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PHASE I INTERIM MEASURE WORK PLAN SOURCE DELINEATION SAMPLING AND ANALYSIS PLAN AREA OF CONCERN 613 (AOC 613) ZONE F WITH TRANSMITTAL CNC CHARLESTON SC
6/11/2002
CH2M HILL

PHASE I INTERIM MEASURE WORK PLAN

Source Delineation Sampling and Analysis Plan
AOC 613, Zone F

Charleston Naval Complex
North Charleston, South Carolina

SUBMITTED TO
U.S. Navy Southern Division
Naval Facilities Engineering Command

PREPARED BY
CH2M-Jones

June 2002

Revision No. 0
Contract N62467-99-C-0960
Project No. 158814.ZF.PR.02

CH2M HILL
3011 SW Williston Road
Gainesville, FL
32608-3928
P.O. Box 147009
Gainesville, FL
32614-7009
Tel 352.335.7991
Fax 352.335.2959

CH2MHILL

June 11, 2002

Mr. David Scaturo
South Carolina Department of Health and
Environmental Control
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

Re: Phase I Interim Measure Work Plan (Revision 0) – AOC 613, Zone F

Dear Mr. Scaturo:

Enclosed please find two copies of the Phase I Interim Measure Work Plan (Revision 0) for AOC 613 in Zone F of the Charleston Naval Complex (CNC). This report has been prepared pursuant to agreements by the CNC BRAC Cleanup Team for completing the RCRA Corrective Action process.

The principal author of this document is Louise Palmer. Please contact her at 704/329-0073, extension 296, if you have any questions or comments.

Sincerely,

CH2M HILL

Dean Williamson

Dean Williamson, P.E.

cc: Tim Frederick/Gannett Fleming, Inc., w/att
Rob Harrell/Navy, w/att
Gary Foster/CH2M HILL, w/att

PHASE I INTERIM MEASURE WORK PLAN

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Certification Page for Phase I Interim Measure Work Plan (Revision 0) — AOC 613, Zone F

Source Delineation Sampling and Analysis Plan

I, Dean Williamson, certify that this report has been prepared under my direct supervision. The data and information are, to the best of my knowledge, accurate and correct, and the report has been prepared in accordance with current standards of practice for engineering.

South Carolina

Permit No. 21428

Dean Williamson

Dean Williamson, P.E.

6/6/2002

Date

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A Waterloo™ Profiler Literature

Acronyms and Abbreviations

1,2-DCE	1,2-dichloroethene
AOC	Area of Concern
BRAC	Base Realignment and Closure Act
CA	Corrective Action
CNC	Charleston Naval Complex
CMS	Corrective Measures Study
COC	Chemical of concern
CSAP	Comprehensive Sampling and Analysis Plan
CVOC	Chlorinated volatile organic compound
DMP	Data Management Plan
DPT	Direct-push technology
DQO	Data quality objective
EnSafe	EnSafe Inc.
EPA	U.S. Environmental Protection Agency
ESDSOPQAM	EPA Environmental Services Division *Standard Operating Procedures and Quality Assurance Manual*
Ft bls	Feet below land surface
GIS	Geographic information systems
HHRA	Human health risk assessment
IDW	Investigation-derived waste
IM	Interim measure
MCL	Maximum Contaminant Level
MCS	Media cleanup standard
µg/L	Micrograms per liter
MNA	Monitored natural attenuation
NAIP	Natural attenuation indicator parameter
NAVBASE	Naval Base

Acronyms and Abbreviations, Continued

NAVFACENGCOM	Southern Division Naval Facilities Engineering Command
NFA	No Further Action
QAP	Quality Assurance Plan
PCE	Tetrachloroethene
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SAP	Sampling and analysis plan
SCDHEC	South Carolina Department of Health and Environmental Control
SWMU	Solid Waste Management Unit
TCE	Trichloroethene

Section 1.0

1.0 Introduction

In 1993, Naval Base (NAVBASE) Charleston was added to the list of bases scheduled for closure as part of the Defense Base Realignment and Closure Act (BRAC), which regulates closure and transition of property to the community. The Charleston Naval Complex (CNC) was formed as a result of the dis-establishment of the Charleston Naval Shipyard and NAVBASE on April 1, 1996.

CNC Corrective Action (CA) activities are being conducted under the Resource Conservation and Recovery Act (RCRA) with the South Carolina Department of Health and Environmental Control (SCDHEC) as the lead agency for CA activities at the site. All RCRA CA activities are performed in accordance with the Final Permit (Permit No. SC0 170 022 560).

In April 2000, CH2M-Jones was awarded a contract to provide environmental investigation and remediation services at the CNC. This submittal has been prepared by CH2M-Jones to document the basis for sampling to design an Interim Measure (IM) at Area of Concern (AOC) 613 in Zone F of the CNC.

1.1 Purpose of the Interim Measure Work Plan

An IM is being considered to remediate groundwater contaminated with chlorinated volatile organic compounds (CVOCs), specifically vinyl chloride, at AOC 613 in Zone F of the CNC. Phase I of this IM Work Plan presents the sampling and analysis plan (SAP) that will delineate the area at which an IM may be implemented. Additional phases of the IM may consist of further delineation, if needed, and potentially, implementation of the IM. The Phase I IM sampling will be carried out in the following three stages:

- Well installation
- Groundwater sampling
- Vertical profiling using the Waterloo™ profiler

The primary data collection approach for the Phase I IM involves the collection and analysis of groundwater samples. Samples from selected existing monitoring wells will be analyzed for monitored natural attenuation (MNA) parameters. As the final remedy for AOC 613 could incorporate chemical or biotic reduction processes, MNA parameter data will help evaluate the feasibility of such a remedy. Finally, as monitoring wells will be purged to

collect MNA parameter data, samples will be collected for analysis of CVOCs to evaluate the change in concentrations that has occurred when compared to previous data.

In addition, discrete groundwater interval samples will be collected. A groundwater profiling device, such as the Waterloo profiler will be the primary sampling device for collecting groundwater samples at vertically discrete intervals from borings installed in the suspected source area. Approximately three discrete groundwater samples will be collected from each boring. The technical approach for this task is described in detail in Section 2.0.

1.2 Regulatory Background of AOC 613

CH2M-Jones has prepared this Phase I IM Work Plan on behalf of the Southern Division Naval Facilities Engineering Command (NAVFACENGCOM). A RCRA Facility Investigation (RFI) was conducted for the RFI sites within Zone F, including AOC 613. Following issuance of the *Zone F RFI Report, Revision 0* (EnSafe Inc. [EnSafe], 1997) additional sampling was performed by EnSafe and by CH2M-Jones to further delineate chemicals of concern (COCs) identified in the report. This additional sampling was described in the *Zone F RFI Work Plan Addendum* (CH2M-Jones, 2001).

The *RFI Report Addendum & CMS Work Plan, AOC 613/AOC 615/SWMU 175, Zone F, Revision 0* (CH2M-Jones, 2002) presented an evaluation of the results from the additional samples collected, along with earlier reported results, and the results of a human health risk assessment (HHRA). The report recommended that a Corrective Measures Study (CMS) be undertaken to address CVOC contamination in groundwater. An IM is being considered to address a potential source area of VOC contamination. The proposed Phase I IM will better assess whether such an IM is warranted. After the IM it will be determined if a CMS is warranted for any potential COCs that may remain after the IM has been completed.

Previous groundwater investigations at AOC 613 at the CNC have revealed the presence of vinyl chloride in groundwater at concentrations greater than the maximum contaminant level (MCL) for vinyl chloride (2 micrograms per liter [μg/L]). However, groundwater data from 1996 through 2001 indicate that there is no consistently elevated vinyl chloride concentration in the groundwater at AOC 613. In order to confirm the reported groundwater characteristics, depth-discrete samples will be collected from vertical profiler locations proposed in the suspected source area.

1.3 Description of the Site and Extent of Contamination Targeted by the IM

AOC 613 is the site of the former Locomotive Repair Shop, Building 1169, and is currently occupied by a vehicle maintenance facility, Building 242. East of AOC 613 is Solid Waste Management Unit (SWMU) 175, the site of the former crane-painting area. This area was separated from Building 1169 by a former open-air machine shop, which occupied the current location of Building 255. The location of AOC 613 is depicted on Figure 1-1.

AOC 615, the former Chain Locker, is also located in close proximity to AOC 613. Sites AOC 613, AOC 615, and SWMU 175 were investigated jointly for the RFI. As described in the RFI Report Addendum and CMS Work Plan (CH2M-Jones, 2002), AOC 615 and SWMU 175 are not associated with any COCs, and are proposed for No Further Action (NFA) status. COCs in groundwater associated with AOC 613 are scheduled for study under a CMS, and for IMs.

As a result of soil samples collected at more than 100 locations within the investigative area, it has been concluded that no COCs exist in the soil at this site that are related to site operations based on sample-specific screening, HHRA, and leachability evaluations.

Twenty groundwater monitoring wells have been sampled an average of four times for the RFI, and 66 direct-push technology (DPT) screening groundwater samples were collected within the investigative area. Data from these groundwater sampling events were evaluated, and the CVOCs tetrachloroethene (PCE), trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE) and vinyl chloride, degradation products of PCE and TCE, were identified as groundwater COCs. The greatest CVOC concentrations were detected at DPT location F613GP039 (see Figure 1-2), at which PCE, TCE, and total DCE were detected at concentrations of 1,900, 1,500, and 1,700 µg/L, respectively. A key goal of this Phase I IM is to confirm whether a significant source area can be located in groundwater near this location.

Vinyl chloride was measured at a concentration of 38 µg/L in a sample at screening location F613GP039 in 1996. Vinyl chloride was also detected in monitoring well F613GW004, adjacent to F613GP039, at concentrations as high as 10.8 µg/L. Vinyl chloride was also detected at screening locations F613GP002 (4 J µg/L) and F613GP008 (5 J µg/L), in the northwest corner of AOC 613, and at DPT location LF037GP037 (17.1 µg/L), located south of AOC 613. 1,2- DCE was identified at concentrations exceeding its MCL at F613GP039 and the adjacent well F613GW004. Because the reported concentrations exceed MCLs, these

compounds are considered COCs at AOC 613. Figure 1-2 presents the analytical results for vinyl chloride, in µg/L. Comprehensive data for the chlorinated compounds PCE, TCE, 1,2-DCE, and vinyl chloride are presented in the RFI Report Addendum for AOC 613.

The findings from this sampling effort will be reported in the Phase II IM Work Plan to evaluate the current status of COCs in groundwater and their processes of degradation. The IM will address the approach to attain media cleanup standards (MCSs).

1.4 Organization of the Phase I IM Work Plan

This Phase I IM Work Plan consists of the following sections, including this introductory section:

1.0 Introduction – Presents the purpose of the Phase I IM Work Plan and background information regarding this site.

2.0 Technical Approach – Presents the plan for completing the characterization of the extent of vinyl chloride and 1,2-DCE in groundwater at the site.

3.0 Investigation-Derived Waste – Describes the procedures to be implemented for management of investigation-derived waste (IDW).

4.0 References – Lists the references used in this document.

Appendix A contains literature regarding the Waterloo profiler.

All tables and figures are at the end of their respective sections.

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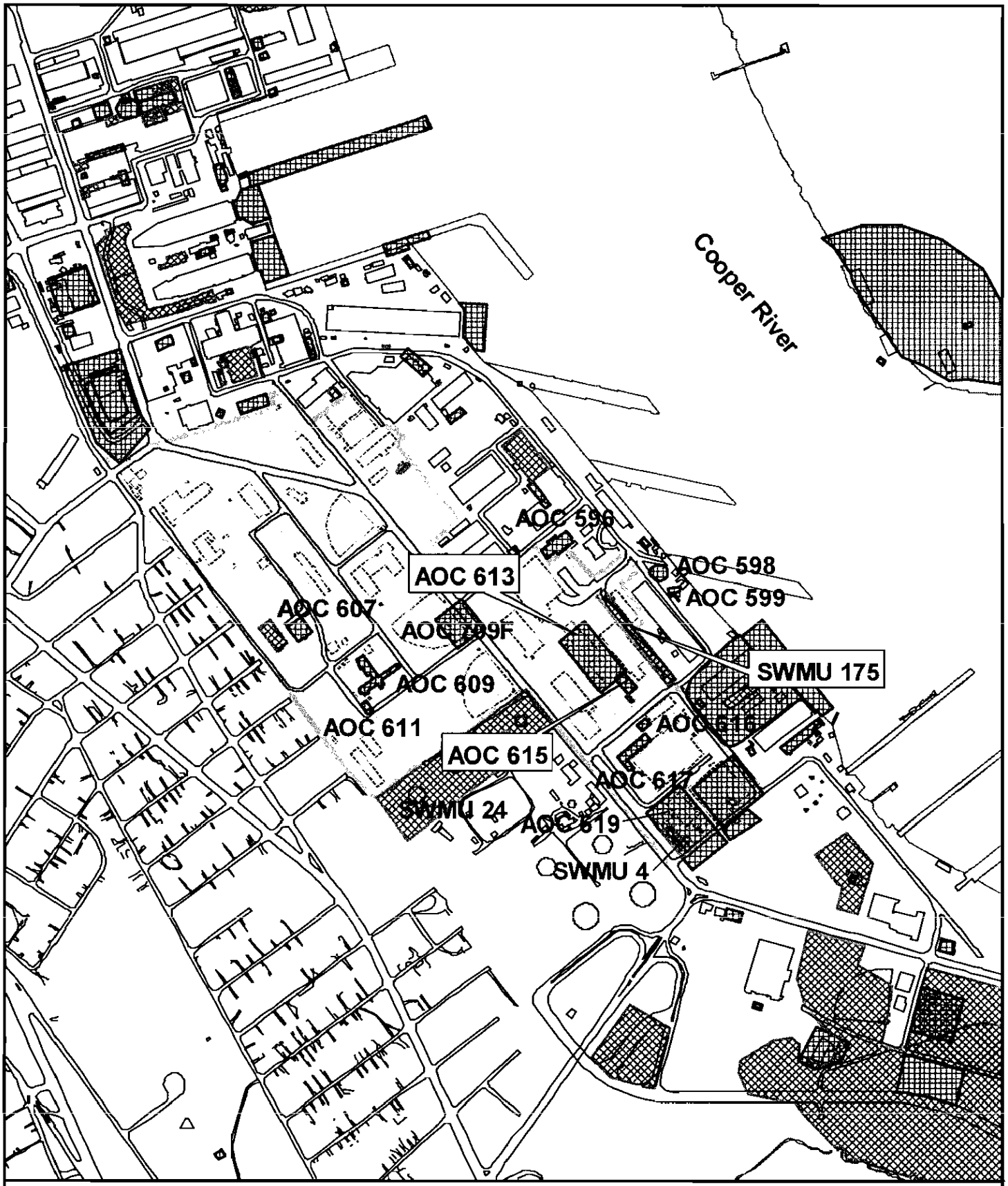


Zone F
Roads
AOC Boundary
SWMU Boundary
Buildings
Shoreline

N

0 600 1200 Feet

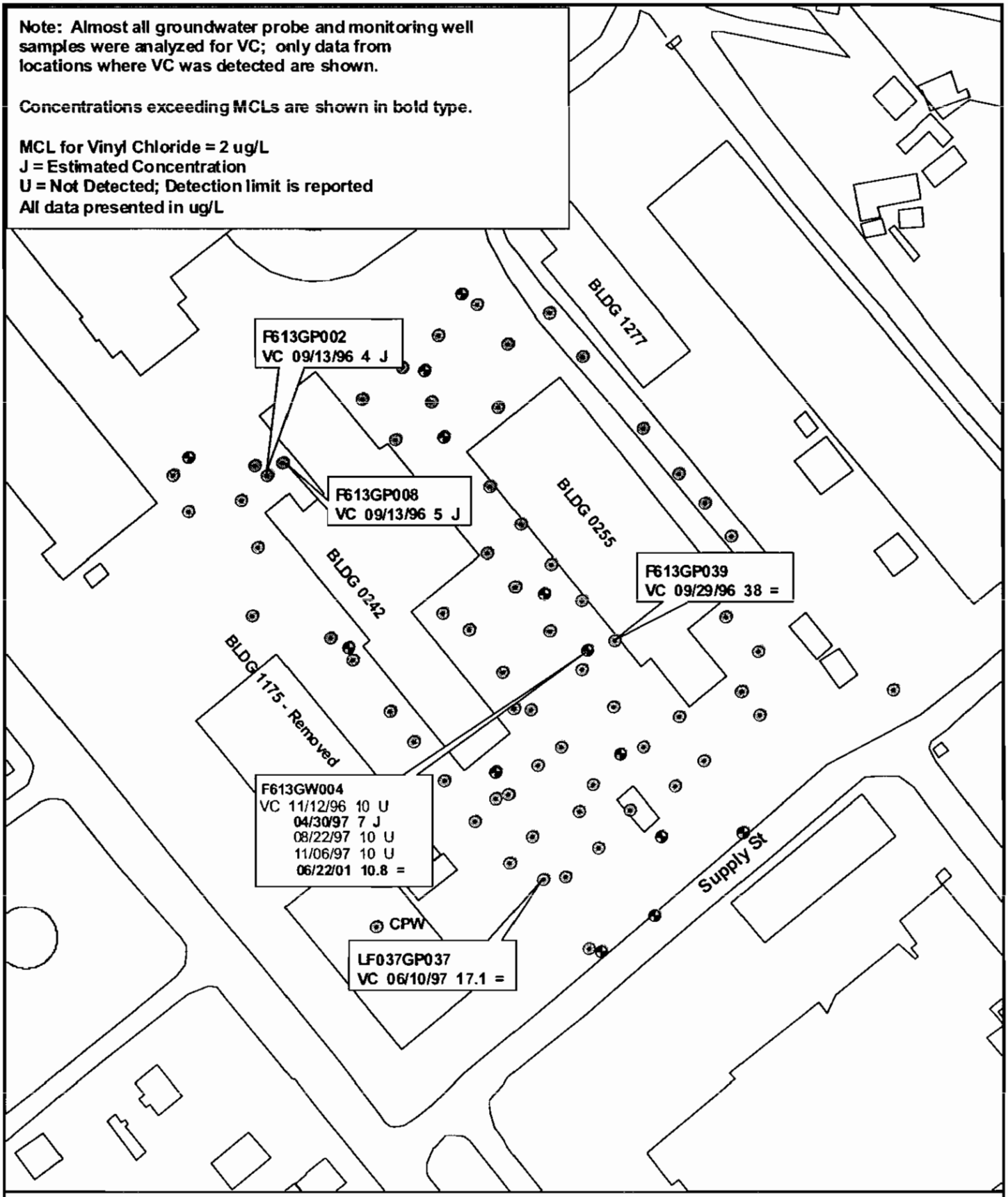
1 inch = 750 feet

Figure 1-1
AOCs 613, 615, and SWMU 175
Zone F
Charleston Naval Complex

CH2MHILL

File Path: C:\18gis\Projects\Zone_F\Aoc_613\Aprs\aoc613_fig1-1.apr, Date: 09 May 2002 10:58, User: JOVERSTR, EGIS: Charleston Naval Complex - Figure 1-1 AOCs 613, 615, and SWMU 175

NOTE: Original figure created in color



Groundwater Probe
Groundwater Well
Roads
Buildings

N

0 100 200 Feet

1 inch = 135 feet

Figure 1-2
Vinyl Chloride Detections in Groundwater
AOC 613, IM Sampling Plan , Zone F
Charleston Naval Complex

CH2MHILL

File Path: C:\18gis\Projects\Zone_F\Aoc_613\Aprs\aoc613_fig2.apr, Date: 09 May 2002 14:42, User: JOVERSTR, EGIS: Charleston Naval Complex - Figure 2 Vinyl Chloride Detections in Groundwater

Section 2.0

2.0 Technical Approach

This section outlines the technical approach for the VOC source area delineation at AOC 613. In this approach, the underground utilities in the area surrounding the proposed groundwater monitoring wells and vertical profiler borings will first be identified, and the locations will be properly cleared prior to initiation of the boring. After two new groundwater monitoring wells are installed, groundwater samples will be collected from these monitoring wells in addition to others identified in the following sections. Also, discrete groundwater samples will be collected at various depths near Building 255, as described in the following sections. Collected samples will be shipped overnight to a certified laboratory for analysis.

2.1 Well Installation

Two permanent groundwater monitoring wells have been proposed to be installed in AOC 613, both screened in the shallow water-bearing zone. These wells are identified as F613GW010 and F613GW011 on Figure 2-1. The location and construction details of the proposed monitoring wells will be presented in the request for installation, which will follow the content requirements as outlined in R.61-79.265 Subpart F of the South Carolina Hazardous Waste Management Regulations and R.61-71 of the South Carolina Well Standards and Regulations. The monitoring wells will be installed according to the approved Comprehensive Sampling and Analysis Plan (CSAP) portion of the *Zone F RFI Work Plan* (EnSafe/Allen & Hoshall, 1996), both with a total depth of 15 feet below land surface (ft bls) and a 10-ft screened interval from 5 to 15 ft bls.

2.2 Groundwater Monitoring Well Sampling

Groundwater samples will be collected from several individual groundwater monitoring wells at AOC 613. Data from the monitoring wells will be compared to historical data results as well as the discrete groundwater samples planned in the area. Table 2-1 presents the monitoring wells to be sampled as well as the associated target parameters. The target parameters include CVOCs and natural attenuation indicator parameters (NAIPs).

Field procedures and groundwater analyses will be conducted in accordance with the approved CSAP portion of the *Zone F RFI Work Plan*. The CSAP outlines all monitoring procedures to be performed during the investigation to characterize the environmental

setting, source, and releases of hazardous constituents. The CSAP also includes the Quality Assurance Plan (QAP) and Data Management Plan (DMP) to verify that all information and data are valid and properly documented. Unless otherwise noted, the sampling strategy and procedures will be performed in accordance with the EPA Environmental Services Division *Standard Operating Procedures and Quality Assurance Manual* (ESDSOPQAM) (EPA, 1996).

2.3 Groundwater Profiling

Groundwater profiling involves a DPT sampling instrument designed to collect depth-discrete groundwater samples in a single hole with one probe entry. Using this method, the site investigation will quickly delineate vertical profiles of contaminants that are dissolved in the groundwater.

Prior to implementation of the groundwater profiling activity, a continuous core of the soils within the surficial aquifer to the top of the Ashley Formation will be collected. The core will be inspected to determine lithologic intervals in which preferential flow paths may be present. This information will be used to select final depth intervals for groundwater sample collection.

2.3.1 Boring Installation and Locations

The profiler will be advanced at ten predetermined grid locations, which are presented in Figure 2-2. The grid was developed to encompass the area where vinyl chloride in excess of the MCL (see Figure 1-2) has been detected in the groundwater (plume area). The bore holes will be started with a hand auger and continued to the extent required to detect buried obstructions, but the groundwater will be sampled by advancing the sampling tool. For the five borings proposed for inside Building 255 (the Warren Lasch Conservation Center) the concrete floor slab will first be cored before hand-augering the boring.

The bore holes inside Building 255 will be cored and hand-augered no more than one day in advance of vertical profiling. The boring installation and vertical profiler sampling of locations outside Building 255 will be completed in advance of beginning the vertical profiler sampling inside the building. Vertical profiler locations inside Building 255 may be adjusted based upon laboratory results or field screening of the outside vertical profiler samples with an air monitoring device such as a photo ionization detector. Samples will be analyzed for CVOCs by method SW846-8260 (as presented in Table 2-2).

The vertical profiler locations will be identified as F613VP001, F613VP002, in sequence through F613VP010. The depth of each sample will be appended to the location identification (e.g., F613VP00115 would be collected at 15 ft bls).

2.3.2 Waterloo™ Profiler (or similar instrument) Sampling Method

The Waterloo-type profiler collects discrete groundwater samples from various depths during a single push (see Appendix A for Waterloo™ product literature). Typically, a profiler consists of screened ports located behind the tip of the tool. The tip is attached to 3-ft lengths of heavy-duty threaded steel pipe that extend to the ground surface. The profiler is advanced by pushing, pounding, or vibrating the steel pipe into the ground. Groundwater samples are conveyed to the surface via small-diameter tubing that is attached to a fitting inside of the profiler tip and passes up through the inside of the threaded steel pipes. The internal tube is made of either stainless steel or Teflon® to minimize sorption of organic compounds.

At sites at which groundwater is shallow (i.e., less than 25 ft bls), samples are collected with a peristaltic suction-lift pump. Samples are collected and preserved in containers that are appropriate for the specific analytical method to be performed. Groundwater samples will be collected at up to three discrete depth intervals for each sample location represented in Figure 2-2. Based on a review of geologic boring logs at the site, preliminary target sampling depths of 5, 8, and 12 ft bls have been selected as approximate target intervals for groundwater sampling. An additional 20-ft depth sample will be collected from F613VP002, near the former location of F613GP039. Sample depths may be adjusted to just above confining layers noted in the continuous core.

The completed vertical profiler holes will be filled to the ground surface with a bentonite grout, in accordance with Rule 61-71.10.B of the South Carolina Well Standards and Regulations. The bentonite grout will be placed into the borehole after removal of the profiling device. The hole will be grouted with a tremie pipe from bottom to top. The soil brought to the surface will be managed as IDW. Locations will be marked with wooden stakes, flags, or paint for the survey team to establish location coordinates and elevation of ground surface.

2.4 Activities within Building 255

CH2M-Jones will coordinate all activities proposed to occur within the confines of Building 255, the Warren Lasch Conservation Center, with Darlene Russo, Office Administrator of

2.4 Activities within Building 255

CH2M-Jones will coordinate all activities proposed to occur within the confines of Building 255, the Warren Lasch Conservation Center, with Darlene Russo, Office Administrator of the facility, in an attempt to mitigate any disturbances to the research and operations within the Center. Five vertical profiler points are proposed to be located inside the building in the gift shop and storage areas. The activities associated with this effort are boring installation and advancing the profiler to collect groundwater samples.

Sampling locations are identified to avoid pile foundations supporting Building 255, as well as pile foundations from the former machine shop. The previous pile foundations were reportedly cut off approximately 2 ft bls, and the pile caps removed. Sample locations are also located within Building 255 to avoid cabinetry and display cases that are not readily moved, and buried utilities.

The boring installations and profiler sampling inside the building will be completed in one continuous field effort, to minimize disruption of activities within the building. The bore holes will be started by coring the 8-inch concrete floor slab to access the subsurface and then hand-augering to the extent required to confirm clearance of utilities and previous building foundations. The vertical profiler locations inside the building may be adjusted based upon results of the outside vertical profiler samples. A truck-mounted unit must be able to access the vertical profiler locations. Temporary berms will be constructed around the vertical profiler locations to contain any water from coring and the profiler sampling. Exhaust fumes from the rigs will be vented to outside the building by routing exhaust through flexible hose to nearby windows and the roll-up door. Industrial-size fans may also be used to direct fugitive exhaust fumes outside.

Upon completion of the sampling event, the vertical profiler locations will be abandoned in accordance with Rule 61-71.10.B of the South Carolina Well Standards and Regulations and the concrete floor will be repaired.

2.5 Field Operations

CH2M-Jones will subcontract with specialty contractors to install the groundwater monitoring wells and to advance the vertical profiler points in the proposed locations and collect groundwater samples. The subcontrators will be certified drillers for the State of South Carolina. CH2M-Jones will provide a field hydrogeologist or engineer who will be responsible for all field operations.

Samples will be delivered to the laboratory to be analyzed according to the methods specified in Table 2-2. Additionally, some MNA parameters will be analyzed in the field. The subcontracted laboratory will meet EPA Data Quality Objective (DQO) Level II Criteria, as specified in the CSAP (EnSafe, 1996).

2.6 Groundwater Sampling Results

The results of the groundwater characterization investigation will be summarized in a Phase I IM Completion Report or a Phase II IM Work Plan, which will be submitted to the Navy and SCDHEC approximately six to eight weeks after receipt of all final data. The report will document the field activities completed during the study, summarize groundwater results, and if appropriate, provide a proposed approach to further evaluate or abate the source area. CH2M-Jones will incorporate the data into a geographic information systems (GIS) database.

2.7 Permits

2.7.1 SCDHEC Well Installation Request

In accordance with R.61-79.265 Subpart F of the South Carolina Hazardous Waste Management Regulations and R.61-71 of the South Carolina Well Standards and Regulations, a request for the installation of the wells and the advancement of the vertical profiler locations will be submitted to SCDHEC two weeks prior to the scheduled activity. The written request will provide the purpose of the well installation and vertical profiler activity and will consist of well construction details, if required, as well as a map depicting the proposed MW and vertical profiler locations. Because the vertical profiler locations are considered temporary, the request will also provide the method used for abandonment.

TABLE 2-1
Sampling Parameters
Phase I IM Work Plan, AOC 613, Zone F, Charleston Naval Complex

Station ID	CVOCs[a] (Method 8260)	NAIPs
Monitoring Wells:		
FCNC22-MW02	X	X
FCNC22-MW07D	X	X
FGELGW011	X	X
FGELGW012	X	X
F613GW004	X	X
F613GW009	X	X
F613GW010	X	X
F613GW011	X	X
Vertical Profiling:		
F613VP001	X	pH, ORP, and Cond
F613VP002	X	pH, ORP, and Cond
F613VP003	X	
F613VP004	X	
F613VP005	X	
F613VP006	X	pH, ORP, and Cond
F613VP007	X	
F613VP008	X	
F613VP009	X	
F613VP0010	X	

[a] CVOCs include PCE, TCE, 1,2 DCE, and vinyl chloride.

Cond Conductivity
NAIP Natural attenuation indicator parameter
ORP Oxygen reduction potential

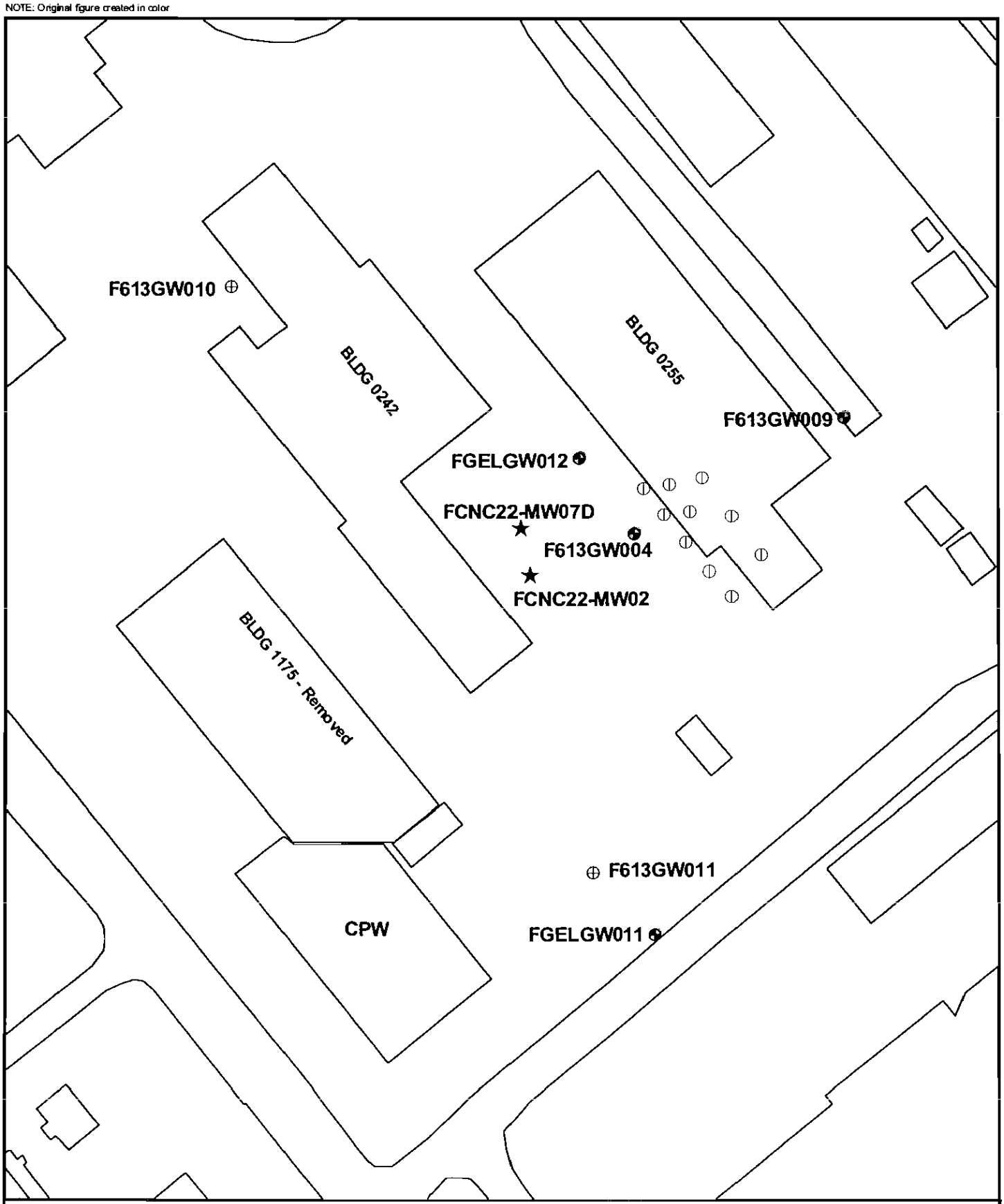
TABLE 2-2
List of Natural Attenuation Indicator Parameters
Phase I IM Work Plan, AOC 613, Zone F, Charleston Naval Complex

NAIP	Objective	Lab or Field	Method
ORGANICS:			
Methane, ethane, ethene	By-product of contaminant degradation	Lab	RSK-175
Carbon dioxide	By-product of contaminant degradation	Lab	RSK-175
ELECTRON ACCEPTORS:			
Dissolved Oxygen (DO)	Preferred electron acceptor	Field	Field DO meter
Nitrate	Electron acceptor	Lab	EPA 300.0 or 353.2
Sulfate	Electron acceptor	Lab	EPA 300.0 or 375.4
GENERAL WATER CHEMISTRY:			
Temperature	General water quality parameter	Field	Field meter
Alkalinity	Microbial activity (CO_2 generation)	Lab	EPA 310.1
Chloride	For ion balance	Lab	EPA 300.0
Iron (II)	Indicator of low redox conditions	Lab	SW6010 or 3500-Fe-C
pH	General water quality parameter	Field	Field pH meter
ORP	Indicator of redox conditions	Field	Field Eh meter
Conductivity	General water quality parameter	Field	Field meter

Items highlighted in bold represent MNA parameters.

DO Dissolved oxygen
MNA Monitored natural attenuation
NAIP Natural attenuation indicator parameter
ORP Oxygen reduction potential

NOTE: Original figure created in color



Proposed Vertical Profiler Samples
UST Investigation Wells
Proposed Monitoring Wells
Groundwater Well
Roads
Buildings

N

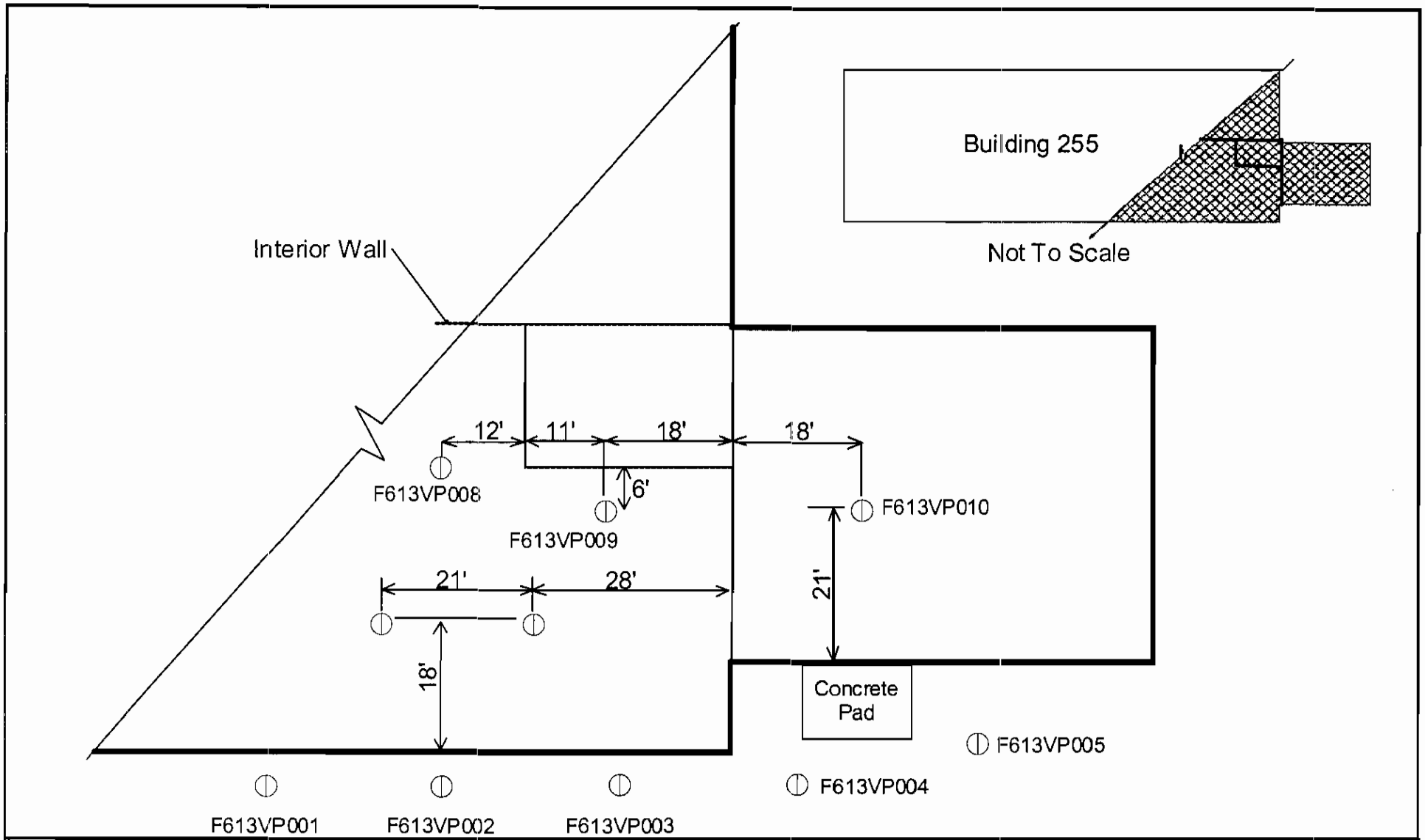
0 80 160 Feet

1 inch = 100 feet

Figure 2-1
Proposed IM Sampling Locations
AOC 613 IM Sampling Plan
Charleston Naval Complex

CH2MHILL

File Path: C:\18gis\Projects\Zone_F\Aoc_613\Aprs\aoc613_fig3.apr, Date: 10 May 2002 19:20 User: JOVERSTR, EGIS: Charleston Naval Complex - Figure 3 Proposed IM Sampling Locations



Building 255
Interior Wall
Proposed Vertical Profiler Samples

1 inch = 20 feet

0 20 40 Feet

Figure 2-2
Proposed IM Vertical Profiling Locations
AOC 613, Zone F
Charleston Naval Complex

CH2MHILL

File Path: c:\18gis\projects\zone_f\aoc_613\aprs\aoc613.apr, Date: 03 Jun 2002 12:59, User: AHOLECEK, CAD drawing - Figure 2-2 Proposed IM Vertical Profiling Locations

Section 3.0

3.0 Investigation-Derived Waste

IDW that is generated during this effort will include pavement cores, purge water from the groundwater sampling activities, and soil cuttings. IDW will be collected in labeled 55-gallon drums or a portable tank for proper handling. Contained IDW will remain on site temporarily until transported to the fewer-than-90-days storage facility located at Building 1824. Once the analytical results have been reviewed, the 55-gallon drums or the portable tank containing the groundwater contents will be transported, as required, to a permitted and licensed facility for treatment or disposal.

Section 4.0

4.0 References

CH2M-Jones. *Zone F RFI Work Plan Addendum*. February 13, 2001.

CH2M-Jones. *RFI Report Addendum & CMS Work Plan, AOC 613/AOC 615/SWMU 175, Zone F, Revision 0*. March 5, 2002.

EnSafe Inc./Allen & Hoshall. *Final Comprehensive Sampling and Analysis Plan*. RCRA Facility Investigation. July 30, 1996.

EnSafe Inc. *Zone F RFI Report, NAVBASE Charleston*. Revision 0. December 31, 1997.

U.S. Environmental Protection Agency. *Environmental Services Division Standard Operating Procedures and Quality Assurance Manual*. Region IV, Environmental Services Division. 1996.

Appendix A

PRECISION

TECHNICAL NOTE No.3

The Waterloo Profiler for Groundwater Sampling

The Waterloo Profiler is a new direct-push (DP) groundwater sampling tool developed by researchers at the University of Waterloo in Ontario, Canada[1]. The Profiler is the only DP tool designed to collect depth-discrete groundwater samples in a single hole with one probe entry. With the Waterloo Profiler, site investigators can quickly delineate vertical profiles of contaminants dissolved in groundwater.

Why Vertical Profiling is Necessary

Recent long-term natural gradient tracer studies show that in most granular aquifers, very little vertical mixing of contaminants occurs as the groundwater flows along its flow path[2,3,4,5]. Depth-discrete groundwater sampling (referred to as vertical profiling) at these sites shows that the concentration of dissolved organic compounds often varies by several orders of magnitude over vertical distances of one foot or less. This indicates that significant vertical mixing does not occur in most environments; if it did, the contaminants would be more evenly distributed and concentrations would be more uniform.

Groundwater mixing, also referred to as hydrodynamic dispersion, is a function of the groundwater velocity and the dispersivity (α) of the formation. Numerical simulations of data collected during the natural gradient tracer tests show that vertical dispersivity (α_V), which controls vertical mixing, is much lower than was thought in the 1970s and early 1980s[2]. This explains why very little vertical mixing of contaminants occurs in nature, even in relatively homogeneous materials.

If dissolved contamination is highly stratified, can samples collected from conventional monitoring wells provide an accurate representation of the true concentration and distribution of contaminants in groundwater? The answer is no. When a conventional monitoring well is sampled, clean or slightly-contaminated water is drawn into the well, diluting the sample. Therefore, even with screen lengths as short as 5 or 10 feet, monitoring wells yield samples that are composited over the screened interval. Thus, high concentrations of contaminants present in a thin zone – and even non-aqueous phase liquids (NAPLs) – are significantly diluted in the process of sampling conventional monitoring wells. In some cases, the contamination can be diluted below the detection limit of the chemical analytical method.

Moreover, for non-biodegradable contaminants (like most chlorinated solvents and MTBE), if significant mixing with clean water does not occur as groundwater flows in the subsurface, the high solute concentrations in the contaminated zone are maintained. Thus, thin zones with high concentrations of contaminants can flow for great distances without being diluted. A recent investigation at an industrial facility – where detailed vertical monitoring was performed – identified a high-strength core of contamination that extends for over 7 kilometers[6].

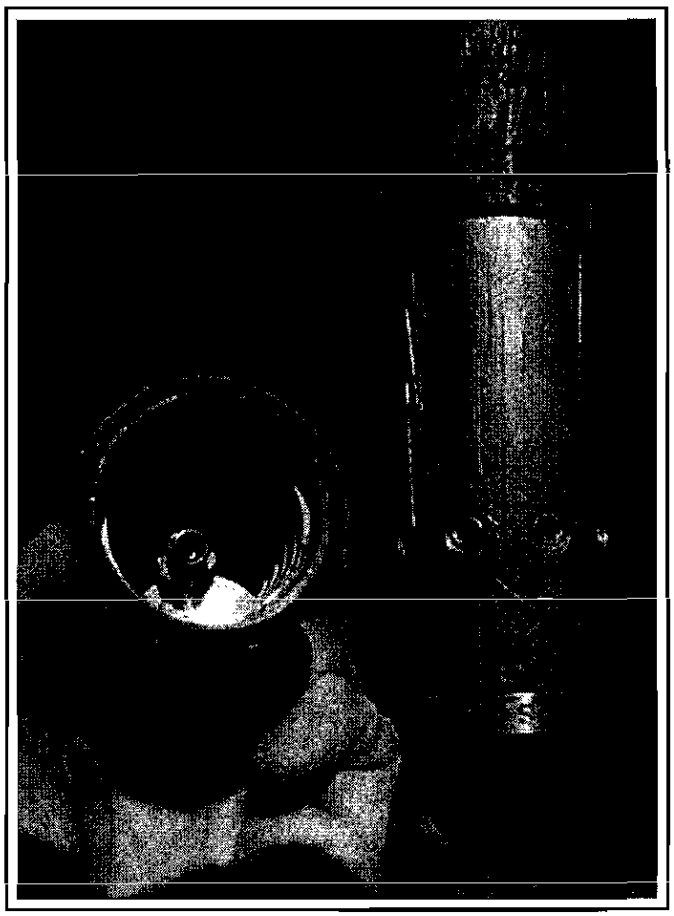


Figure 1. Depth-discrete groundwater samples are drawn through screened ports in the tip of the sampling tool. The ports are connected to an internal fitting inside of the tool (shown at left). Tubing attached to the internal fitting and running inside of the steel pipe conveys the water sample to the surface.

Inaccurate delineation of groundwater contamination can have tremendous consequences. Without an accurate understanding of the true magnitude and distribution of contamination, it is not possible to make intelligent corrective action decisions. Underestimating the maximum contaminant concentrations invalidates any risk assessment. Not identifying free product or localized contaminant hot spots may expose nearby receptors to unacceptable risks. And, without knowing the true distribution of subsurface contamination, it is impossible to design effective active or passive remediation systems.

Regulators and site investigators across North America are discovering that collecting multiple, closely-spaced, depth-discrete groundwater samples – i.e., vertical groundwater profiling – is necessary to define the true extent and distribution of dissolved contaminants in the subsurface.

Description and Operation of the Waterloo Profiler

The Waterloo Profiler collects discrete groundwater samples from numerous depths during a single push. Figure 1 shows the tip of the Waterloo Profiler, which has screened ports located at the tip of the tool. The Profiler tip is attached to 3-foot lengths of heavy-duty threaded steel pipe that extend to the ground surface. The Profiler is advanced by pushing, pounding, or vibrating the steel pipe into the ground using one of Precision's custom-made sampling rigs. Three-foot lengths of pipe are continually added as the tool is advanced deeper into the ground to the first sampling depth. Groundwater samples are conveyed to the surface via small-diameter tubing that is attached to a fitting inside of the Profiler tip and passes up through the inside of the threaded steel pipes.

At sites where groundwater is shallow (i.e., less than 25 feet below the ground surface), samples can be collected using a peristaltic suction-lift pump (Figure 2). Samples are collected in 40 ml glass vials placed in the sampling line, upstream from the peristaltic pump. Positioning the glass vials in the sampling line upstream from the peristaltic pump minimizes the loss of volatile organic compounds (VOCs) since the sample is never exposed to the atmosphere. However, at sites where groundwater has high concentrations of dissolved gases such as carbon dioxide or methane, pressure changes during sampling can cause bubbling in the sample line as the dissolved gases come out of solution. In such environments, VOCs in the groundwater can partition into the bubbles, reducing the concentration in the water. A recent study by Baerg et al. indicates that the negative bias in samples collected using a peristaltic pump is on the order of 12% for tetrachloroethene (PCE) and 7% for trichloroethylene (TCE)[7]. While this error is not insignificant, the advantage of being able to delineate the plumes in detail outweighs the sampling bias caused by the sample collection method, especially when the natural variation in the samples is in the order of three to four orders of magnitude. Nevertheless, the investigator is cautioned to be aware that negative biases exist when using peristaltic pumps, and to consider not only the partial pressures of dissolved gases, but also the volatility of the target analyte. Additional discussion of sample bias associated with the Waterloo Profiler is presented by Pitkin, et al.[8].

Once a sample is collected in the 40 ml vials, new glass vials are placed in the sample holder and the Profiler is pushed to the next sampling depth. The next sampling depth can be any distance below the previous depth, but usually ranges between 2 and 5 feet deeper. To prevent the ports from clogging as the tool is pushed through the soil, deionized water is slowly pumped through the inner tube and out of the sampling ports as the tool is being advanced. Note that only a very small amount of water is injected – typically less than 10 milliliters per minute – just enough to keep the ports from becoming plugged. For injection pressures up to approximately 50 pounds per square inch (psi), the water is injected by reversing the flow on the peristaltic pump. In addition to keeping the ports open, injecting DI water while advancing the tool purges the tubing of the water left over from the previous sampling event. This prevents cross contamination of the next groundwater sample.

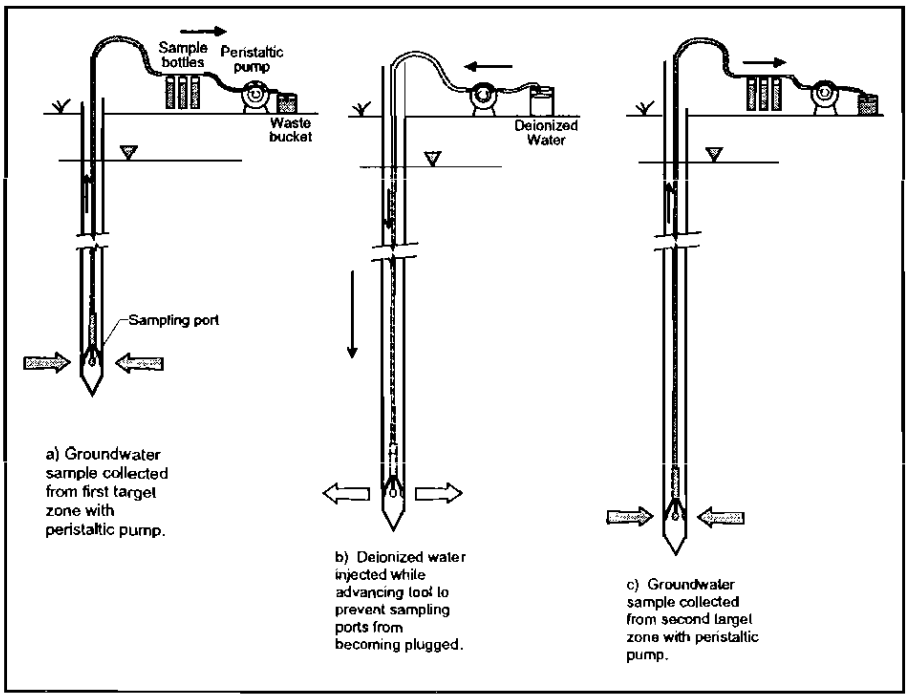


Figure 2. Collecting depth-discrete groundwater samples with the Waterloo Profiler

Note that the pressure/flow relationship of the injection water can be monitored to provide an indication of the hydraulic conductivity of the formation. This way, geologic contacts (i.e., the contact between a sand and an underlying clay confining unit) can be accurately identified as the profiler tool is advanced.

Once the tool has been advanced to the next sampling depth, the flow of the pump is reversed, and groundwater from the aquifer is again extracted. Purging of the system is required, since the tubing and ports now contain DI water that had been pumped down through the system. The electrical conductivity of the extracted groundwater can be monitored during purging. Several other chemical parameters such as salinity, temperature, pH, and dissolved oxygen (DO) can be monitored using in-line sensors mounted in flow-cells in the sampling line. Once the investigator is confident that formation water is being extracted, the 40 ml glass sample vials are removed and capped, ready to be analyzed by the on- or off-site laboratory.

The primary advantage of the Waterloo Profiler is that because the tubing is purged between samples, several depth-discrete ground-water samples can be collected in one push, without having to remove, clean, and re-insert the tool.

Sealing the Hole Created with the Waterloo Profiler

Probe holes should be sealed to prevent the holes from becoming conduits for contaminant migration. This is espe-

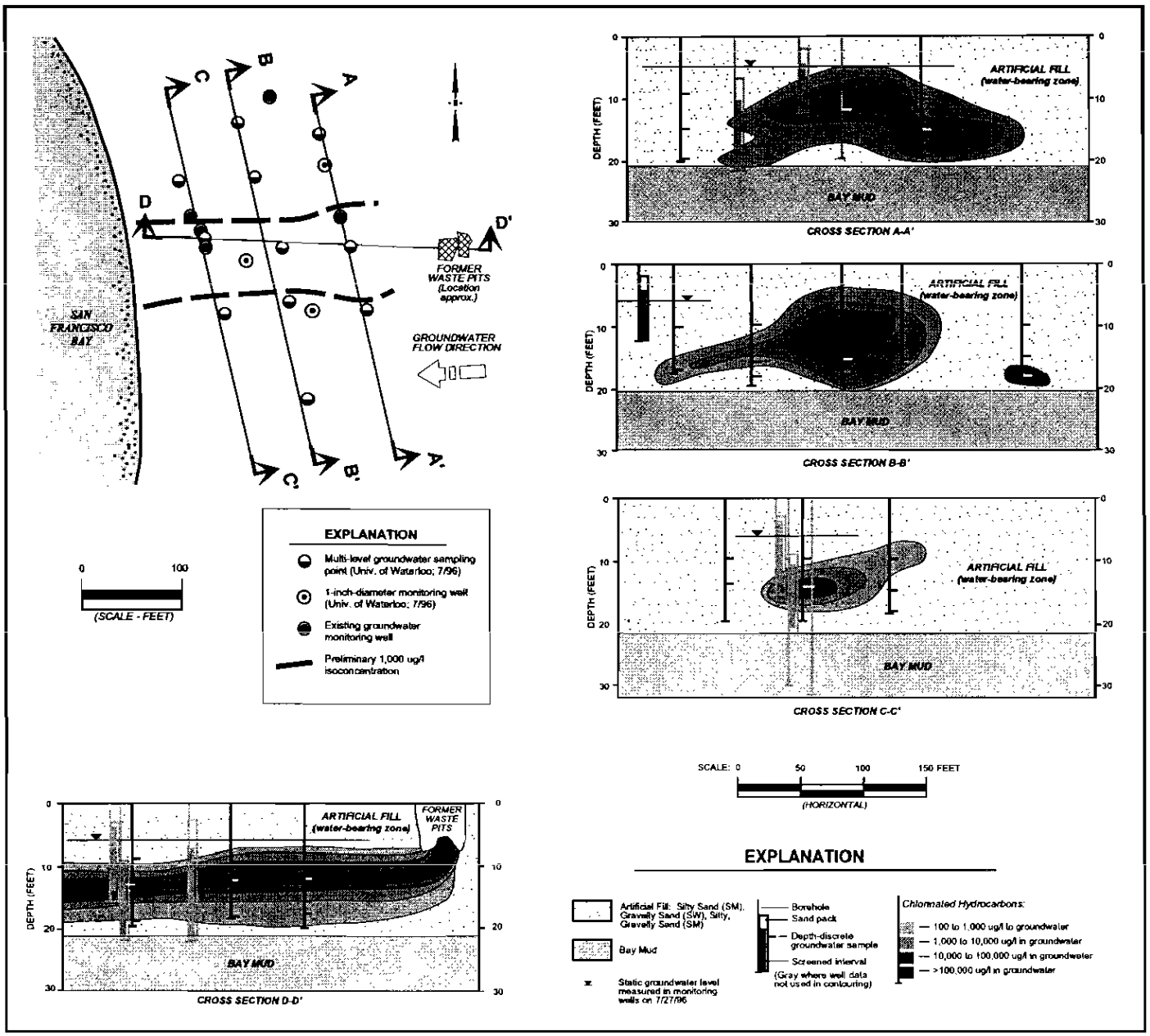


Figure 3. Map and transects from a site characterization at Alameda Naval Air Station in California. Note the great vertical variation in the concentration of dissolved contaminants, even in this homogeneous sand.

cially important at sites where DNAPL is present that could flow down the open probe holes and contaminate deeper aquifers. In most homogeneous sands, the sand will collapse as soon as the Profiler is withdrawn, restoring the original permeability of the formation. However, in other geologic formations, the soil may not collapse, and other methods of sealing the probe hole are necessary. The Waterloo Profiler is equipped with a knock-out disposable tip that facilitates reliable retraction grouting (Figure 1). Once the last groundwater sample has been collected, cement or bentonite grout is pumped down the steel pipe using a high-pressure grout pump. The disposable tip separates from the rest of the tool upon pull back, and grout flows out of the pipe into the probe hole. The grout is continuously pumped, filling the probe hole as the pipe is removed. This ensures that the probe hole is effectively sealed. Retraction grouting using the Waterloo Profiler is much more reliable than re-entry methods used with other sealed-screen groundwater sampling systems[9].

Case Study

The Waterloo Profiler was used to delineate the areal and vertical extent of a plume of chlorinated organics and petroleum hydrocarbons at a portion of Alameda Naval Air Station in California. The investigation was performed to define the optimum location and depth of an innovative in-situ reactive-wall funnel and gate remediation system[10]. Continuous soil cores were first collected with Precision's Enviro-Core system to define the site geology (the Enviro-Core soil coring system is described in Technical Note # 1). Next, depth-discrete groundwater samples were collected with the Waterloo Profiler at 14 locations (Figure 3). The locations were along three transects drawn perpendicular to the presumed plume orientation. Groundwater samples were analyzed on site for chlorinated organic compounds and petroleum hydrocarbons by GC/MS methods.

As shown in Figure 3, Precision's investigation accurately delineated the dissolved plume in three dimensions. The plume does indeed have a very concentrated core, with concentrations of vinyl chloride as high as 130,000 ug/l, that had been missed by the existing conventional monitoring wells. Projection of concentration contours to the ground surface shows that the plume emanates from a former waste disposal pit, and flows to the west where it discharges into San Francisco Bay. Note that groundwater samples collected from the base of the aquifer had much lower concentrations of all compounds than samples collected higher up in the aquifer. This is conclusive evidence that a pool of DNAPL does not occur atop the Bay Mud aquitard in that part of the site.

The site characterization was comprehensive and yielded accurate data that the investigators needed to install the passive remediation system. Yet, the investigation was neither lengthy nor costly. Precision performed the entire investigation in 4 days at a cost slightly under $10,000.

Maximum Depth, Productivity, and Limitations

Like other direct-push groundwater sampling tools, the Waterloo Profiler is intended for use in unconsolidated sand and gravel formations. The maximum sampling depth depends on the site-specific soil conditions. It has been advanced to depths greater than 100 feet near Cape Canaveral, Florida and Cape Cod, Mass.

Sample collection is the most time-consuming part of the operation; advancing the sampling tool usually takes very little time. In coarse-grained sands and gravels, sample collection takes less than 10 minutes per sample. In fine- to medium-grained sand, 20 to 30 minutes is typically required to purge and collect a sample. In sediment finer than a fine-grained sand, collecting groundwater samples with the Waterloo Profiler is time consuming and may not be economically feasible.

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