement of the slurry.

6.8.2.5 Bentonite solids -- solid granular bentonite may be used as grout material only in saturated zones. The bentonite shall be placed directly into the appropriate interval. If bentonite is dropped directly into the hole, its placement shall subsequently be verified.

6.9 Allow sufficient time for the abandonment material to set up per manufacturer's recommendations.

6.10 Once the abandonment material has set up, place a minimum 2-foot concrete plug in the borehole. The top of the concrete must be far enough below the ground surface that it will not pose a hazard for vehicles operating in the area such as mowers or plows. A steel marker may be placed in the concrete if it is desirable to locate the borehole with a magnetometer in the future.

6.11 Backfill the borehole to the surface with material compatible with the surrounding surface materials.

6.12 Restore the site to blend with the immediate surroundings. Grade to contour and reseed if necessary.

6.13 All materials recovered from the borehole and all waste created from the abandonment effort will be disposed of in accordance with UNC Geotech policies and in compliance with all applicable local, State, and Federal requirements or agreements.

7. Report

7.1 A record will be kept of all abandonment activities, and will include the well i.d. or registration number, coordinates of the well (tied to a permanent marker), date abandoned, personnel responsible for abandonment, contractor performing the procedures, permits or approvals received (state if none were necessary), methods used, materials removed and disposal methods, depths, hole diameters, materials and quantities used, unusual occurrences, and other pertinent data.

MULTIPLE-LEVEL MONITOR WELL INSTALLATION

INTRODUCTION

Defining the extent of a groundwater contaminant plume in geologic materials requires a three-dimensional array of sampling points. Such an array is commonly installed by placing a single pizeometer in each of a series of boreholes.

When ground water contaminant plumes are suspected of having significant depth as well as lateral distribution, a three-dimensional array of monitoring points is needed to identify and characterize such plumes. Thus, ground water data must be obtained from a number of different locations and from a number of different depths at each location. As a result, either a large number of drillholes are required, each with a separate instrument installed, or instruments must be combined and installed at multiple levels in each of a smaller number of drillholes.

The basic requirements of any ground water monitoring system are that it provide the user with the ability to measure fluid pressure, purge the monitoring zone prior to sampling, obtain fluid samples, and undertake standard hydrogeologic tests, such as permeability tests and tracer tests. In addition, quality assurance plans for groundwater monitoring programs have led to a requirement for periodic testing and calibration of all aspects of ground water monitoring devices.

REFERENCE DOCUMENT

Black, W.H., H.R. Smith and F.D. Patton. Multiple-Level Groundwater Monitoring with the MP System: Proceedings of the NWWA-AGU Conference on Surface and Borehole Geophysical Methods and Groundwater Instrumentation, Denver, Colorado, October 15-17, 1986, pp 41-61

APPARATUS

Multiple-level ground water monitoring devices use a single, closed access tube with valved ports. The valved ports provide access to several different levels of a drillhole in a single well casing. The modular design permits as many monitoring zones as desired to be established in a drillhole. Furthermore, at the time of installation, zones may be added or modified without affecting other zones or significantly complicating the installation.

Multiple-level systems consist of casing components, which are permanently installed in the drillhole, portable pressure measurement and sampling probes, and specialized tools. The casing components include casing sections of various lengths, regular couplings, and valved port couplings with different capabilities.

Casing Components

The casing components are made in either plastic or stainless steel. The descriptions that follow apply to both types of material. Most of the components referred to are shown in Figure 1.

Casing

Casing is available in a number of different lengths to provide flexibility in establishing the position of monitoring zones and associated seals in the drillhole. Common nominal casing lengths are 5 ft and 10 ft . Actual casing lengths are less than the nominal lengths to account for the lengths of the couplings. The casing ends are machined to mate with couplings.

Couplings and End Caps

Regular couplings are used to connect casing lengths where valved couplings are not required. The couplings incorporate O-rings for a positive hydraulic seal. No adhesives are used when joining casings and couplings. End caps are placed on the bottom of a casing string. They also incorporate an O-ring seal so that the entire casing string is hydraulically sealed during installation. End caps will be used to seal the top of the casing between monitoring periods.

Valved Couplings

There are two types of valved couplings, measurement port couplings and pumping port couplings. Measurement port couplings (or measurement ports) are used where pressure measurements and fluid samples are required. In addition to the features of a regular coupling, measurement ports incorporate a valve in the wall of the coupling, a leaf spring which normally holds the valve closed, and a cover plate which holds the spring in place. When the valve is opened, an access port is provided for the ground water to enter the coupling.

Pumping port couplings (or pumping ports) are used where the injection or withdrawal of large volumes of fluid is desired (such as for well development or hydraulic conductivity testing). Pumping ports incorporate an interior sleeve valve, sealed by O-rings, which can be moved to expose or cover slots that allow ground water to pass through the wall of the coupling. A screen is normally fastened around the coupling outside the slots.

Seals

When there are many monitoring zones in a single drillhole, multiple seals are required to prevent fluid migration from one zone to another along the annular opening between the drillhole wall and the casing.

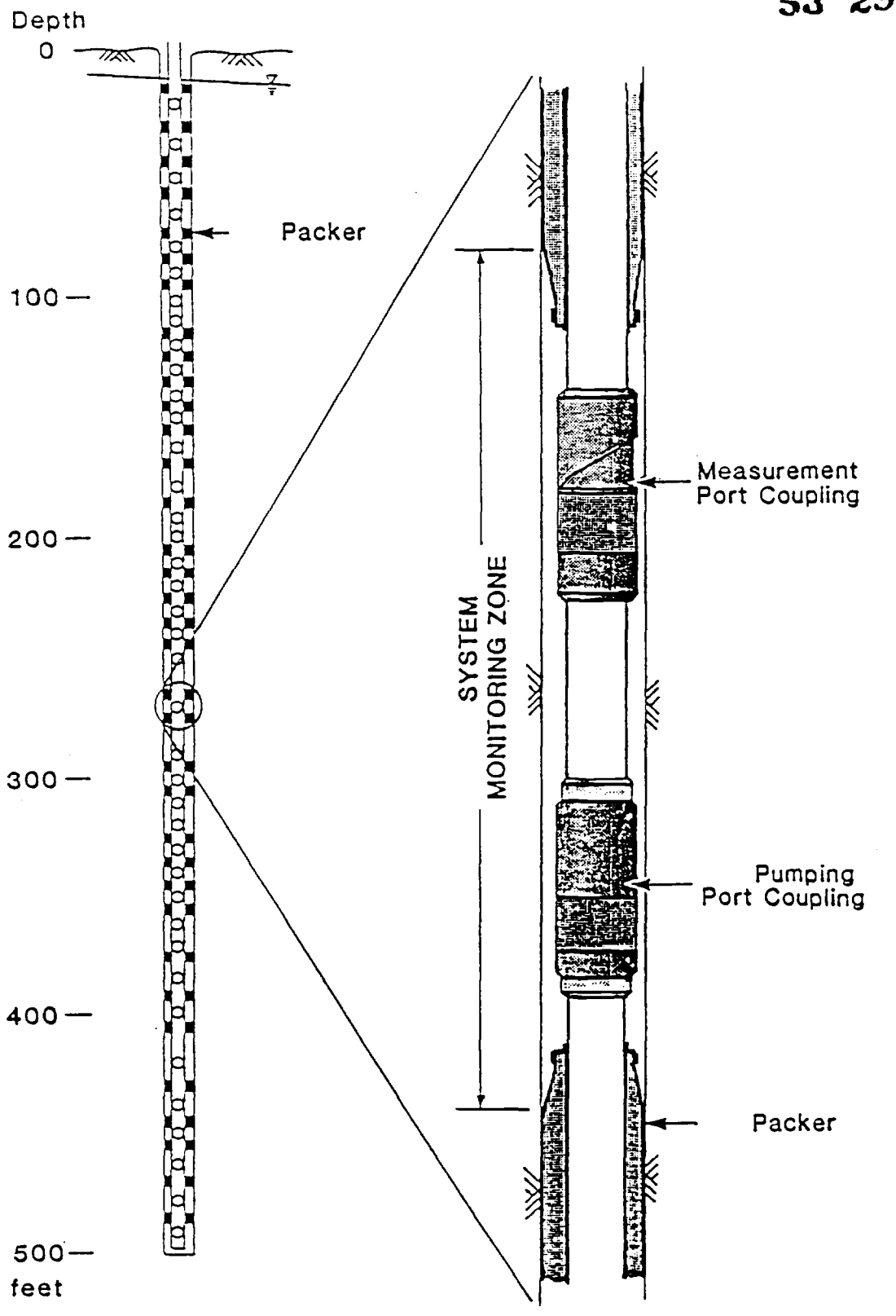


Figure 1. System installation with monitoring zones isolated by packers.

Seals are obtained by backfilling with alternating layers of sand and bentonite or grout. A single measurement zone where the multiple-level system is completed by backfilling is shown in Figure 1.

Backfilling is recommended for: a) large diameter drillholes, b) shallow drillholes, c) drillholes where little or no fluid circulation is anticipated in the hole during installation (i.e., when near-hydrostatic fluid pressures or low hydraulic conductivity is present over the length of the drillhole), and d) where packer gland materials are incompatible with the chemistry of the fluids present, as at Plant 4.

Backfill seals may include bentonite and/or grout slurries, bentonite chips or pellets or other materials with a relatively low hydraulic conductivity in comparison to that of the natural formations present.

Screens and Filters

Where both pumping ports and measurement ports are being used and the ports are likely to be surrounded by sand fill, a single well screen is generally placed over both the measurement port coupling and pumping port coupling in each monitoring zone as shown in Figure 1. The screen helps ensure that the zone influenced by pumping from a pumping port coupling will extend to and include the region surrounding the adjacent measurement port coupling. Screen slot size and length will be chosen with a knowledge of local site conditions.

INSTALLATION PROCEDURES

Selection of Casing Components

The valved couplings (measurement port couplings and pumping port couplings) allow many monitoring zones to be established in a single drillhole. Horizons of hydrogeological interest are targeted on the basis of lithologic logs available. An installation log is prepared showing the locations of the casing components. Because sampling, fluid withdrawal or fluid injection is anticipated, both a pumping port coupling and a measurement port coupling will be installed in each monitoring zone. This is the case illustrated in Figure 1. Sampling of light nonaqueous phase liquids (LNAPLs) will not be done using a multiple-level monitoring device due to fluctuations in the water table that make it difficult to place a sampling port at the proper depth for sample collection. Sampling of dense nonaqueous phase liquids (DNAPLs) will be done by installing the sampling port immediately below the top of the confining layer. This will require that the well be drilled approximately 5 feet into the confining layer to allow room for the multiple-level installation and a DNAPL trap.

The casing lengths are chosen based on the desired locations of the monitoring zones and seals. This requires an interpretation of the lithology and the hydrogeologic conditions anticipated in each drillhole.

MONITOR WELL INSTALLATION

1. The downhole components - casing, and couplings - are laid out on clean polyethylene at the site of the proposed monitoring well in accordance with the casing installation log. At that time, any last minute adjustments required to make the positions of the monitoring zones and seals match hydrogeologic details of the drillhole are completed and the appropriate revisions are made to the installation log.

2. The required coupling is attached to the top of each length of casing. The casing layout is checked again for compliance with the installation log. The casing string is then assembled by lowering the casing segments into the drillhole and attaching each successive segment to the adjacent coupling one at a time.

   Casing layouts can be placed in various sizes of boreholes, with or without protective drill casing, as long as the borehole diameter (and casing) is compatible with the backfilling method. Backfilling will involve the use of one or more tremie pipes. During placement of the multilevel casing in holes where there is a high static water level, clean water may be added to the inside of the multilevel casing to reduce its buoyancy.

3. Once the casing has been placed in the drillhole, the backfill is placed (see Figure 1). If the casing was lowered inside protective steel rods or drill casing, this casing may be withdrawn in steps as the backfilling operation proceeds. An incremental casing withdrawal can reduce the opportunity for the drillhole wall to loosen and cave prior to the placement of seals.

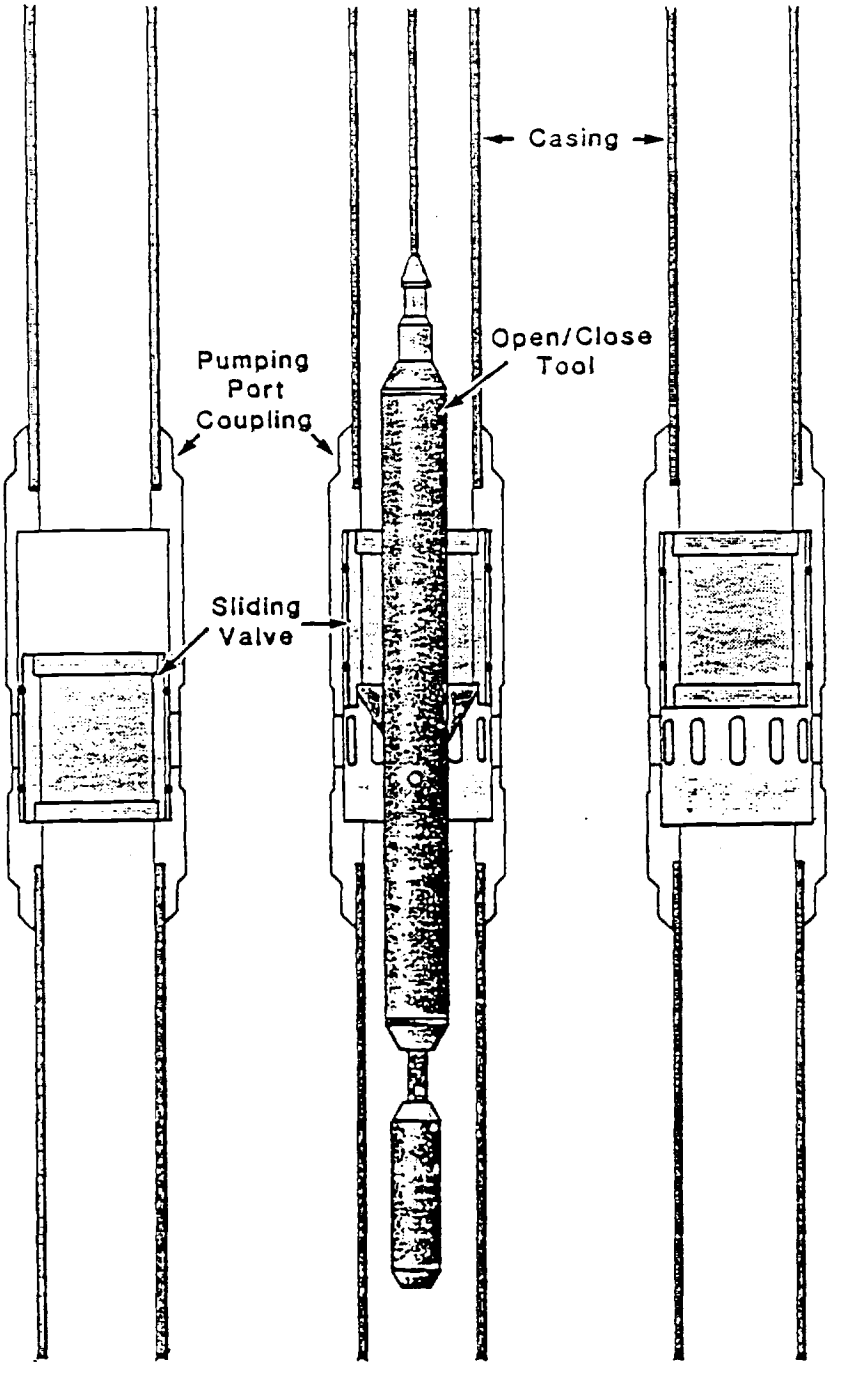
DEVELOPMENT of MONITORING ZONES

The strategy for developing the monitoring zones may vary depending on site conditions. Once the casing and annular seals have been installed, the development of the monitoring zones can proceed. Monitoring zones can be developed individually or several at a time. The development procedures are essentially the same as would be used for a single standpipe piezometer. One procedure which has been successfully used is described below.

1. An environmentally acceptable and convenient tracer is added to the drill fluid during drilling.

2. After the casing has been installed and the seals have been set, the pumping ports in all or a portion of the monitoring zones are opened with the use of an open/close tool (Figure 2).

3. Fluid from the inside of the casing is pumped out of the hole. Either a suction lift pump or a momentum lift device equipped with a foot valve will be used to remove the fluid and any solids. The pumping time will depend on many factors including: the drilling method, the length of time the hole was left open prior to completion, the hydrogeological



a) Pumping Port Closed.

b) Open/Close Tool Pulled Up to Open Slide Valve.

c) Pumping Port Open.

Figure 2. Steps in opening a pumping port.

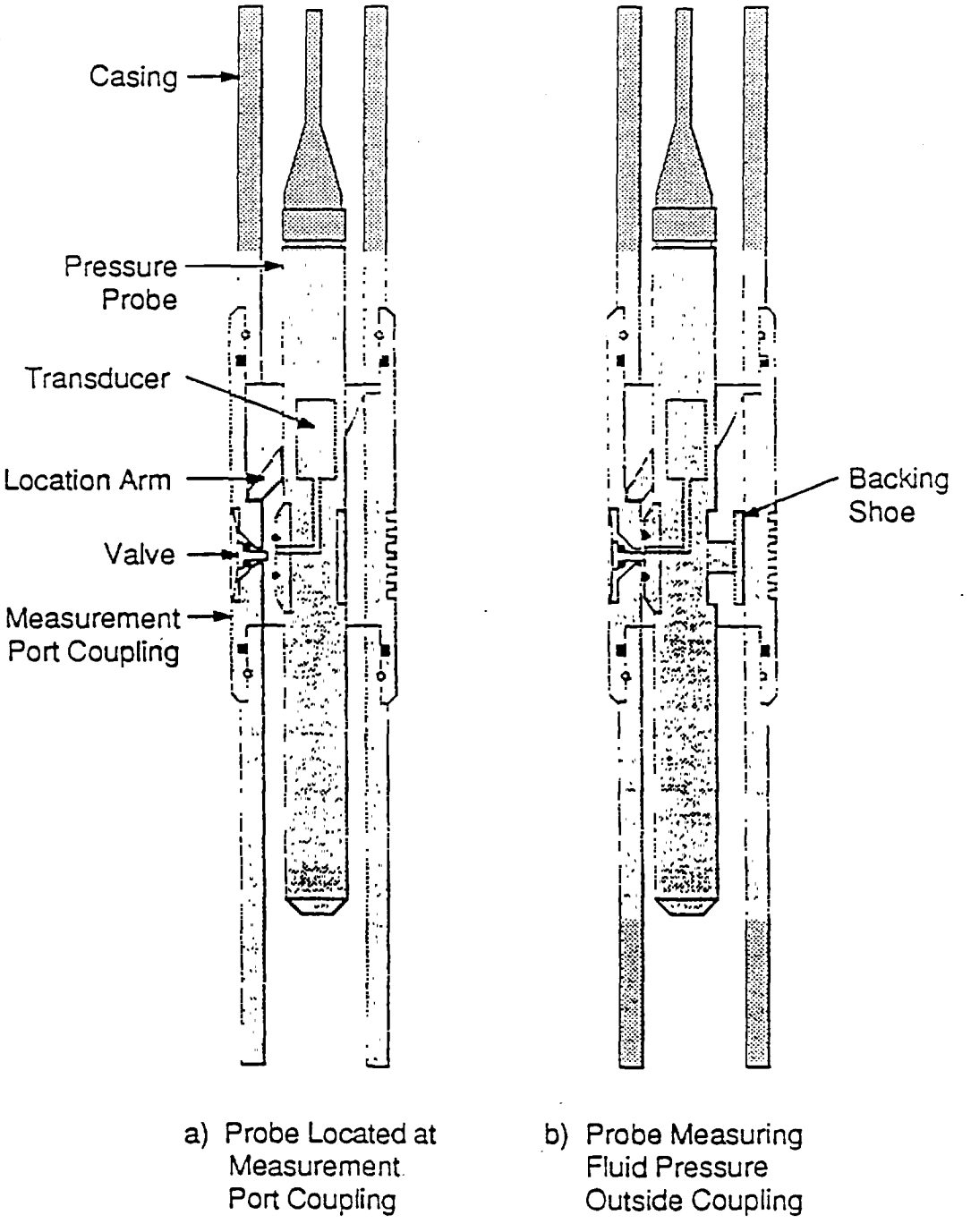


Figure 3. Operation of a pressure probe.

conditions in the drillhole, and the accuracy required. The tracer can be helpful in determining when the pumping is completed.

4. Once the pumping has been completed, all the pumping ports except one are closed with the use of the open/close tool. With one pumping port open, the casing is hydraulically identical to a standpipe piezometer. A small quantity of fluid may be pumped from inside the casing to complete the development of this monitoring zone. Hydrogeologic testing of this zone and its adjacent casing seals can be done at this time. This pumping port is then closed, the next one opened, and the process repeated.

Following development, the multiple-level system is ready for sampling and for pressure measurements.

GROUNDWATER SAMPLING AND AQUIFER TESTING - DISCUSSION

To operate the pumping port valve, an open/close tool is used as illustrated in Figure 5. This tool has spring loaded "jaws" which can be opened from the surface. The pumping port is shown closed in Figure 5a. To open the valve, the tool is lowered on a wireline with the jaws extended and pointing upward (i.e., so that they will catch on shoulders when the tool is raised). In this condition, the jaws will spring through the couplings as the tool is lowered to just below the desired pumping port coupling. The tool is then pulled up so that the jaws engage the bottom shoulder of the sliding valve. By continuing to pull up on the wireline, the valve can be opened, as in Figure 5b. Once the valve is opened, the jaws can be collapsed into the housing and the tool recovered. With this one valve opened, fluids can be added to or removed from the monitoring interval by injecting or pumping from the casing. Other zones may still be monitored in the normal manner using a pressure probe or sampling probe as they will not be hydraulically connected to the interior of the casing.

To close the pumping port coupling, the open/close tool is brought to the surface and the housing is reversed so that the jaws point downward (i.e., the tool will stop on exposed shoulders when the tool is lowered). The tool is lowered to the open pumping port with the jaws collapsed into the housing. Once the tool is located near the pumping port, the jaws are released and the valve is closed by tapping on the top shoulder of the sliding valve with the tool.

Aquifer Testing

Fluid Pressure Measurements

Fluid pressure measurements can be made at each location in a drillhole where a measurement port coupling has been installed. The measurement coupling includes a helical landing ring and a leaf spring valve which is normally closed. The fluid pressure is measured using a pressure probe which incorporates a location arm, a backing shoe, a face seal, and a fluid pressure transducer. These features are shown on Figure 3. The probe is operated on a cable and a readout unit at the surface displays the

transducer output. Electronic pressure probes also display the temperature of the transducer.

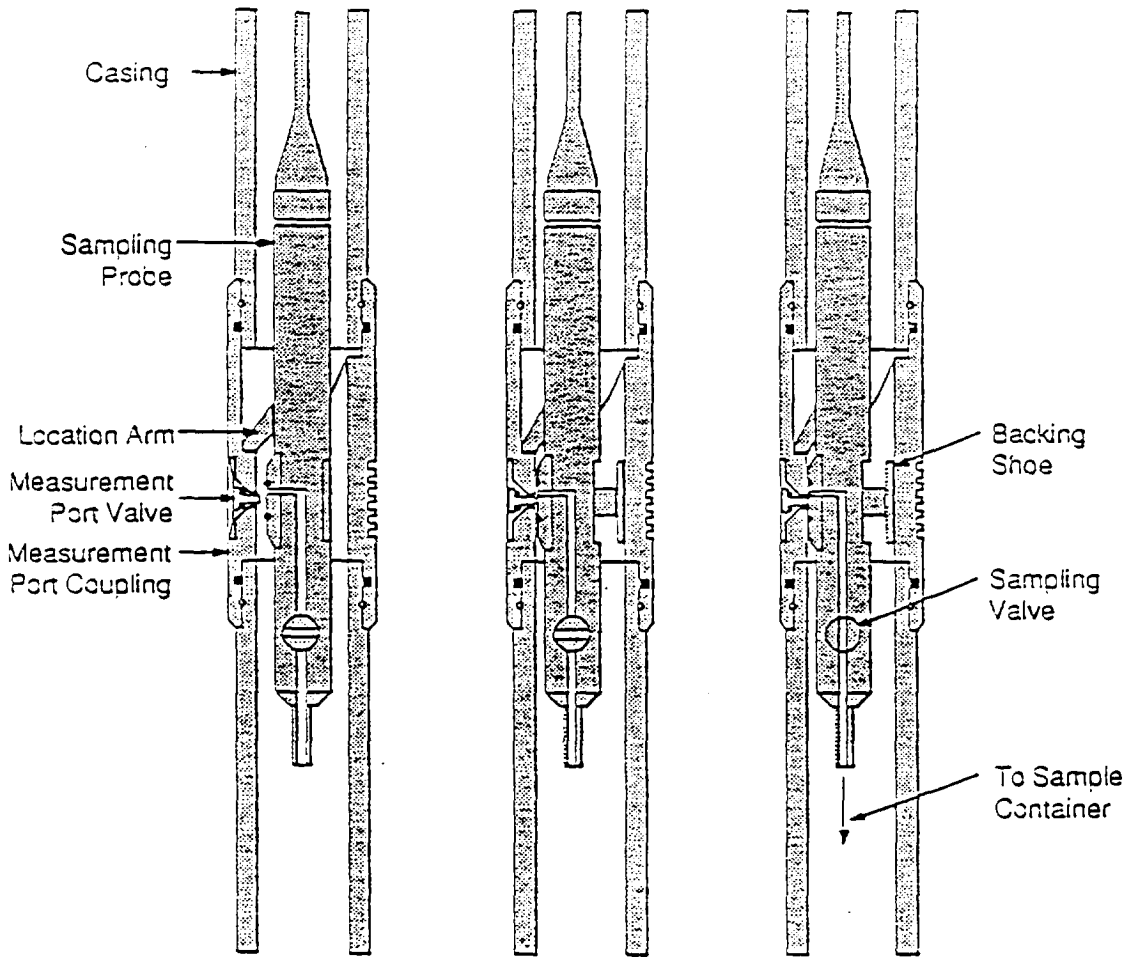
The following procedure is used to make fluid pressure measurements. The probe is lowered to a point below the deepest measurement port to be accessed. The backing shoe is briefly activated (extended). This releases the location arm from within the probe body. The location arm will remain out until the probe is removed from the borehole and the location arm can be manually pushed back into the body. The probe is raised to just above the lowest measurement port coupling and then lowered until the location arm rests on the helical landing ring inside the coupling. The weight of the probe will cause it to rotate into position at the correct depth and orientation to operate the valve (Figure 3a). At this point the pressure transducer will be measuring the fluid pressure inside the casing at that depth and this reading will be displayed on the surface data unit.

The backing shoe is then activated. It pushes the probe to the wall of the coupling so that the face seal on the probe seals around the measurement port valve at the same time as the face of the probe pushes the valve open. The transducer is now hydraulically connected to the fluid outside the coupling and isolated from the fluid inside the casing (Figure 3B). The reading displayed on the surface data unit will be the fluid pressure in the formation outside the measurement port. After the reading has been recorded, the probe backing shoe is deactivated (retracted) and the valve in the coupling reseals. The probe will again be measuring the fluid pressure inside the casing (Figure 3a).

The probe is then moved up to the next measurement port and the procedure is repeated.

Hydraulic Conductivity Testing

Multiple-level monitoring systems are designed to allow measurement of the change in pressure during fluid withdrawal. An open/close tool is lowered into the well and a pumping port opened. The open/close tool is removed from the well. An electric water level recorder is used to determine the fluid level. A specialized pressure probe containing an electronic pressure transducer is then lowered inside the casing until it is 6 inches above the bottom of the casing. A sealed and weighted bailer will then be lowered inside the casing until the top of the bailer is 6 inches below the fluid level. The fluid will be allowed to stabilize from the effect of placing the transducer and bailer into the fluid. After the fluid level has stabilized the bailer will be withdrawn from the fluid as described in Appendix Section 11.4. The procedure for a single well aquifer test will then be followed to determine hydraulic conductivity. This method will determine the hydraulic conductivity of the materials surrounding each pumping port and may be repeated for each pumping port in turn.



a) Probe Located at Measurement Port Coupling. Sampling Valve Closed.

b) Probe Activated. Sampling Valve Closed.

c) Probe Activated. Sampling Valve Open.

Figure 4. Operation of a sampling probe.

Groundwater Sampling

Fluid samples are obtained by lowering a sampling probe and sample container to the desired measurement port coupling. As shown in Figure 4, the sampling probe operates in similar fashion to the pressure probe except that a ground water sample is drawn through the measurement port coupling.

Ground Water Sampling Procedure

1. A clean, empty sample container (sample bottle) is attached to the sampling probe. The sampling valve is closed to prevent the fluid inside the casing from entering the sample container. The probe and container are lowered to below a selected measurement port coupling. The backing shoe is briefly activated to release the location arm and the probe is then positioned in the measurement port coupling (Figure 4a).

2. The backing shoe is activated and pushes the probe to the wall of the coupling so that the face seal on the probe seals around the measurement port valve at the same time as the face of the probe pushes the valve open. The interior passage of the probe is now hydraulically connected to water outside the coupling (Figure 4b).

3. The sampling valve in the probe is opened by the surface controls which allows fluid from outside the measurement port to enter the sample bottle (Figure 4c). Once the bottle is full, the sampling valve is closed (Figure 4b), the backing shoe is deactivated (retracted) (Figure 4a) and the sampling probe and sample bottle are pulled to the surface. The sampling probe can then be cleaned, a clean bottle attached, and the procedure repeated.

The advantages of this discrete sampling method can be summarized as follows:

1) The sample is drawn directly from formation fluids outside the measurement port and the fluids inside the casing are unlikely to be a significant factor. Therefore, there is no need for pumping a number of well volumes prior to each sampling period. Because there is no pumping prior to sampling, the sample is obtained with minimal distortion of the natural ground water flow regime.

2) The lack of pumping means samples can be obtained very quickly, often at an average rate of one sample every 5 to 10 minutes.

3) The sample travels a short distance into a sample container, typically from 1 to 2 ft, regardless of depth.

4) There is a greatly reduced requirement to safely dispose of purged fluids containing contaminants.

Several different containers can be used for samples. Samples can be obtained which have had no contact with the atmosphere. Containers are also available which maintain the sample at the pressure in the formation during recovery from the well and transportation to a laboratory. Other containers allow the sample to depressurize as it is brought to the surface.

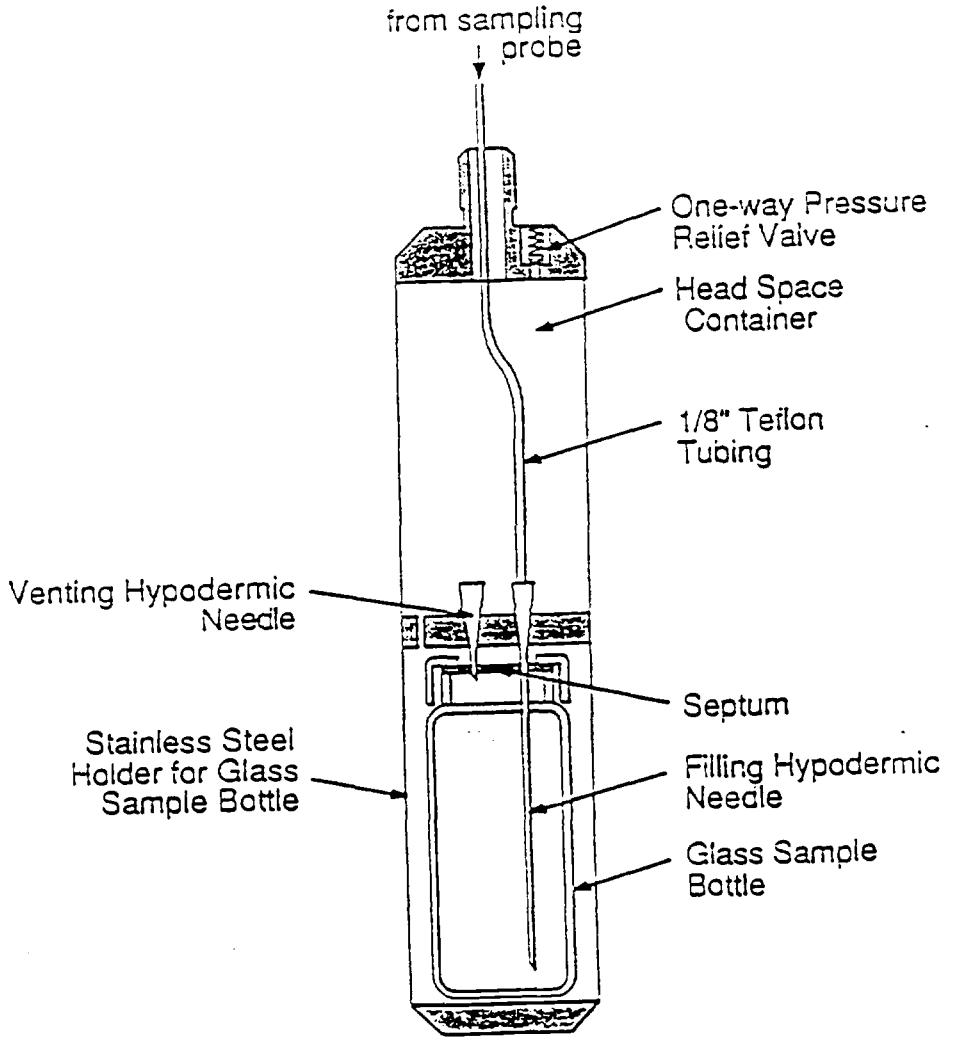


Figure 5. Sample bottle holder containing glass VOA sample bottle.

One type of container, which is used for collecting samples for volatile organic analysis, is illustrated in Figure 5. With this container, the sample flows from the sampling probe through a 1/8 inch teflon tube and stainless steel hypodermic needle directly into a 40 ml VOA glass sample bottle. A second needle vents the glass bottle so that a full sample bottle can be collected. The second needle, together with the one-way pressure relief valve, also permits flushing of formation fluids through the sample bottle before the final sample is collected. At the surface the perforated septum will be replaced with a new septum to minimize the release of volatiles during shipment to the laboratory.

FIELD QUALITY CONTROL PROCEDURES

Multiple-level systems have many unique features for field quality control that meet the stringent requirements of users in hazardous waste management.

Quality control tests are carried out at various points during the use of the system and tend to be grouped into three periods: during installation, following installation, and during routine monitoring.

During Installation

During installation of the multiple-level system the following operations form part of the quality control procedures.

Drill core or cuttings and geophysical logs are carefully checked to see that monitoring zones and annular seals are placed at the optimum positions.

Casing components are carefully inspected to see that critical surfaces are undamaged, sealing O-rings are clean and in place, and components are correctly oriented. Serial numbers of port couplings are recorded and their position in the installation noted. These operations will tie the field quality control to production test results.

When the multilevel casing string is lowered into the drillhole, the water level inside the casing can be kept at a different level than the water outside the casing. The level inside will be checked periodically to see that no leaks have developed.

Following Installation

Immediately following installation further checks are carried out to verify the operation of the system. These include the initial pressure profile which serves to confirm the operation of the inlet valves of the measurement port couplings. Observed head differences across exterior casing seals directly indicate the seal effectiveness. Where such head differences are not observed, the annular seals can be artificially stressed by opening a pumping port in one monitoring zone and withdrawing or adding a slug of water from inside the casing while using the pressure probe to observe the pressure response in the monitoring zone on the other side of the seal.

During Routine Monitoring

When measuring fluid pressures, the pressures measured inside the multilevel casing at each measurement port are recorded immediately before and after the measurement made through the port. These inside casing

values serve a number of purposes: 1) comparison of the two values confirms that the transducer was operating the same way after the reading as before, 2) comparison of the inside values from one set of measurements to the next confirms transducer stability over the intervening time period, and 3) if the head of fluid inside the casing is known, a direct field calibration of head of water versus transducer pressure output is obtained. In addition, when the electric pressure probe is used, the temperature of the pressure transducer is recorded and may be used to further correct the transducer output. Any unacceptable changes which show up during monitoring can be checked and corrected by laboratory calibration of the instrument.

Water sampling procedures with the multiple-level system improve quality control because: 1) the short flow path between the formation and the container greatly reduces the surface area contacted by the sample, 2) the contacts between the water sample and the atmosphere are eliminated, except when the perforated septum is replaced, and 3) when the water level inside the casing can be observed during sampling and no change is noted, this confirms that the sample obtained is from outside the casing.

During water sampling, field duplicates will be collected using identical procedures for sampling, preservation, handling, and shipping. Trip blanks and field blanks will also be collected using identical procedures for handling, preservation and shipping.

For both fluid pressure and water quality data, the multiple-level system can provide corroborative data. That is, a high density of data can be obtained in a single installation so that significant changes in piezometric pressure and/or water quality can appear as transitions. Thus, neighboring values will corroborate one another rather than indicating abrupt changes which would cause one to question any anomalous values.

SINGLE-WELL AQUIFER TESTS

INTRODUCTION

Single-well aquifer tests will be performed using the slug-withdrawal method. The test data will be used to measure the hydraulic conductivity of the upper zone layers at AFP 4. The test will be performed on all new monitoring-well completions in the upper zone.

REFERENCE DOCUMENTS

Freeze, R. A., and J. A. Cherry, 1979. *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, pp. 339-341.

Hvorslev, M. J., 1951. *Time Lag and Soil Permeability in Groundwater Observations*, Bulletin 36, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

SIGNIFICANCE AND USE

To evaluate the groundwater transport mechanisms at each site at AFP 4, hydraulic conductivity of the upper alluvial deposits must be determined. This information will be used for groundwater flow, and contaminant fate and transport modeling.

APPARATUS

The test apparatus will consist of a sealed, weighted bailer with a known water displacement volume and an electronic pressure transducer connected to an automatic electronic data logger. The bailer support line and pressure transducer cable will be marked to allow proper positioning in the well.

PROCEDURE

1. With the electronic sounder (interface probe), measure the static water level in the well and record in terms of feet below top of casing.

2. Lower the transducer to a position six inches above the bottom of the well casing and tape the cable to the exterior of the casing at the top of the well to hold the transducer in position. Record the transducer reading displayed on the data logger.

3. Lower the bailer until it is totally submerged, with the top of the bailer six inches below the static water level.

4. Monitor the water level until the well stabilizes (the data-logger reading is returns to the value recorded prior to inserting the bailer).

5. Set the recording level on the logger to CONTINUOUS.

6. Rapidly and smoothly lift the bailer out of the water column and remove the bailer assembly from the monitor well. Decontaminate the bailer and support line in accordance with applicable procedures.

7. After the bailer is lifted out of the fluid, the recorder will record continuously for 5 minutes.

8. At 5 minutes, set recording interval to 30 seconds and record for 5 minutes.

9. At 10 minutes from the start, set recording interval to 1 minute.

10. At 20 minutes, set the recording interval to 2 minutes.

11. At 40 minutes, set the recording interval to 5 minutes.

12. At 2 hours, set the interval to 10 minutes and maintain until the water-level recovery rate has become negligible.

13. Upon completion of the test the pressure transducer and support cable will be removed from the well and decontaminated in accordance with applicable procedure.

NOTE: The data at all intervals will be transferred into individual data files on a microcomputer from the logger. The first column will be "time in seconds" and the second will be "hydraulic head in feet." The computer program BAIL, developed and QA-verified by UNC Geotech, will be used to calculate the hydraulic conductivity from the slug test.

MULTIPLE-WELL AQUIFER TESTING PROCEDURE

Hydraulic conductivity data obtained from the analysis of individual slug tests will be used to determine the appropriate combination of pumping rate and pumping-well offset distance (with respect to the monitoring or observation wells). Pumping wells will be selected based on a review of all previous water quality data to ensure that the pumping test has a minimal influence on the spread of contaminants at AFP4. Before pumping tests are conducted on a new well the pumping well will be sampled for hazardous materials and the results will be analyzed. On the basis of the analytical results, the pumped fluid will be discharged to an approved NPDES permitted facility or released. The appropriate regulating agency will be contacted prior to the start of any pumping test for approvals.

If conditions permit, a suction-lift pump will be used to withdraw water from the pumping well. A submersible pump will be used if the static water level in the pumping well is too far below the ground surface to permit suction-lift pumping (the actual limiting value will depend on the performance characteristics of the pump used and the desired drawdown in the pumping well).

Prior to the start of the test, an electronic pressure transducer will be placed in each observation well. Each transducer will be lowered to a position 6 inches above the bottom of the casing, and the transducer cable will be taped to the outside of the well. Another transducer will be placed in the bottom of a sand-filled bucket to monitor barometric pressure changes. All transducers will be connected to an automatic data logger.

The pumping apparatus (either a PVC intake pipe or a submersible pump unit) is then installed in the pumping well. A valve on the discharge line will be set at approximately 75 percent open. As the test progresses and the hydraulic head in the pumping well decreases, a constant flow rate will be maintained by opening this valve further. The pumping rate will be calculated by measuring the time required to fill a large container of known volume. The pumping rate will be measured once every 10 minutes during the first 2 hours of the test, and the valve will be adjusted as needed to maintain a constant pumping rate. After 2 hours, the pumping rate will be measured (and adjusted if necessary) once every 4 hours.

Prior to the start of the pumping test, the static water levels in the pumping well and the observation wells will be measured manually. The data logger is then turned on and observed until all channels show an essentially constant pressure. The recording interval is then set at "continuous" (one set of readings approximately every 4 seconds) and the pump is turned on to begin the test. The continuous recording interval is maintained for the first 10 minutes. At 10 minutes, the recording interval is set to once per minute; at 100 minutes, the interval is set to once per 15 minutes; and at 600 minutes, the interval is set to once per 30 minutes and remains at this setting for the duration of the test.

CONTINUOUS WATER LEVEL RECORDINGS

Explanation and Method

Continuous water level recorders will be placed in several of the wells at Air Force Plant 4 to record fluctuations in water table elevation.

Continuous water level recording equipment consists of electronic pressure transducers and electronic data loggers. The pressure transducers will be decontaminated and lowered into a monitoring well. The transducer is connected to an electronic data logger capable of recording data values (water table elevations) at user-selectable intervals. At Air Force Plant 4 the data interval will be set to record every 15 minutes. The data loggers contain enough memory to store data collected at 15 minute intervals for 16 weeks. The data logger will be connected to a laptop computer every 8 to 14 weeks to dump the previously collected data. Data loggers contain internal batteries which allow data collection for approximately 5 years. Data loggers used at Plant 4 will be maintained by UNC Geotech Electronics Laboratory personnel to verify proper equipment operation.

The electronic pressure transducers are calibrated at the factory and require no further field calibrations. Before the transducer is placed in a well, the water level is measured using an electronic water level recorder. The transducer is then lowered into the well, to a depth that is below any water level fluctuations. The pressure value indicated on the data logger reflects the depth of the pressure transducer below the water level in the well. Before using the data logger, the operator will wait for the water level to stabilize from the effect of placing the transducer and cable into the well.

Reference Document

Hermit Environmental Data Logger, Model 1000b, Owners Manual. June 1986, In-Situ, Inc. Laramie, Wyoming

BIOTA

This protocol was prepared to address the utility and methodology of utilizing plants and aquatic animals as a means of measuring the presence and/or the distribution of hazardous substances in terrestrial and/or aquatic environments. The emphasis is on the use of biological material as sampling media and on the course of action when contemplating the use of biological material.

When biological material is under consideration as the sampling medium, a preliminary reconnaissance of the study area is recommended. The reconnaissance will familiarize the investigators with the area to be studied, provide insight into the efficiency of biological sampling, and indicate the resource requirements (funding, personnel, equipment) for the program.

As a sampling medium, plants are more spatially and temporarily variable than most other commonly sampled environmental media. As such, interpreting data from plants may be extremely complicated.

In at least two situations, the efficacy of plant sampling may be indicated even before the pollutant is identified. In the first, the effect of an agent may be apparent on plants (for example, death of a plant species in a specific area) even though the agent is unknown. In the second, a mixture of pollutants is known to contribute to the damage or effect. Such is the case with smog and some of its constituents, notably ozone, sulfur dioxide, and oxides of nitrogen. Furthermore, vegetation can be a contaminant receptor showing no effects, such as with tritium exposure. In these circumstances, vegetative tissue can be collected and analyzed for the presence of a pollutant.

TERRESTRIAL VEGETATION

Discussion and Applications:

Vegetation sampling is generally recommended when: a) knowing the distribution of plant symptoms can help in determining the areal distribution and the identity or source of the pollutant; b) plants provide the only practical sample for certain pollutants; or c) it is suspected that the agent will be identified and proof of damage can be obtained from the associated symptoms it produces in plants. Viruses, fungi, and/or bacteria can produce symptoms similar to heavy-metal toxicities, sulfur dioxide, fluoride, or herbicide damage. If symptoms caused by a specific pollutant are present and can be identified, the probability exists that sampling and analysis of air, water, or soil would be preferable to sampling and analysis of vegetative tissue.

Factors pertinent to selecting a vegetation sample include:

- Species
- Distribution of species
- Presence of symptoms
- Exposure pathway
- Uptake characteristics of species
- Species location and proximity to a pollutant source
- Geographic and topographic conditions
- Plant parts.

A guide for selecting the species and/or plant organ to sample can be found in Hunter et al., 1984 (see Biota Reference List, Section E7.4). At times, due to the behavior of a specific pollutant, it is important to collect the entire plant or to analyze woody stems and twigs. The usual practice is to sample either the leaves or the roots. The final choice must be a compromise based on several factors, including pollutant behavior, time, and economics, without compromising the sampling objectives.

Plant part selection requires some knowledge of how specific pollutants interact with specific plants. A given chemical may accumulate on a plant, in it, or both. It may initially be deposited on a leaf, move through the leaf's surface, and translocated within the plant. It may also remain on the leaf or be stabilized at some point within the plant. Alternatively, it may be taken up by a root and distributed upward with the plant. It could also be chemically degraded, modified, washed off the plant, or photodecomposed by sunlight.

Species and Symptom Identification:

To collect a small plant specimen for identification, the entire plant (including roots) may be collected. For large plants, take a full representation of leaves, stems, and flowers. Pay attention to details such as collecting enough leaf material with attached stems to determine opposite versus alternate leaf position, full shape(s) of leaf, terminal stems with buds (if collected in winter or spring), along with a large amount of flower material. Collect seed if available.

Plant identification is based primarily on morphological characteristics. The use of a key leads the investigator to a specific identification for the plant. The key is a device that uses a combination of salient characteristics to minimize misidentification of plants. Experience in using keys, plant taxonomy, and terminology will aid the field investigator in plant identification.

In the field, place each plant specimen in an individual, labeled container noting the collection parameters: exact time; date; location with legal description by government survey (i.e., range and township, TUM coordinates, or by street address); investigator's name; adjacent plants (common or scientific names); a unique number given to each specific plant collected; project number; and any landmarks, notes, or pertinent details of the locale. When field identification is not possible, use plastic bags to help retain moisture and keep the plant from wilting before examination. If a long time exists between collection and examination, store the bags in a refrigerator or on ice; however, prolonged storage will lead to mold and/or spotting of the specimen. Although bagging serves to keep plants separated until examined, it is considered a temporary system of storage or is used only during transport.

Species and symptom can often be identified in the field at the time of sampling, but it is usually a better practice to return samples to the laboratory and retain them as a long-term record. Samples for symptom examination cannot be retained as pressed-and-dried specimens, but will be preserved in a commercially available vegetation preservative. Depending on

the program's objective, plant symptoms are best described by a plant pathologist.

Collection Considerations:

Samples are normally not taken from one plant or a single grass. Take eight to ten subsamples at equidistant points around the perimeter of a circular area of an arbitrarily chosen diameter (e.g., 10 or 25 m) and composited into one sample. If this process results in a larger sample than is necessary for the chemical analysis, divide the sample.

Other common design methods include establishing a grid or transects. The use of a grid design involves overlaying a specified size grid on a map of the study area. Grid coordinates are systematically, randomly or judgmentally selected to produce "squares" for sampling. Within each selected grid square, a sample location may be randomly selected or the entire square may be sampled. Cross and/or straight line transects may or may not be located randomly within the sampling area. Arbitrary distances along the transect are selected and a predetermined area around the transect point is sampled. Because of the diverse habitats and variety of species that may be encountered during the environmental survey, a definitive single design cannot be recommended. Detailed sample design methodology is discussed in Green (1974), Hunter et al. (1984), and Smith (1974).

Collection Procedure:

Higher plants may be categorized in three general types:

1) Grasses

2) Shrubs

3) Forbs (weeds).

If preliminary data are unavailable, plant parts from each type may be sampled to provide adequate representation. The preferred plant parts to be sampled for each group are:

1) Grasses--Collect entire (roots and leaf parts) plant. If instructed, separate roots from leaf parts.

2) Shrubs and trees--Collect leaves, stems, and roots separately. Stems may not be required if target specie's biochemical properties are known. Knowledge of potential contaminants may also prove useful in the decision of which plant parts to collect.

3) Forbs--Collect entire plant. If time permits, reproductive structures (i.e., seeds, flowers) should be collected separately from the specimens. This may be possible only in the spring or fall (season is species-dependent). If instructed, separate all plant parts prior to sample preparation.

Preparation Procedure:

Keeping the eventual analysis in mind, sample preparation will attempt to avoid cross-contamination during sampling, retain the sample's chemical integrity, and ensure the sample's identity throughout field handling and shipment. A common problem in environmental sampling problems is maintaining sample identity. Pencil and pen markings may fade or become smeared by moisture, labels placed inside the sample container can alter the chemical integrity, and labels and tags can become detached and lost. A good approach to this problem is to use an indelible ink marker on a tag that can be attached to the sample container by twisted wire. Writing directly on the exterior of the sample container may be acceptable. Field documentation specifics are discussed in Appendix I of this Manual.

Sample containers can be plastic bags, or Teflon or glass jars, depending on the requested chemical analysis. Samples can be collected in plastic bags for trace-metal analysis. Normally samples intended for organic analysis must be collected in Teflon or glass containers, but if intended to identify

a very stable, nonvolatile chemical, they can be wrapped securely in aluminum foil. More complete requirements concerning containers and sample preservation is found in Appendix I of this Manual.

Samples can usually be stripped or broken from the plant manually. However, if cutting or digging tools are required, care must be taken to avoid cross-contamination. The tools will be washed and rinsed thoroughly between samples. Similarly, metallic cutting tools will be avoided when collecting samples for trace-metal analysis. Tools coated with Teflon will minimize metallic contamination. When entire plants are collected, clean the roots by brushing with a natural hair brush, then rinse the plant with deionized, distilled water at the time of sampling. Soil will not be permitted in the sample container with the plant sample.

Vegetative material is subject to mold and decay. Thus, samples must be properly preserved during sampling and transport. Preservation methods are identified in Appendix I of this Manual.

Depending on the analytical requirements, samples may have to be ashed (40 g of ash is generally recommended), digested, or packaged in an appropriate geometry for radioanalysis. Compatibility between analytical methods, sample collection, and sample-preparation methods is critical. The analytical protocols should be consulted prior to sample collection and preparation.

AQUATIC VEGETATION

Discussion and Application:

Commonly occurring macrophytes are rooted vascular plants that are usually arranged in zones or belts corresponding closely to successively greater depths. Each deeper zone has its dominant vegetation composed of species more tolerant of decreasing illumination. Processes of erosion and deposition are constantly controlling the extent to which these plant zones develop. The characteristic plant forms that dominate these environmental gradients (in order of decreasing depth) are: 1) submersed rooted aquatics, 2) floating-leaved rooted aquatics, and 3) environmental rooted aquatics.

Communities of vascular plants also may live unattached in the water, and because depth of water is of no consequence, these plants may occur anywhere on the water surface.

Bryophytes, the mosses and liverworts, are less conspicuous than the vascular plants. They generally grow in mats attached to submerged or partly submerged rocks in swiftly flowing water. In shallow quiet water, particularly along the edge, mosses and liverworts may grow attached to submerged rock and mud substrata among rooted vascular plants. It may not be cost effective to collect these specimens, as methods are intensive and time-consuming.

Algae are plants that lack true roots, stems, and leaves. They include the smaller of the chlorophyll-bearing plants, consisting of a single cell commonly found in the plankton, as well as marine representatives ranging to several tens of meters (hundreds of feet) in length. Fresh-water species of algae, which range in size between these two extremes, occur as individual plants or in large patches attached to rocks in flowing water. Such plants may be gray, green, blue-green, or olive, and are slimy to the touch, such as Batrachospermum. Or, they may be green and have a coarse filamentous structure with profuse lateral branching, such as Cladophora. It may not be cost effective to sample algae if a large sample size is required.

Growth of aquatic macrophytes depends on the availability of nutrients. In some bodies of water, nutrient enrichment results in excessive growth of macrophytes, and this acceleration of productivity is a major nuisance condition and an important water-quality problem. Tissue analysis of these plants may provide information for evaluating nutrient levels and pollutant levels in aquatic systems.

Collection Procedures:

Sampling procedures may involve establishing transects, grids, or small plots following procedures adapted from terrestrial plant survey techniques. Samples are generally collected by hand, with grappling devices, rakes, or dredges. If water is sufficiently shallow, collection by hand is

recommended. In deeper waters, grappling device or rake is preferred. Analytical requirements may determine that these tools be coated with Teflon. Take care to avoid snagging tools on submerged rocks or logs, as this may result in loss of plant sample and damaged equipment.

A transect design may prove more effective when grappling hooks or rakes are employed. Transects can be placed across the entire width of lakes, rivers, parks, and/or streams, and may cross various habitats. In small ponds or lakes, transects may be laid at intervals yielding a "pie" design.

Collect desired quantity of plants by hand or with a sampling device. Remove selected species, if specified, and place sample in a lettuce spinner or any similar apparatus, to remove excess water. Samples will be placed into preselected containers and labeled. Place containers in a cooler containing dry ice or freezer packs.

TERRESTRIAL AND AQUATIC VEGETATION SAMPLING EQUIPMENT

Camera and film
Clipboard
Compass
Digging stick
Gloves
Ice chest
Maps (local topographic)
Meter stick/tape measure
Metric ruler (e.g., 10 cm)
Pens (indelible ink)
Dry ice/freeze gel packs
Plastic bags

Pole shears* (for woodlands)
Pruning shears*
Clippers
Recordbook
Tags
Tape
Tools (hammer, shovel, trowel)
Tweezers
Vials (small)
Plant grappling bar,* (Ward's Natural Science) or equivalent.
A sample grappling hook may be fabricated by binding the shanks of several hooks removed from wire coathangers with lightweight wire. Provide a loop from an extra long shank for attaching a line.
Steel garden rake*
Dredge
Scoops
Lettuce spinner (or similar device).

FISH

Fish may be the principal aquatic biota of interest in investigations designed to assess the impact of introduced contaminants on aquatic ecosystems. This is particularly true in investigations involving bioaccumulative toxic substances, since some fish species at the upper levels of the aquatic food web provide a direct link in the transfer of these substances from the aquatic environment to man. Because fish bioconcentrate some toxic substances, tissue concentrations frequently exceed the concentrations in ambient waters and in the lower trophic level food organisms by several orders of magnitude. Since the natural life histories of most fish species span several years, sufficient time is available for fish to accumulate high residue levels through continuous low-level exposure.

*Teflon-coated if necessary.

An indication of the relative severity of the toxic impact is the absence of fish or a particular fish species in aquatic habitats subject to toxic pollutants, but otherwise well-suited for habitation. Total absence of fish in a particular habitat, significant reductions in total densities, or a substantial decrease in the number of species present may be attributable to direct lethal effects, chronic reproductive failures, or voluntary avoidance of the contaminated area.

Fish sampling has serious limitations when determining an effluent's toxic effects on receiving water communities. Owing to their mobility, fish are frequently able to avoid exposure to harmful pollutant levels during the pulses of lethally concentrated pollutants. This assumes, of course, that escape routes or temporary refuges with reduced levels of the toxic pollutant are available to the fish.

Another factor that complicates the use of fish as indicators of the degree and extent of severity of toxic effluents is the apparent ability of organisms to acclimate to low-level exposure of metals and other toxic substances. Increasing evidence suggests that fish, and most other organisms, have natural detoxifying capabilities that enable them to withstand exposure to levels of toxic metals at concentrations that would prove lethal to specimens with no previous exposure history.

However, despite the problematic interpretation of community-change significance, a great deal of information can be gathered from analyses of fish communities, in conjunction with examination of other biological ecosystem components.

Prior to initiating any fish collection program, the investigator must make some preliminary determinations. First, he must determine whether fish are present in the particular waterbody, and if so, attempt to establish what species are present. Examination of scientific literature, water quality characteristics, the physical nature of the environment, and temperature regimes will provide a clue as to the type of fisheries expected in a particular stream segment. Generally, it is recommended to collect fish from the three categories listed below because they have one or more of the

following characteristics: they are usually readily available in adequate numbers, they are likely to accumulate any pollutants, and they are often consumed by humans. The three categories of fish are:

1) Gamefish (e.g., trout)

2) Roughfish (e.g., carp)

3) Bottomfish (e.g., catfish).

The number of fish collected from each category is dependent on the sampling design and analytical requirements. Without a specific sampling design, collect a minimum of five fish of a single species from each category.

Assuming that preliminary data indicate fish sampling is feasible, the investigator will proceed with designing the sampling program. Following the assessment of preliminary survey data, the investigator(s) will have an appreciation for the type of sampling design necessary to provide the necessary data.

Fish-collection methods are frequently discussed as either active or passive. Active collection methods include the use of electroshockers, seines, trawls, poisons, and angling gear. Passive methods involve the use of gill, Fyke, trammel, and impoundment nets; D-traps, and purchasing fish from fishermen. Other inventory methods, which normally do not involve collecting specimens, include visual observations and using remote sensing devices (hydroacoustics).

ACTIVE COLLECTION

Electroshocking

Discussion:

This method of fish capture is one of the least selective of the active fish sampling methods. It involves passing an electrical current between two

submerged electrodes or between one electrode and a ground. When an alternating current (AC) is passed between two submerged electrodes, fish present in the field are temporarily stunned. Fish lose equilibrium and are easily removed from the water by a dip net. A direct current (DC) passed between a submerged electrode and a ground induces "galvanetaxis" so that fish move toward the anode and then can be dipped from the water.

Electroshocking units are available for mounting on a boat; smaller units are backpack shockers. The boat-mount shocker uses a 110-V, 60-cycle generator run by an air-cooled gasoline engine. The entire motor/generator assembly weighs approximately 70 lb. Voltage can be varied by a variable voltage pulsator, between 50 and 700 volts AC and between 25 and 350 volts DC.

Application:

Electroshocking is not effective in brackish, salt, or extremely soft waters (< 25 mg/L as $CaCO_3$). In fresh water, DC or pulsed DC is usually used. Pulsed DC reportedly is more effective in leading fish to the anode when used properly. However, in soft waters, AC may be more effective than DC or pulsed DC. Boat-mount shockers can be used effectively in shallow rivers, ponds and lakes, but are not effective in waters deeper than 5 m. Backpack shockers are designed for use in small, wadable streams.

Procedure for Alternating Current Backpack Shocker:

1. Two samplers, each holding the nonconductive handle of a submerged electrode, walk upstream a predetermined distance.

2. A third (and possibly fourth) sampler follows them with a dip net and containment vessel.

3. As the two samplers walk upstream, no more than 5 m apart, the third sampler collects the stunned fish and places them in the containment vessel.

4. Everyone involved in sampling must wear waterproof waders. Note: Never attempt to electroshock alone.

Procedure for Direct Current Backpack Shocker:

1. One sampler holds the cathode (ground) suspended in the water.

2. The second sampler moves the submerged anode plate through the water leading fish to a hand-held dip net for capture.

3. A third sampler holds the dip net and collects the fish.

4. Fish are placed in the containment vessel.

Procedure for Boat-Mount Shocker:

1. Electrodes are extended from bars in front of the boat. Electrodes may be wire, chain, or free-swinging metal rods.

2. Three samplers are required: one to operate the generator, and two to keep the electrodes in place and collect the stunned fish.

3. A second boat may follow the first to collect any late-rising fish.

Seine

Discussion:

Seines are constructed of strips of strong netting with wooden floats attached to the top and heavily weighted line at the bottom. Two basic types of seines are in common use, haul seines and straight seines. Haul seines may be somewhat bag-shaped in the center to aid in confining the fish. The wings of haul seines may be of coarser mesh than the center portion and they may be tapered to the ends where they are attached to stout poles. Hauling lines can be attached to the top and bottom of the poles. Deep-water seining requires the use of a boat and operator as well as someone to remain on shore.

Straight seines are constructed of rectangular-shaped netting strips with floats and weights attached. They are designed for use by two people in shallow waters. The nets have stout poles attached to each end for the operators to use in manipulating and positioning the forward edge of the net.

Application:

In small, shallow, slow-moving streams with relatively smooth bottoms and few obstructions, two-man seining operations can be very effective. When used in waters no deeper than two-thirds the height of the seine, all fish within the seined area that are large enough to be retained by the mesh are subject to capture.

In practice, seining is somewhat selective, in that some fish avoid the net. It is not effective in removing all the fish in waters deeper than two-thirds the height of the net, because fish will pass over or under the net. Obstructions in the stream and irregular bottoms interfere with seining operations and allow fish to escape.

Procedure:

1. Two samplers hold opposite ends of the seine and stretch the net out perpendicular to the shore.

2. Haul the seine parallel to shore for the prescribed distance upstream, in seining streams, keep the lead line in contact with the substrate at all times. Always haul with speed of current when sampling streams.

3. Keep onshore end as close to the shore as possible, avoiding obstacles. Offshore end should slightly precede onshore end during the haul.

4. After hauling the seine the desired distance, pivot offshore end toward shore.

5. Slowly pull both ends of lead line onto shore. Do not pull lead lines in too rapidly as the float line will submerge allowing fish to escape.

6. As float line and seine become slack, pull seine into shore allowing for a pocket to remain in center of seine; shake fish into this pocket.

7. Remove the desired number and types of fish, returning other fish to the water.

Trawl

Discussion and Application:

Trawls are specialized seines designed to be towed behind a boat in large open-water bodies at speeds sufficient to overtake the fish. Three basic types include: 1) the beam trawl used to capture bottom fish; 2) the otter trawl used to capture bottom and near-bottom fish; and 3) the open water trawl used to capture schooling fish.

Trawls have little application in most flowing systems except in very large rivers. The beam trawl and open-water trawl are both too cumbersome to handle from small boats because of their construction. Modified otter trawls can be used from small boats manned by an experienced crew.

Methods for trawl use can be found in Bagenal (1978), and Nielsen and Johnson (1983). See Section E7.4 for complete references.

Angling

Discussion and Application:

The "hook and line" approach is one of the most selective forms of fish collection. It can be as simple as still-fishing using a hand-held rod, trolling lures or baited hooks, or it may involve the use of trout lines and

multiple baited hooks. This method is generally unsuitable for detailed survey work because it is too selective in sizes and species caught. Furthermore, the catch per unit effort is generally low. It cannot be considered as anything more than a supportive technique or a method for obtaining a few adult specimens when other techniques are inappropriate. For example, it could be an appropriate protocol for obtaining a few specimens for tissue analyses.

Chemical Poisoning

Discussion and Application:

This method is not recommended, but is a possible means of sampling that requires experienced practitioners. Various chemicals have been used for sampling entire fish communities. Historically, the most common chemicals used included rotenone, toxaphene, cresol, copper sulfate, and sodium cyanide. Rotenone is generally considered the most acceptable because it is highly degradable and does not pose problems with precipitation or persistent toxicity as do some of the others. It is also relatively safe for the user, although at high concentrations (132 mg/kg) it is toxic to mammals, including man. Several of the chemicals historically used for this purpose are now on the EPA priority pollutant list (e.g., copper, cyanide, and toxaphene). If the purpose of fish sampling is to analyze tissues for toxic substrate, the use of poison as a sampling technique must be avoided. The poison could induce physiological changes that alter the concentration of pollutants in tissue. Chemical means for collecting fish may be appropriate when radioanalysis is required.

PASSIVE COLLECTION

Passive techniques usually require less effort than active techniques, but they are also usually less suitable for shallow water collecting because many species evade entanglement and entrapment devices. In general, the size of the catch obtained with passive techniques is a function of the size of the population being sampled and the movement of the fish population.

Entanglement Nets

Discussion and Application:

Gill and trammel nets are commonly used to sample fish populations in lakes, reservoirs, estuaries, and large rivers. They can be fished at the bottom, at mid-depth or at the surface and can be operated as stationary or movable gear. They are not well-suited to fast-moving rivers because they are nearly impossible to hold in place and tend to clog with debris. The problem of clogging is also a serious drawback in slow-moving rivers that carry a heavy debris load. When used as movable gear in rivers, the netting operation is hindered by the snagging of rocks and debris.

Gill nets are considered to be species and size selective because the mesh size determines the catch. Gill nets can be constructed of several sections, each of different mesh size, thereby providing a greater range of sizes and species collected. They can be constructed of multifilament or monofilament nylon. The monofilament nets are more expensive and more difficult to use than multifilament nets, but they also generally capture more fish. To reduce chances of net entanglement, the individual floats and lead weights normally supplied with the nets can be replaced with float lines and solid-core lead lines.

Gill nets require at least two individuals working from a boat to set and retrieve them. They are effective in collecting pelagic fish, but present a severe tangling problem when used where species with large or barbed spines (such as catfish) are present.

Trammel nets are constructed of a layer of large-mesh netting on each side of loosely hung smaller gill netting. Small fish are collected in the gill netting and larger fish are captured in the pocket of the gill netting that is formed as the smaller meshed netting is forced through an opening of the larger meshed netting.

Trammel nets are used in the same manner as gill nets, i.e., across the anticipated path of movement of the fish, or they are placed to encircle a

visible school. As for gill nets, at least two people are required to set the nets, but because of the severe entanglement problem associated with removal of the catch, additional help is desirable when retrieving the nets.

Procedure:

1. Untie free end of gill net from storage hook.

2. Tie off float line to shore so that the beginning of the gill net is in at least 0.5 to 1.0 m of water. Set the smallest mesh size closest to shore.

3. Stretch out gill net perpendicular to shore. Attach anchor to lead line and marker float to float line. Make sure net is as taut as possible. Nets may be set in pelagic waters using sufficient anchoring to maintain tautness.

4. Leave net in water the prescribed length of time.

5. Retrieve net in same order as it was set, beginning with the smallest mesh.

6. Pull net on shore removing fish as they are encountered.

7. Remove all fish. Stretch out net to dry and rack.

Entrapment Devices

Discussion and Application:

The hoop net is most effectively used in shallow water because of the difficulty involved in setting it properly in deep water. It is best used in rivers with a fair current where the direction of fish movement is predictable.

The construction of the net facilitates easy handling and it can be stored or carried on, and deployed from, a small boat. Hoop nets 2 to 6 ft in diameter can be purchased commercially.

The Fyke net is a hoop net with wings or leads attached to the first frame to funnel the fish toward the enclosure. Fyke nets can be used in nonflowing waters where the movement of fish is random. The efficiency of Fyke nets may be impaired in streams by trash and debris lodging against the wings. Like the hoop net, the Fyke net is best used in fairly shallow waters, and it can be deployed from a small boat. The Fyke net is a more permanent structure than the hoop net because of the posts and anchors required to secure the leads.

Trap nets are based on much the same principle as hoop nets, but they are more complex. Floats and weights give the devices their shape, and considerable experience is required to use them successfully. They can be fished from shore or from a boat in deep or shallow water. A simple version of the trap net is the common minnow trap, which is generally constructed of wire mesh, plastic or glass. Many variations of trap nets have evolved (e.g., D-traps, lobster pots). Traps can be fished very effectively for slow-moving sunfish, perch, and catfish, when baited with cheese, cottonseed cake, etc. The trap design and netting mesh size can be selected to meet the needs of the survey. Traps can be useful for sampling fish in fast-moving, deep waters where other methods are not effective. They are most efficient in turbid water and are especially well-suited to taking bottom feeders. Like most passive techniques, traps are most effective during periods of extensive fish movement. Traps are considered to be the best all-around method of taking samples of fish in large streams.

Additional information for the use and deployment of entrapment devices can be found in Bagenal (1978), and Neilsen and Johnson (1983).

SAMPLE PREPARATION

Discussion:

Preparation of fish samples follows the same general guidelines as for vegetation samples. If samples are to be analyzed for heavy metals, samples may be wrapped in plastic or placed in plastic bags. Samples analyzed for organic pollutants may be wrapped in foil.

Procedure:

1. Collect the desired number of fish necessary for analysis.

2. Weigh each fish to the nearest tenth of a gram.

3. If directed, remove internal organs by slitting from vent, anteriorally, to pectoral girdle. Fish should be weighed before and after removal of organs.

4. Place fish in appropriate container.

5. Accurately label the fish sample with the following information:

   - Date
   - Location
   - Habitat type (stream, pond, lake, etc.)
   - Investigator name
   - Method of collection (electroshocking, netting, etc.)
   - Species of fish
   - Weight (before and after organ removal, if applicable) and length
   - Comments (any notable characteristic of the habitat, fish abnormalities, weather, etc.)
   - Sample number
   - Project number.

POPULATION ESTIMATION

It is generally impractical and may not be appropriate for an initial survey to attempt to obtain complete counts or absolute biomass measures by size class and/or species in most fisheries' surveys. The biologist will obtain reasonable estimates of these parameters based on population samples. Such estimates are especially difficult in large rivers, as pointed out in Cleary and Green Bank (1954).

On a whole, a large river may contain a less uniformly distributed fish population and a less stable one, in any given locality, than does either a lake or small stream. Thus, it is extremely difficult to make a quantitative population estimate of a river, or even of a sizable stretch of it, by sampling random localities at random times (unless a formidably large number of samples are taken). The task is made all the more difficult by the fact that most known sampling devices do not take a non-selective sample even in the immediate locality in which they are operated.

Finally, it must be remembered that the total population changes from day to day, season to season, and year to year. Recruitment comes about by hatching of young, ingress, and by artificial stocking. Removal is by angling, commercial fishing, predation, death by natural and unnatural causes, and exodus into connecting waters.

Collecting random samples may be adequate for determining the presence of toxic and/or radionuclide contaminants. The collection and preparation of fish samples must be compatible with the analytical requirements.

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DECONTAMINATION PROCEDURES

INTRODUCTION

Decontamination is essential to ensure the congruence of data from site-to-site within a study area and to provide quality control and quality assurance for the data collected. This procedure deals strictly with the decontamination of equipment. Personnel decontamination is covered in the AFP 4 *Health and Safety Plan* (Volume IV).

REFERENCE DOCUMENTS

A variety of decontamination protocols currently exist from state and federal regulatory agencies. There is no single guidance document that has been adopted by the U.S. Environmental Protection Agency (EPA) for hazardous waste site investigations. The following will be used as the basis for procedures in this appendix:

U.S. Environmental Protection Agency, 1981. *Technical Methods for Investigating Sites Containing Hazardous Substances*, Technical Monograph No. 23, June 1981.

U.S. Environmental Protection Agency, 1985. *Decontamination Techniques for Mobile Response Equipment Used at Waste Sites (state-of-the-art survey)*, EPA/600/2-85/105, August 1985.

U.S. Environmental Protection Agency, 1986. *RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD)*, OSWER-9950.1, September 1986.

SIGNIFICANCE AND USE

A major portion of the work effort in the RI/FS process during the site investigations is associated with the collection of chemical data. To that end, procedures described in this section are critical to the credibility of the chemical data collected. Decontamination procedures are directed at the highest level of data quality proposed for the AFP 4 site (Level III).

APPARATUS

Generic Use

- Photoionization detector; Either an Hnu, TIP II, or a SIP 1000. After decontamination has been completed, equipment will be scanned for residual contamination before the equipment is used again. If contamination is detected the equipment will be processed through a full decontamination cycle. All photoionization detectors will have current calibrations.

Soil Sampling Equipment (including split-barrel sampler)

- 6-mil Plastic Sheeting Ground Cover
- Stainless Steel Pans With Lids
- Wire Brush

- Scrub Brush
- Teflon Squeeze or Spray Bottles
- Aluminum Foil
- Waste-Water and Waste-Solvent Storage Containers

Drilling Equipment

- 6-mil Plastic Sheeting for Decontamination pad
- High-Pressure, Hot-Water Washer or Steam Cleaner
- Methanol and Distilled Water Sprayers

Monitoring Well Pumping and Sampling Equipment

- Stainless Steel Buckets
- Steel Barrels

Soil Gas Equipment

- Ultra Pure Zero Air
- Methanol
- Rifle cleaning wire brush

PROCEDURE

Soil Sampling Equipment

1. Set up decontamination station using plastic for ground cover. Place four stainless steel pans along the plastic with the first containing Alconox or equivalent and potable water, the second containing clean potable water, the third to be used to contain excess solvent from the solvent rinse, and the fourth to catch the waste from the deionized water rinse.
2. Remove all visible contamination with a steel brush and/or paper towel.
3. Wash equipment with scrub brushes and soapy water.
4. Rinse equipment with clean potable water.
5. Rinse equipment with laboratory-grade methanol

6. Rinse equipment with distilled or deionized water.

7. Air dry.

8. Where practical, wrap decontaminated equipment in aluminum foil and then place in a plastic bag and seal until ready for reuse.

9. Place waste wash water and solvents in appropriate containers for later disposal.

Drilling Equipment

1. Clean auger flights, bits, and any other downhole tools prior to start of drilling with a high-pressure, high-temperature cleaner using potable water, followed by a methanol rinse, then followed by a deionized water rinse.

2. Place cleaned tools on clean plastic sheeting to avoid contamination from the soil or cuttings and allow to air dry. If equipment is transported to a drilling location, it will be protected from contamination by covering with a clean plastic tarp or sheet.

3. The work area of the drill rig will also be cleaned prior to the start of work at the site.

   NOTE: Sufficient auger flights and drill rods will be provided to avoid unnecessary downtime related to decontamination procedures. After the initial decontamination of all downhole drilling equipment, subsequent decontamination will be performed only as needed.

4. Collect all decontamination waste water and place in containers for later disposal based on analytical results from a sample of the waste water.

Monitoring Well Pumping and Sampling Equipment

1. As measurement and/or sampling equipment are removed from a monitoring well, after having come in contact with the water, clean outside surface first by using clean rags or paper towels.

2. Continue cleaning of outer surface by scrubbing with soapy water, followed by a clean potable water rinse, a methanol rinse, and deionized water rinse.

3. For equipment such as pumps and tubing that may become contaminated internally, clean by filling buckets with soapy water and pumping the soapy water through the system into an appropriate waste container.

4. Follow the soapy rinse with clean potable water by placing the pump in buckets of clean potable water and allowing sufficient pumping to clear the system of the soapy rinse. Containerize the water for later disposal.

5. If the system is to be used in the collection of volatile organics, pump a small amount of methanol through the system followed by a deionized or

distilled water rinse.

6. Collect rinsate from decontaminated equipment according to the schedule determined in the *Sampling and Analysis Plan* (Volume II) and send to the laboratory for analysis to help determine the effectiveness of the decontamination procedure.

Soil Gas Equipment

1. Between samples, flush stainless steel pipe, tube, and probe tips with ultra pure bottled air.

2. Before sampling, rinse expendable probe tips with methanol, rinse with distilled water and allow to air dry.

3. Sampling probes will be washed with laboratory soap, using a brush to clean the inside tube. This will be followed by a tap water rinse and a distilled water rinse. Sample probes used in areas with hydrocarbon contamination will be rinsed with methanol before the distilled water rinse and allowed to air dry for 24 hours. All sampling probes will be vented with ultra pure zero air before use.

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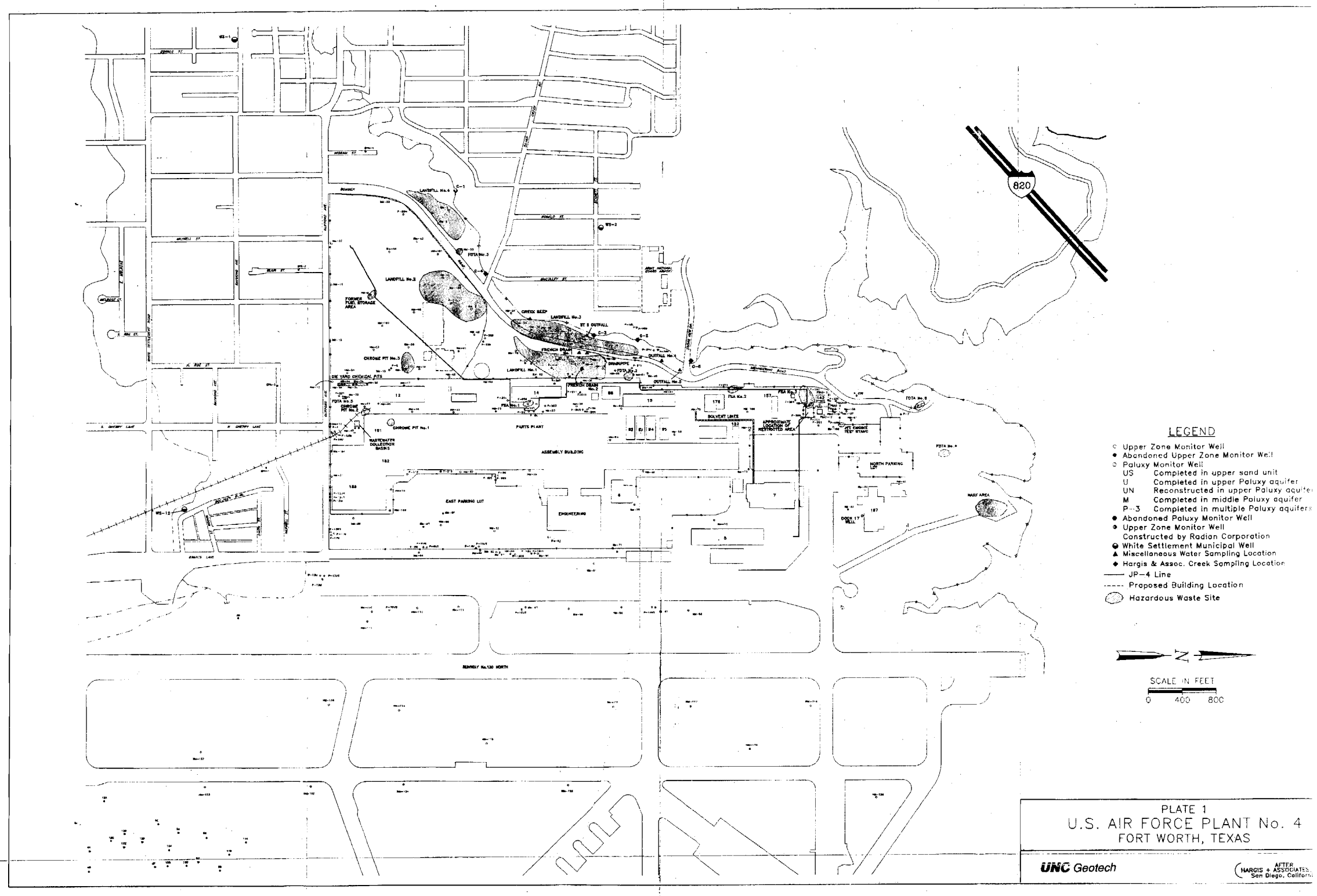
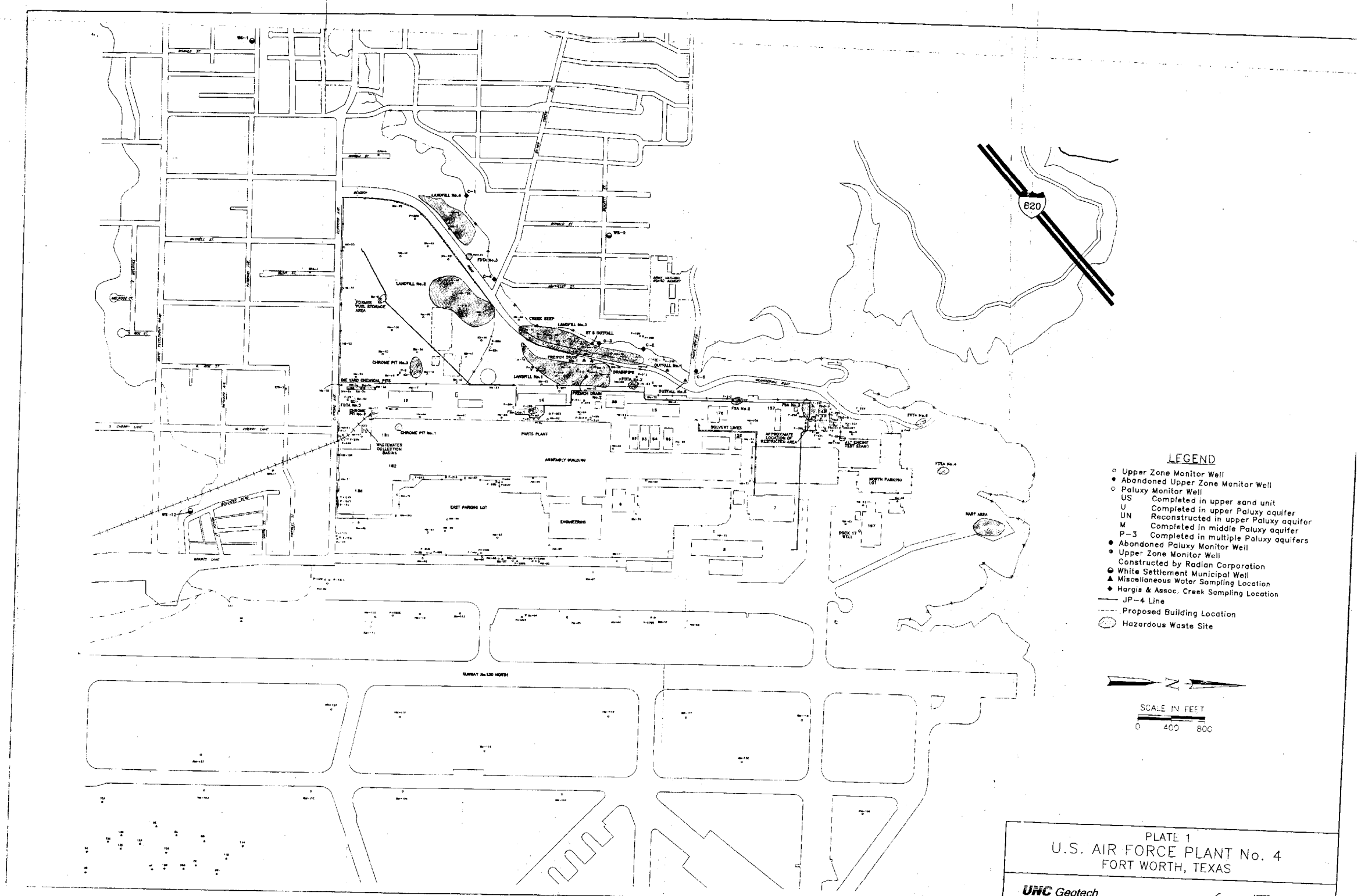


PLATE 1
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS

UNC Geotech

AFTER HARGIS + ASSOCIATES San Diego, California

53 335


LEGEND
Upper Zone Monitor Well
Abandoned Upper Zone Monitor Well
Paluxy Monitor Well
US Completed in upper sand unit
U Completed in upper Paluxy aquifer
UN Reconstructed in upper Paluxy aquifer
M Completed in middle Paluxy aquifer
P-3 Completed in multiple Paluxy aquifers
Abandoned Paluxy Monitor Well
Upper Zone Monitor Well Constructed by Radian Corporation
White Settlement Municipal Well
Miscellaneous Water Sampling Location
Hargis & Assoc. Creek Sampling Location
JP-4 Line
Proposed Building Location
Hazardous Waste Site
SCALE IN FEET
0 400 800
820
LANDFILL No.4
LANDFILL No.3
LANDFILL No.2
LANDFILL No.1
CREEK SEEP
ST 6 OUTFALL
OUTFALL No.1
OUTFALL No.2
DRAINPIPE
FRENCH DRAIN No.1
FRENCH DRAIN No.2
CHROME PIT No.3
CHROME PIT No.1
DE SAND ORCHARD PITS
WASTEWATER COLLECTION BASINS
PARTS PLANT
ASSEMBLY BUILDING
EAST PARKING LOT
ENGINEERING
SOLVENT LINES
GOVERNMENT INSPECTED AREA
FUEL FACILITY TEST STAND
NORTH PARKING LOT
DOCK 17 WELL
WARP AREA
FOTA No.1
FOTA No.2
FOTA No.3
FOTA No.4
FOTA No.5
FOTA No.6
POLICE LINE
RUNWAY No.13/31 NORTH
PLATE 1
U.S. AIR FORCE PLANT No. 4
FORT WORTH, TEXAS
UNC Geotech
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FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE