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Final

Summary Work Plan
Remedial Investigation and Feasibility Study
Landfill C (Site 3) and Landfill D (Site 4)

St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order 0027

May 1997

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
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Prepared by

CDM Federal Programs Corporation

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Submitted by

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Herndon, Virginia

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Introduction

This summary work plan documents the tasks necessary to conduct a remedial investigation and feasibility study (RI/FS) of Landfill C and Landfill D at the St. Juliens Creek Annex, Chesapeake, Virginia. Background information for the site is also documented. The RI determines the nature and extent of contamination, evaluates potential contamination migration from the site, and evaluates risks to human health and the environment. The RI generally follows on a preliminary assessment and site investigation (PA/SI) or an initial assessment study and confirmation study (IAS/CS) that identifies potentially contaminated areas. The FS evaluates feasable cleanup methods to achieve environmental standards for human health and the environment. The RI and FS of Site 3 and Site 4 are proceeding under standard methodologies as prescribed by the Comprehensive Environmental Response, Compensation, And Liability Act (CERCLA) guidance.

The St. Juliens Creek Annex Facility is situated at the confluence of St. Juliens Creek and the Elizabeth River in the city of Chesapeake, located in southeastern Virginia (Figure 1). The facility covers approximately 490 acres and includes 221 buildings, 653 feet of wharf, a central heating plant, numerous non-operational industrial facilities, and miscellaneous structures including a housing area.

Landfill C (Site 3) covers 10 acres along the northern edge of the Annex and is accessible by way of a patrol road (Figure 2). The area was originally a mudflat where refuse was dumped and allowed to burn; the ash was then used to fill in the area. The landfill is unlined. Operation began in 1940 and continued until 1970.

Refuse disposed of at Landfill C included solvents, acids, bases, and mixed municipal waste. The total volume of trichloroethene (TCE), waste oil, and oil sludge's was estimated to be 750,000 cubic feet prior to burning. Two pits reportedly used for disposal of oils and oily sludge's, as well as for periodic burning were also located at the Landfill C site.

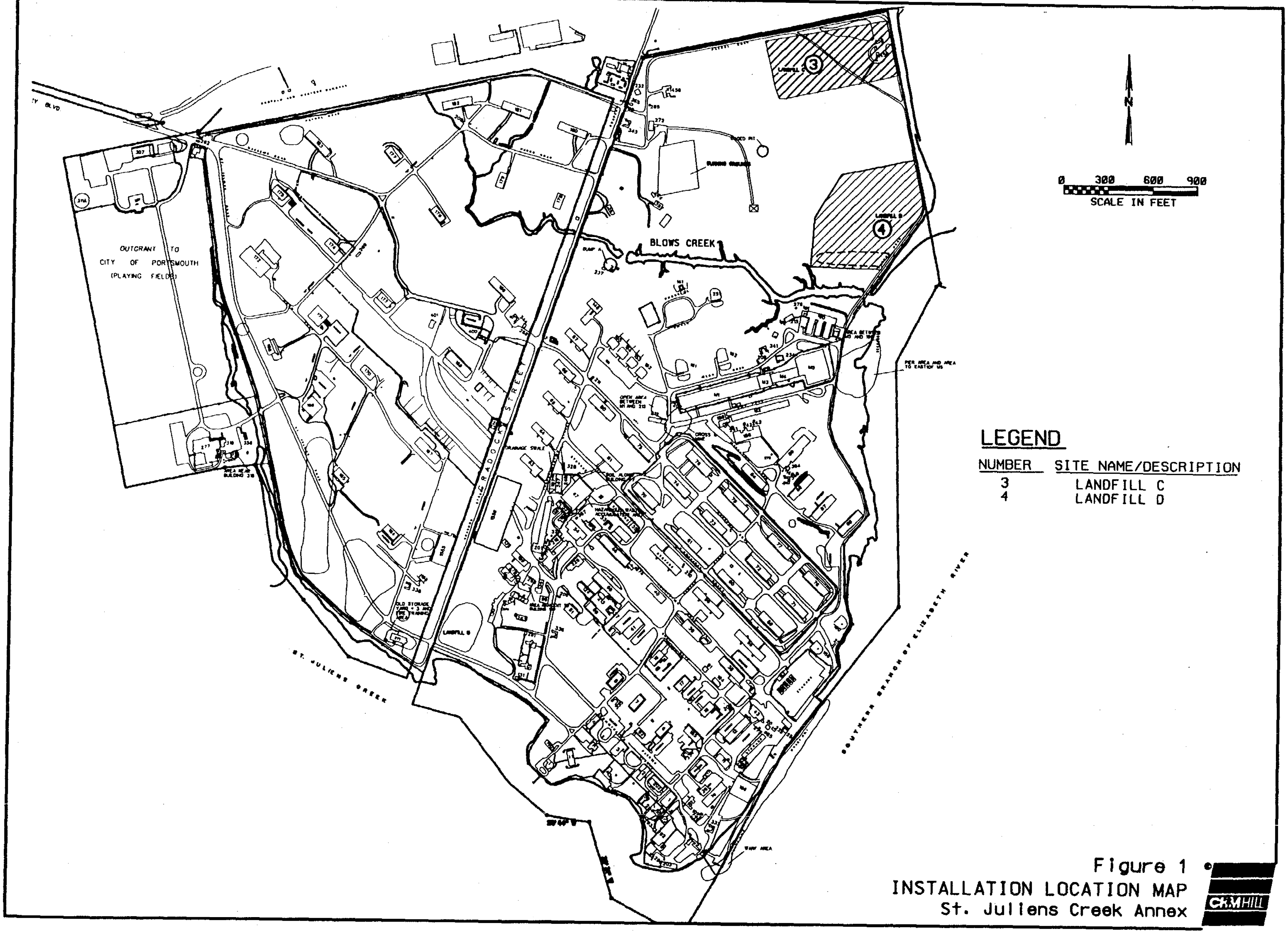
Landfill D (Site 4) covers an estimated 5 acres approximately 300 feet south of Site 3 (Figure 3). Site 4 was an unlined trench and fill landfill that operated from 1970 to 1981. The first trench was approximately 1,000 feet long and was located parallel to and 500 feet north of Blows Creek. Soil from subsequent trenches were used to cover previous trenches. The total number of trenches dug in the landfill is not known.

Refuse disposed of at Site 4 included drums of unknown wastes and polychlorinated biphenyls (PCBs). According to personnel at the public works department, the PCBs probably came from ballast containers for fluorescent light fixtures. Also, previous reports have indicated that several tanks with undetermined wastes were also once located in the area. Total volumes of disposal are unknown.

This document discusses the site background and physical setting of the St. Juliens Creek Annex, the initial evaluation of Site 3 and Site 4, and the technical approach to the RI/FS work plan tasks. A project schedule is also included.

Installation Restoration Program

The St. Juliens Creek Annex Facility is not listed on the United States Environmental Protection Agency (USEPA) National Priorities List (NPL). Therefore the Navy is acting as the lead agency in environmental investigations at the Base. The environmental condition of the Base



LEGEND

NUMBER	SITE NAME/DESCRIPTION
3	LANDFILL C
4	LANDFILL D

Figure 1
INSTALLATION LOCATION MAP
St. Juliens Creek Annex

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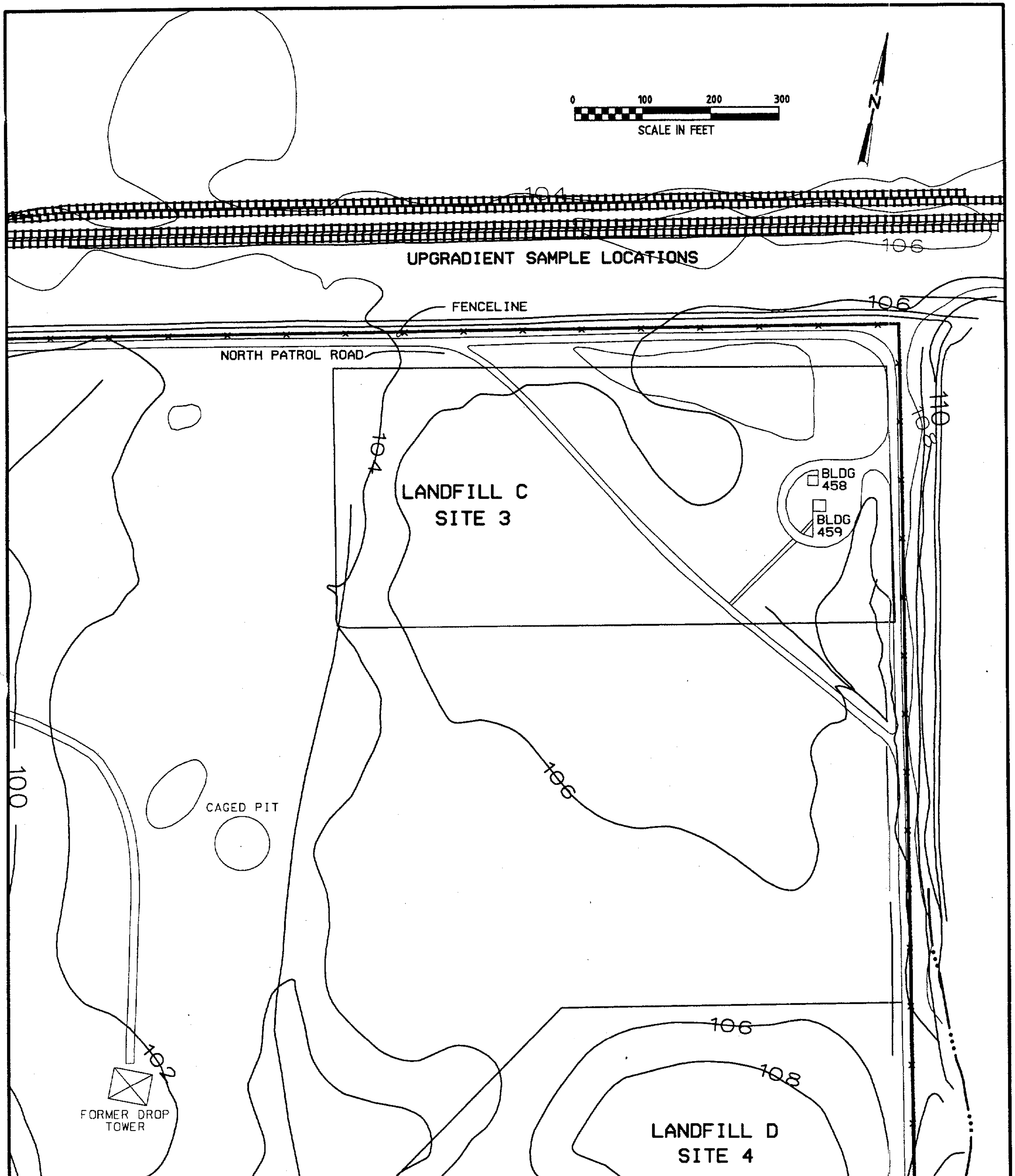

Figure 2

SITE 3 - LANDFILL C
St. Juliens Creek Annex

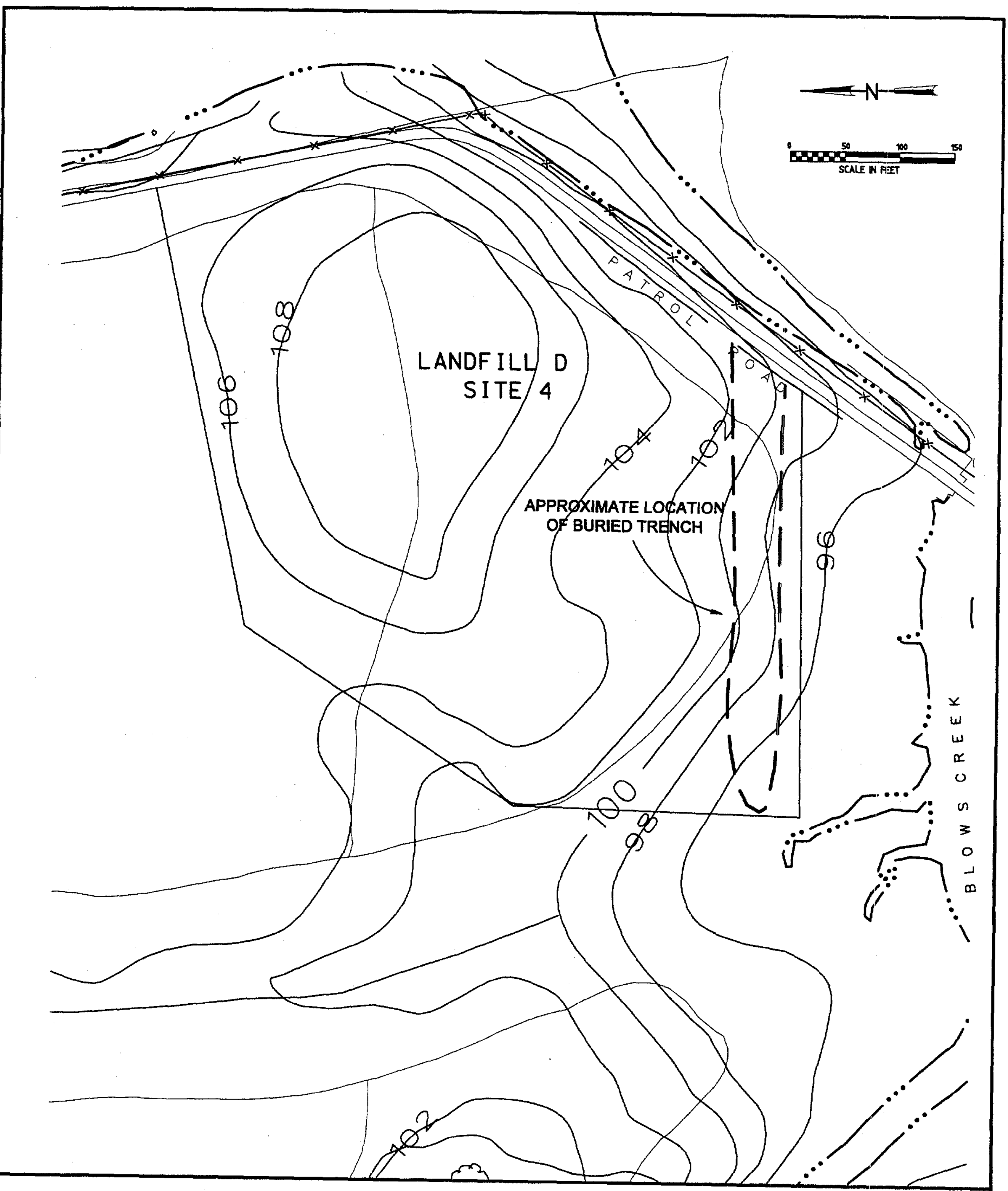

Figure 3

SITE 4 - LANDFILL D
St. Juliens Creek Annex

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is being investigated through the United States Department of Defense (DOD) IRP. The IRP at the St. Juliens Creek Annex facility has been conducted in accordance with applicable federal and state environmental regulations and requirements. In addition, the Navy has solicited involvement and comments from federal and state regulatory agencies (USEPA and the Virginia Department of Environmental Quality [VDEQ]) throughout the IRP process by submitting documents for their review.

In 1975, DOD began a program for assessing past hazardous-material and toxic-material storage and disposal activities at military installations. The goals of the program, now known as the IRP, were to identify environmental contamination resulting from past hazardous-material management practices, assess the effects of the contamination on public health and the environment, and develop corrective measures as required to mitigate adverse effects on public health and the environment.

In 1976, RCRA was passed by Congress to address potentially adverse human health and environmental effects of management and disposal practices for hazardous waste. RCRA was legislated to manage the present and future disposal of hazardous wastes. In 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or "Superfund," was passed to investigate and remediate areas resulting from past hazardous-waste management practices. The program is administered by USEPA or state agencies.

In 1981, DOD's IRP was reissued, additional responsibilities and authorities specified in CERCLA being delegated to the Secretary of Defense. The Navy subsequently restructured the IRP to match the terminology and structure of the USEPA CERCLA Program. The current IRP is consistent with CERCLA and applicable state environmental laws.

Site Background and Physical Setting

The St. Juliens Creek Annex began operations as a naval facility in 1849. At that time, the area, known as Fort Norfolk, was transferred from the War Department to the Navy Department for use as a storage facility for ordnance and materials. In 1902, the name was changed to U.S. Naval Magazine, St. Juliens Creek. The Magazine was at that time fully operational and provided critical support to the fleet during the end of the Spanish-American War. In 1917, the facility installed equipment for loading MARK VI mines. The facility's name was changed again, to Naval Ammunition Depot (NAD), St. Juliens Creek, and operated under the Commandant Fifth Naval District. The facility operated at its peak level from 1942 to 1944, during World War II. An additional 119 acres of land were purchased, and additional magazines, filling houses, and other facilities were constructed. The mission of NAD St. Juliens Creek during World War II included loading, assembling, issuing, and receiving naval gun ammunition. The depot also served as the principal experimental and test loading facility for new ammunition types for the Bureau of Ordnance. In October 1969, after 50 years as an independent facility, NAD St. Juliens Creek was disestablished under the Department of Defense "Project 703", and was consolidated as an annex to the Naval Weapons Station, Yorktown, Virginia. On October 1, 1977, the Annex was transferred to the Norfolk Naval Shipyard.

Currently, the St. Juliens Creek Annex provides administrative offices, light industrial shops and storage facilities for tenant naval commands, and a radar testing range for the nearby Norfolk Naval Shipyard and other local Navy activities.

St. Juliens Creek Annex facility is located in the outer Atlantic Coastal Plain Physiographic Province which is characterized by low elevations and gently sloping relief. The Annex is underlain by more than 2,000 feet of gently dipping sand, silt, and clay, sediments. The uppermost geologic strata is composed of approximately 40 feet of fine sands and silts that comprise the water table aquifer. Depth to the water table is usually 15 feet or less. A confining unit of relatively impermeable silt and clay separates the water table aquifer from the underlying Yorktown Aquifer. Water bearing zones in the Yorktown Aquifer consist of fine to coarse sand, gravel, and shells. Several older formations comprise deeper aquifers and confining units.

Previous Investigations

Previous basewide investigations completed through the IRP include the initial assessment study (IAS), dated August 1981; a Phase II RCRA Facility Assessment (RFA), dated March 1989; and a Relative Risk Ranking (RRR) System Data Collection Report, dated April 1996.

In 1981, the U.S. Navy conducted the IAS as part of the Naval Assessment and Control of Installation Pollutants (NACIP) Program. The purpose of the IAS was to identify and assess sites that posed a potential threat to human health or the environment because of contamination from past handling of and operations involving hazardous materials. Results of this study revealed that low level concentrations of ordnance materials were determined to exist throughout the facility. However, the sites identified were determined not to pose a threat to human health and the environment, and no confirmation study was conducted. No sampling was conducted as part of the study.

In 1983, NUS Corporation, Superfund Division (NUS), conducted a Preliminary Assessment (PA) at seven sites at the facility. These sites included: Cross and Mine; Building 249; Dump A; Dump B; Dump B Incinerator; Dump C; and Dump D. Each site was monitored for volatile organic compounds (VOCs) and radiation with an organic vapor meter and radiation meter, respectively. No sampling was conducted as part of the PA. NUS did not observe significant signs of contamination at the sites observed.

In 1989, A.T. Kearney, Inc. and K.W. Brown & Associates, Inc. prepared a Phase II RFA for the U.S. Environmental Protection Agency (EPA), Region III. The RFA included a preliminary review of all available relevant documents and a visual site inspection (VSI) of the Annex, including 34 Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs). Eleven of the SWMUs and AOCs were recommended for RCRA Facility Investigations (RFIs). Sampling was not conducted as part of the RFA.

In April 1996, CH2M Hill Federal Group, Ltd. submitted to the Department of the Navy an Relative Risk Ranking System (RRR)Data Collection Report for the St. Juliens Creek Annex. The report contained results from sampling conducted at 21 sites at the Annex where no sampling data had previously been available. The goal of the sampling effort was to gather data for the Navy to perform assessments of the sites using the Navy's RRR System.

CH2M Hill and CDM Federal Programs Corporation performed a visual site inspection of Site 3 and Site 4 on October 10, 1996. Landfill C (Site 3) is relatively flat and as a result, fill boundaries are not easily distinguishable. The surface is grass covered and no visible signs of debris were noted. Several low-lying areas inside the estimated boundaries were filled with water at the time of the site visit and drainage swales adjacent to a gravel perimeter road (North Patrol Road) also contained water.

Landfill D (Site 4) boundaries are somewhat more evident than Landfill C with raised surface features and areas which lack vegetation. A brush line borders the northern edge of the landfill with brush also extending beyond the western and southern edges. North Patrol Road and the adjacent property boundary borders the landfills eastern edge. A small debris pile was located in the center of the site with metal cable and wooden posts visible and concrete debris was visible in the western part of the site. Site drainage appears to be in a southern and eastern direction towards Blows Creek. Ponded water was noted within the line of brush at the northern edge of the landfill.

Technical Approach and Investigation Procedures

This section summarizes the technical approach developed to perform the RI/FS activities at Site 3 and Site 4. The tasks included in the technical approach are listed below. The remainder of the section contains a brief summary of each task.

Task 1:	Project Planning
Task 2:	Fieldwork Support
Task 3:	Field Investigation
Task 4:	Sample Analysis and Data Validation
Task 5:	Risk Assessment
Task 6:	RI Report
Task 7 :	Feasibility Study
Task 8:	Feasibility Study Report
Task 9:	PRAP and ROD Report

Task 1: Project Planning

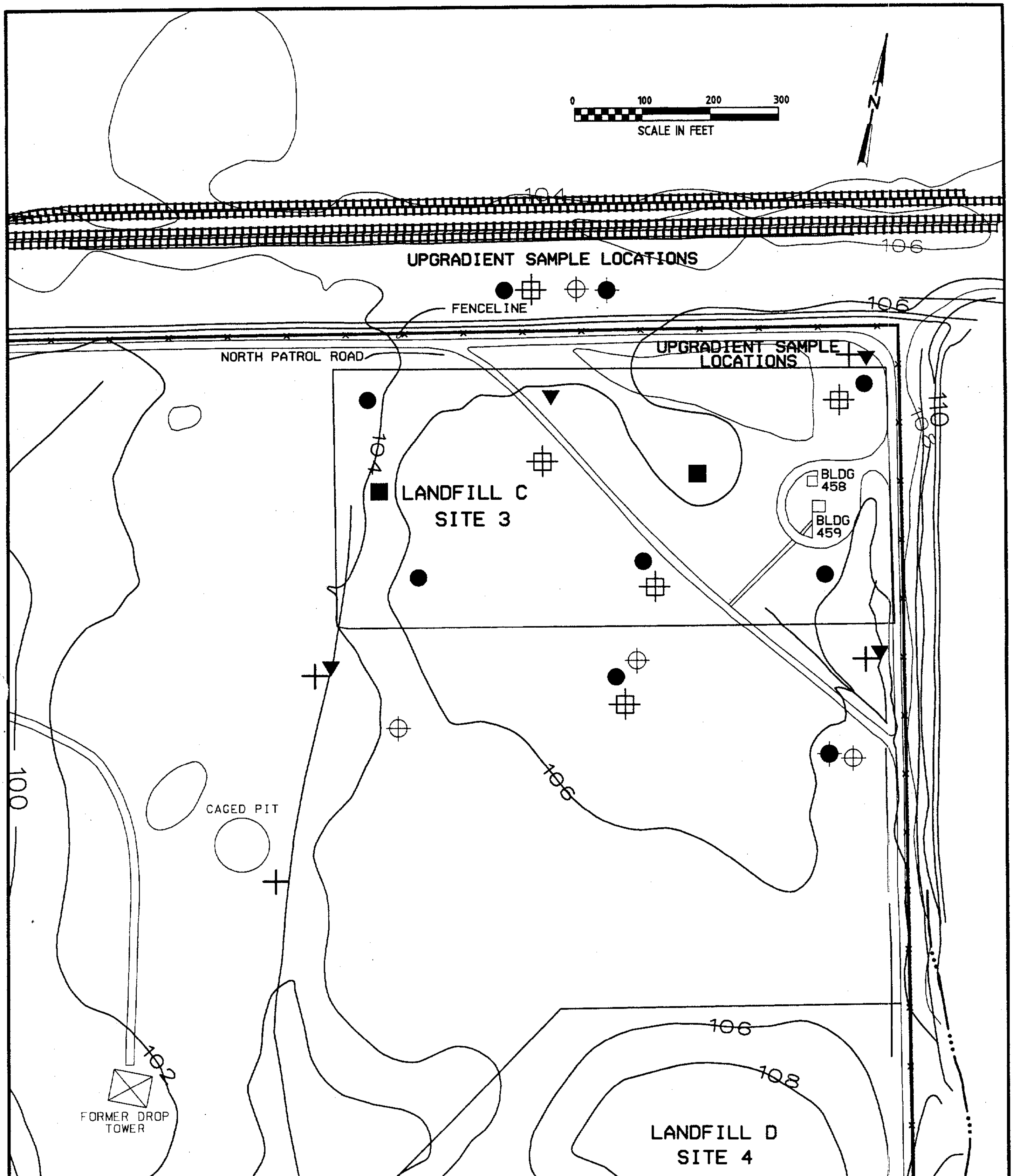
This task consists of preparing the work plan, the sampling and analysis plan (SAP), and the health and safety plan (HSP). Project planning also includes any project-related meetings and all project management activities, such as technical support, subcontractor coordination, and budget and schedule tracking.

Task 2: Fieldwork Support

This task includes subcontractor procurement for certain services such as drilling, surveying, analytical laboratory, data validation, and waste management services. The mobilization and demobilization of CDM Federals field team and equipment are also included in this task, as well as the procurement of utility clearances for the proposed areas and potential areas of intrusive field activities.

Task 3: Field Investigation

The field investigation includes all RI/FS activities associated with monitoring well installation and the collection of soil and groundwater samples at Site 3 and Site 4. The areal and vertical distribution and magnitude of site contamination will be investigated by installing and sampling subsurface soil borings and monitoring wells. Surface soil, surface water, and sediment samples will also be collected. The task also includes surveying of sample locations by a subcontracted surveyor licensed in the State of Virginia. Figure 4 provides the approximate locations of the wells and sampling points at Site 3 and Figure 5 provides the approximate locations of the wells and sampling points at Site 4. All samples will be analyzed for Target Compound List (TCL) organics (including semivolatiles, pesticides, and PCBs) and Target Analyte List (TAL) inorganics (including metals and cyanide).



LEGEND

- ● Surface soil sample location
- ■ Composite soil sample location (0-3')
- ⊞ Subsurface soil sample location
- ▼ Sediment sample location
- ● Deep monitoring well location
- ⊕ Shallow monitoring well location
- + Surface water sample location

Figure 4

SAMPLING LOCATIONS
SITE 3 - LANDFILL C
St. Juliens Creek Annex

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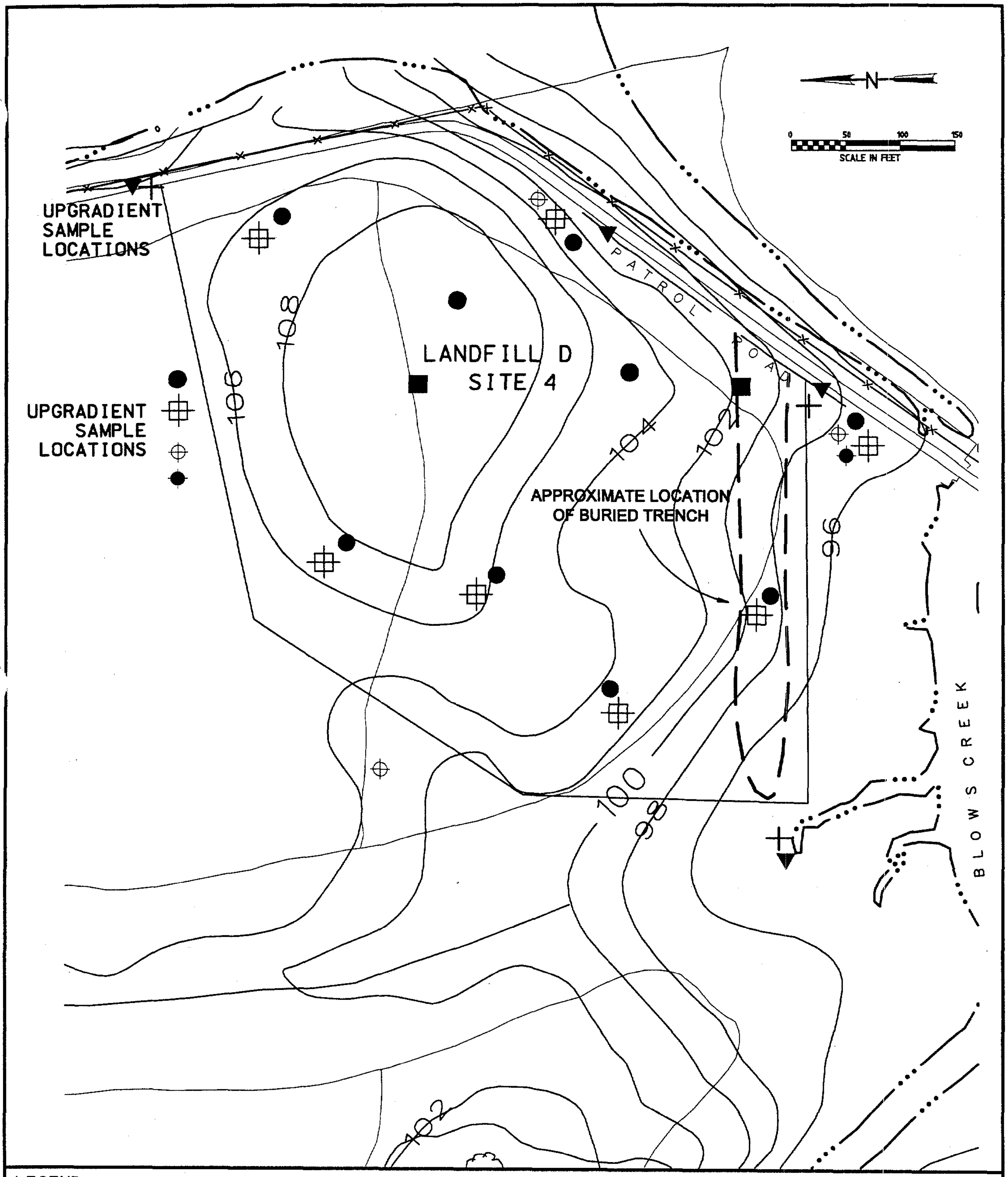

LEGEND

- ▼ Sediment sample location
- ● Surface soil sample location
- ✛ Surface water sample location
- ■ Composite soil sample location (0-3')
- ⊞ Subsurface soil sample location
- ⊕ Shallow monitoring well location
- ● Deep monitoring well location

Figure 5
SAMPLING LOCATIONS
SITE 4 – LANDFILL D
St. Juliens Creek Annex

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Task 4: Sample Analysis and Data Validation

All analyses of soil and groundwater will be conducted at a laboratory that fulfills all requirements of the U.S. Navy's quality assurance/quality control (QA/QC) program and US EPA's Contract Lab Program (CLP). Field quality control samples (field blanks, equipment blanks and duplicate samples will be collected and analyzed to ensure that the analytical results are representative of site conditions. All RI/FS and PA/SI data will be validated by an independent subcontractor. Finally, the data set as a whole will be examined for consistency, anomalous results, and reasonableness.

Task 5: Risk Assessment

A Baseline Risk Assessment (BLRA) and a Baseline Ecological Risk Assessment (BERA) will be performed for the RI of Site 3 and Site 4 using the analytical data collected during the RI. The risk assessments will evaluate the potential effects of existing site contamination on both current and potential future exposed populations and biota in the area. Future risks will be based on current site conditions, assuming no additional remedial action is conducted at the site. The future use of the site is expected to remain industrial. Although groundwater beneath and surrounding the site is not currently used as a potable water supply, and groundwater in the aquifer beneath the site is classified as non-potable, a future industrial groundwater-use scenario will be evaluated for information and decision-making.

Task 6: RI Report

The results of the investigations and risk assessments will be compiled in a RI report for Site 3 and Site 4. The RI report will include the history and background of the site, a description of the site's features and environmental setting, a summary of the RI activities that took place, the sampling and analytical methods used during the investigation, a presentation and evaluation of the analytical data, a discussion of the nature and extent of contamination, and the results of the risk assessments.

Task 7: Feasibility Study

A Feasibility Study (FS) will be conducted for Site 3 and Site 4. The FS will involve a screening and an evaluation of alternatives for remediating site contamination. CDM Federal will develop and screen a range of distinct alternatives for waste management that, if implemented, would potentially remediate or control contaminated media (e.g., soil, groundwater) as deemed necessary in the RI to provide adequate protection of human health and the environment. A detailed analysis will be performed on soil and groundwater remedial alternatives that pass the screening process. The results of the detailed analysis of alternatives will be the formulation and documentation of recommendations for one or more feasible actions that might be implemented to address Site 3 and Site 4 contamination.

Task 8: Feasibility Study Report

A report will be prepared that documents the results of the FS for Site 3 and Site 4. All steps taken during the screening and evaluation of remedial alternatives will be described. Several remedial alternatives and their estimated costs will be provided to cover a wide range of technologies and costs.

Task 9: PRAP and ROD Reporting

A Proposed Remedial Action Plan (PRAP) will be prepared as part of this task to summarize the RI/FS and the preferred remedial alternative and to solicit public comments during the public comment and review period. A public notice will be prepared to announce the completion of the PRAP, the date of the public meeting, and the opening and closing dates of the public comment period. A Record of Decision (ROD) will be prepared to document the decision for the selected remedial alternative and responses to all public comments on the PRAP.

Attachment A - Project Schedule

CH2M HILL NAVY C.L.E.A.N. CONTRACT
CTO-0027
RI/FS of Landfill C and Landfill D at St. Julien's Creek Annex, Chesapeake, Virginia

ID	Task Name	Duration	Start
1	Notice to Proceed	0d	9/20/96
2	**Project Planning (PP)**	**617d**	**9/20/96**
3	Project Mnaagement (PP.PM)	617d	9/20/96
4	Meetings (PP.MG)	617d	9/20/96
5	**Workplan Preparation (PP.WP)**	**207d**	**10/10/96**
6	Prepare Draft Workplan	40d	10/10/96
7	Submit Draft Workplan	0d	11/18/96
8	Navy Review	48d	11/19/96
9	Prepare Draft Final Workplan and Executive Summary	17d	1/11/97
10	Submit Draft Final Workplan	0d	1/27/97
11	Navy and Regulatory Review	48d	1/29/97
12	Prepare Final Workplan	29d	4/11/97
13	Submit Final Workplan	0d	5/9/97
14	**RI Field Investigation (FI)**	**168d**	**5/12/97**
15	Fieldwork Support/Subcontractor Procurement (FI.FK)	29d	5/12/97
16	Surface Geophysical Surveying	5d	6/23/97
17	Monitoring Well Installation (FI.FI)	19d	6/30/97
18	Groundwater Sampling - First Round (FI.FQ)	3d	7/22/97
19	Groundwater Sampling - Second Round (FI.FQ)	4d	10/23/97
20	Soil Sampling (FI.FS)	8d	7/6/97
21	Sediment/Surface Water Sampling (FI.FW)	2d	7/14/97
22	RI-Derived Waste Disposal (FI.FF)	1d	7/25/97
23	Surveying (FI.FM)	3d	7/22/97
24	**Sample Analysis and Validation (SA)**	**70d**	**7/30/97**
25	Sample Management (SA.SM)	70d	7/30/97
26	Data Validation (SA.DV)	60d	7/30/97
27	**Data Evaluation (DE)**	**30d**	**9/28/97**
28	Data Evaluation (DE.DE)	30d	9/28/97
29	**RA Reports (AR)**	**135d**	**9/28/97**
30	**Prepare HHRA and ERA Reports (AR.HH) & (AR.ER)**	**135d**	**9/28/97**
31	Prepare Draft HHRA and ERA Reports	60d	9/28/97
32	Submit Draft HHRA and ERA Reports	0d	11/26/97
33	Navy Review	15d	11/27/97
34	Prepare Draft Final HHRA and ERA Reports and Executive Summ:	15d	12/12/97
35	Submit Draft Final HHRA and ERA Reports and Executive Summa	0d	12/26/97
36	Navy and Regulatory Review	30d	12/27/97
37	Prepare Final HHRA and ERA Reports and Executive Summary	15d	1/26/98
38	Submit Final HHRA and ERA Reports	0d	2/9/98
39	**RI Report (RI)**	**135d**	**9/28/97**
40	Prepare Draft RI Reports (RI.DR)	60d	9/28/97
41	Submit Draft RI Reports	0d	11/26/97
42	Navy Review	15d	11/27/97
43	Prepare Draft Final RI Reports and Executive Summary (RI.DF)	15d	12/12/97
44	Submit Draft Final RI Reports and Executive Summary	0d	12/26/97
45	Navy and Regulatory Review	30d	12/27/97
46	Prepare Final RI Reports and Executive Summary (RI.FR)	15d	1/26/98
47	Submit Final RI Reports	0d	2/9/98
48	**Remedial Alternatives Screening (AS)**	**34d**	**12/19/97**
49	AlternativesDevelopment and Screening (AS.AD)	14d	12/19/97

Date: 5/8/97 | Task | Milestone | Summary

ID	Task Name	Duration	Start
50	Technology Screening (AS.AT)	14d	12/29/97
51	General Response Actions (AS.GR)	14d	1/8/98
52	**Alternatives Evaluation (AE)**	**28d**	**1/18/98**
53	Alternative Evaluations (AE.AE)	14d	1/18/98
54	Cost Estimate (AE.EC)	14d	2/1/98
55	**FS Report (FS)**	**147d**	**12/19/97**
56	Prepare Draft FS Reports (FS.DR)	60d	12/19/97
57	Submit Draft FS Reports	0d	2/16/98
58	Navy Review	15d	2/17/98
59	Prepare Draft Final FS Reports (FS.DF)	27d	3/4/98
60	Submit Draft Final FS Reports	0d	3/30/98
61	Navy and Regulatory Review	30d	3/31/98
62	Prepare Final FS Report (FS.FR)	15d	4/30/98
63	Submit Final FS Report	0d	5/14/98
64	**Post RI/FS Support (PS)**	**180d**	**5/15/98**
65	**Prepare PRAPs and RODs (PS.PS)**	**180d**	**5/15/98**
66	Prepare Draft PRAPs	15d	5/15/98
67	Submit Draft PRAPs	0d	5/29/98
68	Navy Review of PRAPs	10d	5/30/98
69	Prepare Draft Final PRAPs	15d	6/9/98
70	Submit Draft Final PRAPs	0d	6/23/98
71	Navy and Regulatory Review of PRAPs	20d	6/24/98
72	Prepare Final PRAPs	10d	7/14/98
73	Public Notice (PS.PN)	45d	7/24/98
74	Prepare Draft RODs	15d	9/7/98
75	Navy Review of RODs	15d	9/22/98
76	Prepare Draft Final ROD	15d	10/7/98
77	Navy and Regulatory Review of RODs	20d	10/22/98
78	Submit Final PRAPs and RODs	0d	11/10/98

Timeline: mber 15 22 29 | October 6 13 20 27 | November 3 10 17 24 | December 1 8 15 22 29 | January 5 12 19 26 | February 2 9 16 23 | March 2 9 16 23 30 | April 6 13 20 27 | May 4 11 18 25 | June 1 8 15 22 29 | July 6 13 20 27 | August 3 10 17 24 31 | September 7 14 21

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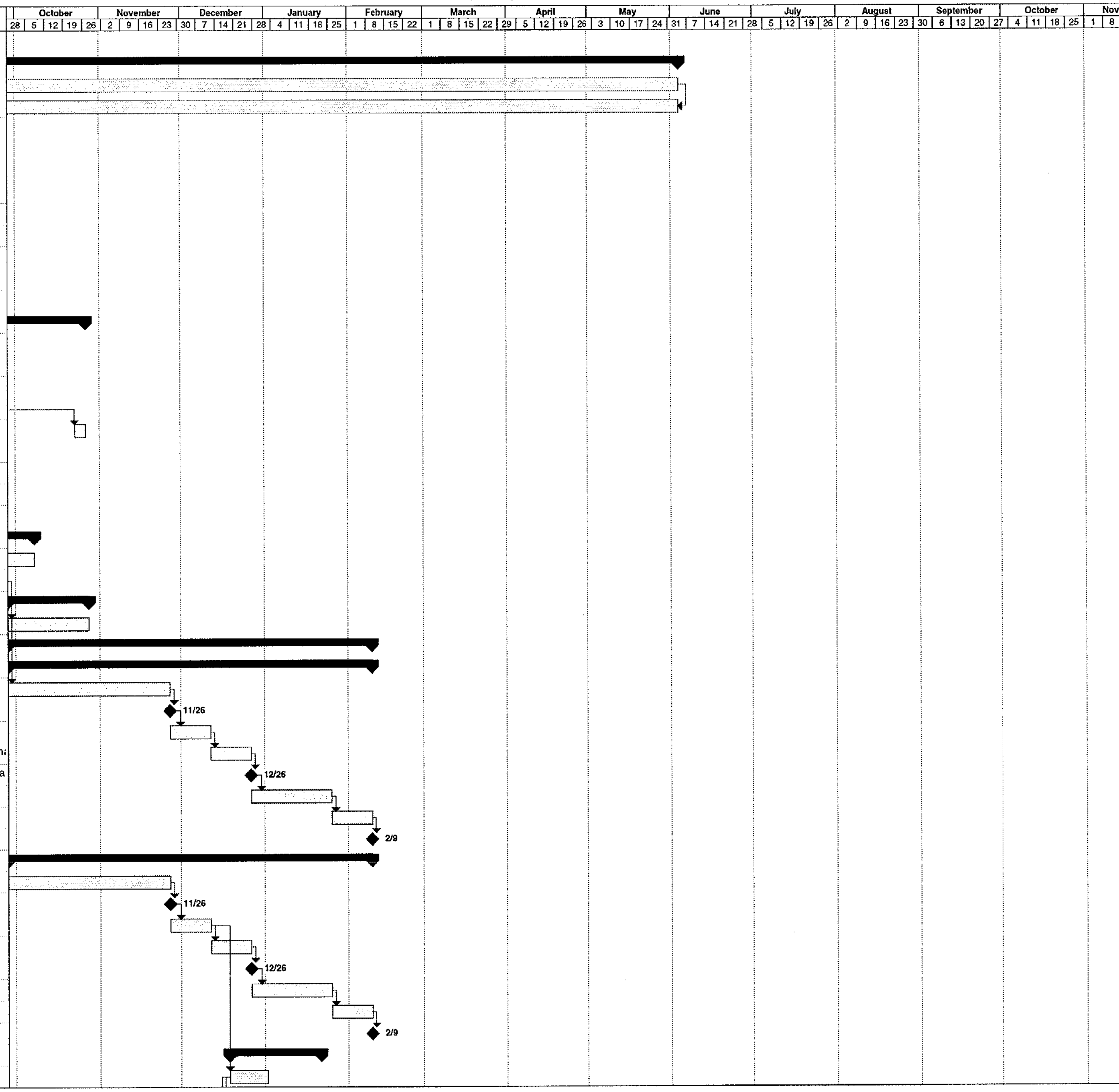
46	Prepare Final RI Reports and Executive Summary (RI.FR)
47	Submit Final RI Reports
48	**Remedial Alternatives Screening (AS)**
49	AlternativesDevelopment and Screening (AS.AD)



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51	General Response Actions (AS.GR)
52	**Alternatives Evaluation (AE)**
53	Alternative Evaluations (AE.AE)
54	Cost Estimate (AE.EC)
55	**FS Report (FS)**
56	Prepare Draft FS Reports (FS.DR)
57	Submit Draft FS Reports
58	Navy Review
59	Prepare Draft Final FS Reports (FS.DF)
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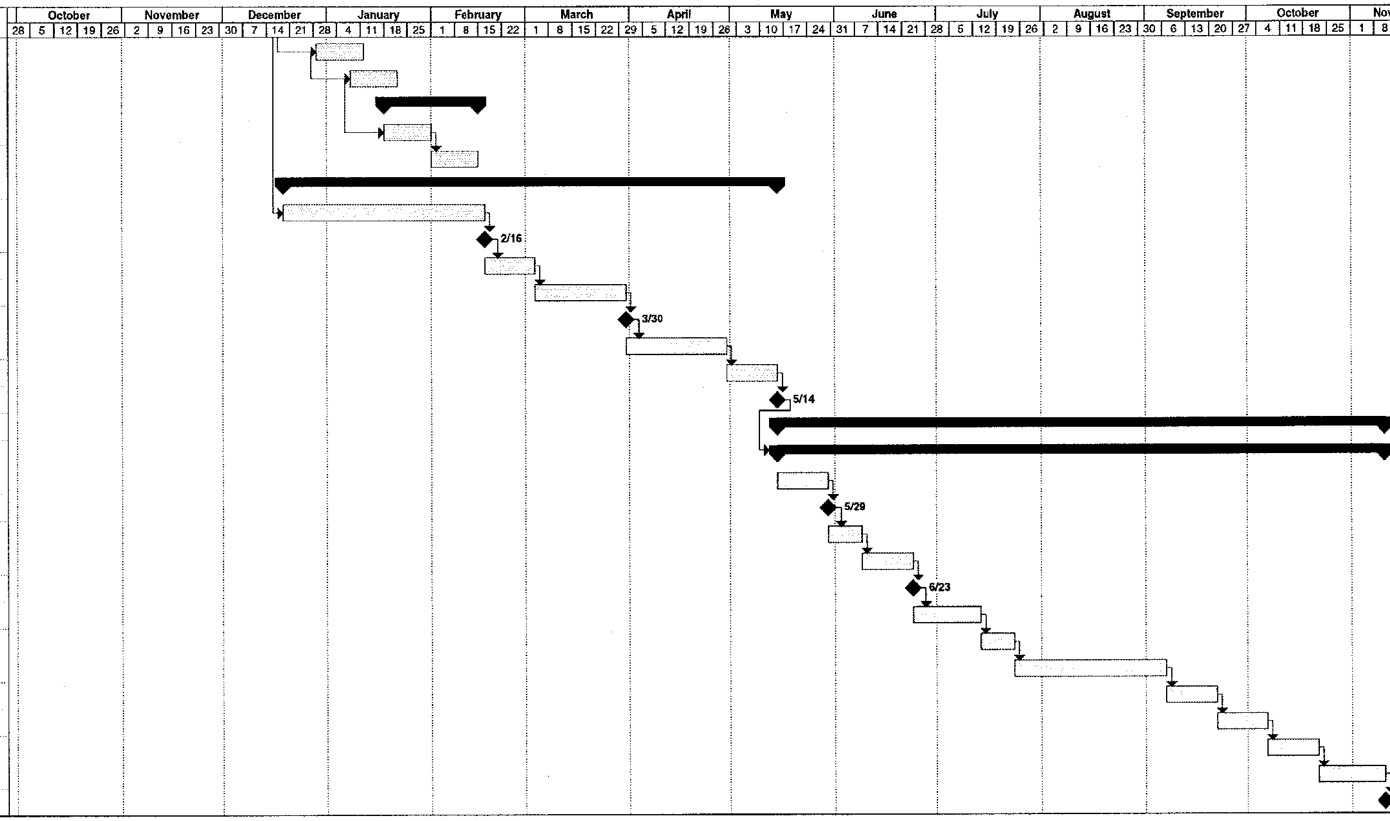
69	Prepare Draft Final PRAPs
70	Submit Draft Final PRAPs
71	Navy and Regulatory Review of PRAPs
72	Prepare Final PRAPs
73	Public Notice (PS.PN)
74	Prepare Draft RODs
75	Navy Review of RODs
76	Prepare Draft Final ROD
77	Navy and Regulatory Review of RODs
78	Submit Final PRAPs and RODs



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SIGNATURE PAGE

FINAL WORK PLAN

Landfill C (Site 3) and Landfill D (Site 4)
Remedial Investigation and Feasibility Study
St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order Number - 0027
Contract Number N62470-95-D-6007
Navy CLEAN II Program

Prepared by

CDM Federal Programs Corporation

May 9, 1997

Submitted by

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COMMENTS ON Draft RI/FS Work Plan for St. Juliens Creek Annex
Chesapeake, Virginia
March 1997

Commonwealth of Virginia

GENERAL COMMENTS

1. The RI/FS Work Plan does not address wetland delineation. Will wetland boundaries be surveyed? DEQ recommends that wetland boundaries be delineated to help in the ecological characterization of the sites.

Response: The approximate boundaries of all habitats present onsite, including wetlands, will be mapped based on review of aerial photographs and the site ecological reconnaissance. Delineation of the boundaries of the jurisdictional wetlands present onsite will not be performed at this time. If future site activities, such as site remediation, appear to be necessary in areas within or adjacent to the identified wetlands, delineation following the procedures established in the 1987 Corps manual will be performed in preparation for the necessary mitigation planning.

2. Sampling locations designated as "background" locations should be designated as upgradient or downgradient.

Response: All reference to "background" sample locations have been changed to "upgradient".

3. DEQ recommends that surface water samples be analyzed for hardness, alkalinity, BOD, COD, total suspended solids, and total dissolved solids. Sediment samples should be analyzed for pH, Eh, temperature, and conductivity.

Response: The work plan has been revised to indicate that all surface water samples will be analyzed for hardness, alkalinity, BOD, COD, total suspended solids, and total dissolved solids. The Work Plan has also been revised to include the analysis of Eh, temperature, and conductivity in sediment samples. The analysis of pH in sediment samples has already been proposed.

4. DEQ's review of the historic aerial photography of St. Juliens depicts many of the site boundaries to be larger than they appear on the report figures. It is recommended that you review the aerial photography and expand/change the boundaries of the appropriate sites and adjust the sampling plan accordingly. (See EPA Aerial Photographic Site Analysis Norfolk Naval Shipyard: Annex Areas Norfolk, Va. 1995.)

Response: Site boundaries at Landfill B (Site 2), Landfill C (Site 3), and Landfill D (Site 4) have been revised based on the review of historical aerial photographs and discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ). It was determined that site boundaries of The Burning Grounds (Site 5) were appropriate. However, the "Caged Pit" area and possible "Drop Tower" east of The Burning Grounds have been included in sampling activities at The Burning Grounds.

5. DEQ recommends adding dioxin and phosphorus to the sampling analysis list. This is recommended due to the fact that St. Juliens handled, burned and disposed large amounts of pyrotechnics.

Response: Phosphorus has been added to the analysis of all environmental samples collected at Landfill B (Site 2), Landfill C (Site 3), Landfill D (Site 4), and The Burning Grounds (Site 5). Dioxin analysis will be performed on five soil samples collected at The Burning Grounds. These samples will be collected in areas which exhibit staining in historical aerial photographs. In addition, two dioxin samples will be reserved in the event subsurface soil samples from any of the landfill sites indicate the presence of "ash" which may have originated from burning activities at The Burning Grounds.

6. **Page 4-17 -** Sample Analysis and Data Validation - This section states that appropriate field duplicate samples will be taken at a frequency of 1 per 10 field samples and the location of the duplicate sample will be randomly selected. DEQ recommends that duplicate samples be taken in "hot" spots or areas suspected of containing contamination. Additionally, the Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples should be taken in areas of low or unsuspected contamination. The rationale for this is that duplicate samples are a QA/QC check. If a "hot" spot or area of high contamination is detected, the duplicate sample will confirm/deny the results. Subsequently, the MS/MSD sample is already spiked with a known aliquot, and is used solely to calibrate the laboratory equipment and set detection limits.

Response: Comment noted. Duplicate sample collection will attempt to identify areas of suspected contamination. The collection of MS/MSD samples will not intentionally target known or suspected contamination.

SITE SPECIFIC COMMENTS

1. **Page 1 - Landfill B:** - Historic photography depicts Landfill B as being larger than the report figures. (See General Comment 4.) This area also shows that the area was labeled "HI-X," which is indicative of storage/waste disposal activity. Sampling activity in this area should be adjusted to account for this information.

Response: Landfill B site boundaries have been adjusted as discussed in Response to Comment #4. The significance of the "HI-X" markings which appear in some of the historical photographs has not been determined and may have been warnings to airplanes rather than being associated with actual storage sites at St. Juliens Creek. At this time, no specific sampling is proposed in these areas.

2. **Page 1 - Burning Grounds:** A review of the aerial photography for St. Juliens reveals evidence that there are more than one burning ground/EOD range. (See 1937 photography.) Experience also says that a facility with such a diverse history as St. Juliens would have more than one burning ground/EOD range. DEQ believes that these burning grounds should also be included in the investigation.

Response: Based on discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), no additional sites will be added to the investigation at this time.

3. **Page 4-18 and 4-19 - Risk Assessment** - This section states that the future use of the site is expected to remain industrial. Please explain how this determination was reached? DEQ recommends that a residential as well as an industrial scenario be utilized in the risk assessment. This information will also be useful in the Feasibility Study.

Response: Comment noted. Both residential and industrial risk scenarios will be included during the risk assessment.

4. DEQ recommends that the Baseline Ecological Risk Assessment (BERA) set criteria for the selection of ecological receptors, and include the habitat preferences of investigated species. Additionally, please explain if the ecological receptors will be assessed in a qualitative or quantitative manner.

Response: The first phase of the Baseline Ecological Risk Assessment (BERA) will consist of a screening assessment. Maximum exposure point concentrations for each media of concern and each habitat of concern will be compared with the appropriate August 9, 1995 Revised Region III BTAG Screening Levels. Criteria for the selection of ecological receptors will be established in the BERA. Subsequent phases of the BERA will detail the selection process and will include a description of the selected receptors, including their habitat preferences.

USN St. Julien Creek Annex, Va.
Sites 3 and 4
Review of the Navy's Draft RI/FS Work Plan

United States Environmental Protection Agency
Region III
Office of Superfund

GENERAL COMMENTS

1. The RI/FS Work Plan was assembled with nine major subsections as listed above. However, there is no overall Table of Contents provided and no discussion of document organization. As a result, the document's overall organization is confusing, although within each section, the organization is clear and well organized. The Navy should provide an overall Table of Contents for this document and a brief summary of the sections including the type of information presented in each section.

Response: Comment noted. A Preface has been inserted at the beginning of the document which explains the Work Plan organization and provides a brief summary of it's contents.

Draft Final Work Plan

1. The text of the Baseline Ecological Risk Assessment (BERA) is identical between the RI/FS Work Plan for Sites 3 and 4 and the RI/FS Work Plan for Sites 2 and 5. While some general description of a BERA is acceptable, the work scope should also outline specific activities consistent with a site's size, ecology, accessibility and contaminant history.

Response: The first phase proposed for the BERA is a Screening Level Assessment. The scope of work presented is believed to be consistent with this phase of assessment. Specific activities consistent with the site s size, ecology, accessibility, contaminant history, current levels of contamination, and identified receptors and exposure pathways will be detailed in preparation for future phases of the BERA as these factors will be established during the course of the remedial investigation.

2. The RI/FS Work Plan does not provide clean objectives for the BERA. Bulleted activities are provided but are not linked to site specific or base wide objectives. Also, the level of ecological assessment is not specified (e.g. screening level or semi-quantitative).

Response: The Work Plan has been revised to provide clear objectives for the BERA. As previously noted, the preliminary phase of the BERA will consist of a screening level assessment.

3. The sections of the RI/FS Work Plan relative to the BERA lack many important components and do not adhere to EPA guidance. It is recommended that the RI/FS Work Plan provide specifics on how the following will be accomplished and presented in the BERA Report:
   - problem formulation and conceptual model,
   - source characterization and exposure pathways,
   - exposure assessment,
   - ecological effects characterization, and
   - risk characterization.

Response: The Work Plan has been revised to address the key components of a BERA as established in EPA guidance.

4. The RI/FS Work Plan does not provide details on wetland delineation. Will wetland boundaries be surveyed? Will a global positioning system be utilized to map the wetlands for presentation in the RI report? It is recommended that wetlands be delineated with the boundaries mapped to aid in the ecological characterization of all sites.

Response: The approximate boundaries of all habitats present onsite, including wetlands, will be mapped based on review of aerial photographs and the site ecological reconnaissance. Delineation of the boundaries of the jurisdictional wetlands present onsite will not be performed at this time. If future site activities, such as site remediation, appear to be necessary in areas within or adjacent to the identified wetlands, delineation following the procedures established in the 1987 Corps manual will be performed in preparation for the necessary mitigation planning and the boundaries will be more accurately mapped.

5. Sampling locations designated as "background" sampling locations are really upgradient or downgradient sampling locations, and do not represent true "background" sampling locations. "Background" sampling is the attempt to establish naturally-occurring inorganic concentrations that are minimally influenced by human activity. Additionally, the establishment of naturally-occurring background concentrations is accomplished statistically and, for soil, is accomplished per soil classification. The draft Work Plan does not attempt to do this. Attached, please find a section of the Radford Army Ammunition Plant Work Plan describing an acceptable methodology for establishing facility-wide naturally-occurring background concentrations.

Response: All reference to "background" sample locations have been changed to "upgradient".

Draft Final Field Sampling Plan

1. The number of surface water and sediment samples currently proposed are adequate only for a screening level ecological risk assessment where only the maximum detected concentrations are compared to ecological benchmarks. Without additional sampling, it will be difficult to characterize the extent of contamination and develop reasonable ecological exposure pathways. Since the RI/FS Work Plan does not specify the level of ecological risk assessment to be performed, it is recommended that the sampling regime be re-evaluated once the ecological problem formulation is enhanced.

Response: Text has been revised to indicate that a screening level ecological risk assessment will be performed during this phase of field activities.

2. A tiered approach for additional sediment sampling should be presented in the RI/FS Work Plan and should include Simultaneously Extracted Metals and Acid Volatile Sulfide (SEM/AVS) analysis to assist with the bioavailability assessment of inorganic contaminants, specifically divalent metals if these are found to be Contaminants of Concern.

Response: During discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), the SEM/AVS analysis of sediment samples is not required at this time.

3. The following field data should be collected for sediments: temperature, Eh, pH, conductivity, and Munsell color. In the current Draft Final Field Sampling Plan, only pH is proposed.

Response: The analysis of temperature, Eh, conductivity, and Munsell color have been added to the required analysis of all sediment samples.

4. All surface water samples should be analyzed for alkalinity, hardness, BOD, COD, total suspended solids, and total dissolved solids. The Draft Final Field Sampling Plan only proposes that surface water samples be analyzed for hardness. Also, the hardness method proposed, EPA Method 130.1, does not also provide an alkalinity result.

Response: The work plan has been revised to indicate that all surface water samples will be analyzed for hardness, alkalinity, BOD, COD, total suspended solids, and total dissolved solids.

5. The sample designation scheme does not appear to consider multiple rounds at the same sampling location. It is recommended that the sample number explanation be expanded to include the maintenance of unique sample designations in the event of multiple rounds of the same media at the same sampling location.

Response: The sample designation scheme has been revised to accommodate multiple rounds of sampling at the same location.

SPECIFIC COMMENTS

Draft Final Work Plan

1. Page 3-1, Background, Landfill C

Review of historic aerial photography of the SJCA may depict Landfill C as encompassing an area larger than depicted in Figure 2-1. 1949 aerial photography depicts a large disturbed area in the general location of "Landfill C," extending somewhat southward of the current boundaries of Landfill C. Based upon review of aerial photography, waste disposal activity is evident at Landfill C until approximately 1970-1974. It is suggested that the area of investigation for Landfill C be expanded south-southwest to include trenching and waste disposal activity occurring on both sides of Patrol Road in 1958, 1964, and 1974 aerial photography.

Response: Based on the review of historical aerial photographs and discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), the Landfill C western boundary was moved to the east, equal with the drainage swale and the break in slope visible in the field. It was agreed that these surface features should accurately represent the Landfill C western boundary and that the other site boundaries were accurately represented.

2. Page 3-1, Background, Landfill D

Historic aerial photography depicts significant activity occurring at the Landfill D area before the reported opening date of the landfill in 1970. In fact, significant ground disturbance and waste disposal activities occur on both the northern and southern areas of the Landfill D vicinity in both 1961 and 1964 aerial photography. Based upon a review of historic aerial photography, it is suggested that the boundaries of the investigation of Landfill D be expanded to the west-southwest to include the ground disturbance seen in 1964 and 1974 aerial photography.

Response: Comment noted. Landfill D site boundaries have been expanded to include the ground disturbance to the west-southwest seen in the 1964 and 1974 aerial photographs.

3. Figure 4-1

-The boundaries of the Landfill C should be expanded to the south-southwest to include trenching and waste disposal activity occurring on both sides of Patrol Road in 1958, 1964, and 1974 aerial photography.

-The referenced "background" samples should be re-designated as "upgradient" sampling locations. Also, the depicted "background" sampling locations may not be appropriate background sampling locations as they are located in close approximation to railroad tracks, and may actually be located in fill supporting the rail line.

Response: Based on the review of historical aerial photographs and discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), the Landfill C western boundary was moved to the east, equal with the drainage swale and the break in slope visible in the field. It was agreed that these surface features should accurately represent the Landfill C western boundary and that the other site boundaries were accurately represented.

All reference to "background" sample locations have been changed to "upgradient". The upgradient sample locations at Landfill C are south of the railroad tracks and should not be located in fill supporting the rail line.

4. Figure 4-2

The "background" sampling locations depicted on Figure 4-2 should be designated as "upgradient sampling locations. Also, as depicted, the background sampling locations lie within the boundaries of the Landfill D, and should be re-located based upon a review of aerial photography.

Response: All reference to "background" sample locations have been changed to "upgradient". Upgradient sample locations have been moved outside the site boundaries.

5. Figure 4-3

The boundaries of Landfill C should be expanded to the south-southwest to include trenching and waste disposal activity occurring on both sides of Patrol Road in 1958, 1964, and 1974 aerial photography.

Response: Based on the review of historical aerial photographs and discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), the Landfill C western boundary was moved to the east, equal with the drainage swale and the break in slope visible in the field. It was agreed that these surface features should accurately represent the Landfill C western boundary and that the other site boundaries were accurately represented.

6. Figure 4-4

The boundaries of the investigation of Landfill D should be expanded to the west-southwest to include the ground disturbance seen in 1964 and 1974 aerial photography.

Response: Comment noted. Landfill D site boundaries have been revised to include the ground disturbance to the west-southwest seen in the 1964 and 1974 aerial photographs.

7. Page 4-4, Monitoring Well Installation, Landfill C

An additional shallow monitoring well is recommended to be installed east of the "caged pit" location, between contoured elevations 106 and 104.

Response: Based on discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), no additional monitoring wells at Landfill C have been proposed at this time.

8. Page 4-4, Geophysical Survey Techniques, Landfill C

The geophysical survey of the Landfill C should attempt to locate the following:

- trenching and waste disposal activity occurring on both sides of Patrol Road in 1958, 1964, and 1974 aerial photography
- waste disposal activity south of Patrol Road depicted in 1970 aerial photography
- large pit depicted in 1961 aerial photography. The pit is situated north of Patrol Road
- ground disturbance occurring in the vicinity of the drop tower.

Additionally, supposed ordnance testing(?) occurred at Building 354(?), including the drop testing of ordnance. Did ordnance testing occur at the Landfill C vicinity, i.e., at the tower? If so, should ordnance clearance be conducted at Landfill C before intrusive operations begin?

Response: As discussed with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), the surface geophysical survey for Landfill C will focus on areas within and immediately outside the site boundaries as proposed in the Draft Final Work Plan. After further review, ordnance clearing may be added to areas around Landfill C.

9. Page 4-4, Geophysical Survey Techniques, Landfill D

The geophysical survey of the Landfill D should attempt to locate the following:

- waste disposal activity occurring on the north end of Landfill D depicted in 1961, 1964, 1970, 1981, 1982, 1986, and 1990 aerial photography
- waste disposal activity occurring on the south end of Landfill D depicted in 1961, 1964, 1970, 1976 and 1982 aerial photography
- disposal trench evident in 1970 and 1976 aerial photography.

Response: As discussed with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), the surface geophysical survey for Landfill D will focus on areas within and immediately outside the revised site boundaries as proposed in the Draft Final Work Plan. In addition to EM-31 surface geophysical equipment, EM-61 and GPR will also be used at Landfill D. Based on EM-31 and EM-61 surveys, GPR will focus on areas which may indicate the presence of buried drums at Landfill D.

10. Page 4-7, Groundwater Sampling, Groundwater Sample Numbers and Location

This section indicates that samples for both total and dissolved metals will be collected and analyzed. A brief discussion of the filtering procedure to be followed should be included in the Groundwater Sampling Techniques section. A more thorough discussion of the field filtering techniques should be included in the Sampling and Analysis Plan.

Response: Comment noted. Text revised.

11. Page 4-8, Table 4-1

Table notes indicate that trip blanks for volatile analysis will be collected at a frequency of 1 per cooler of volatile samples. It is recommended that separate trip blanks be used to monitor contamination of groundwater samples since groundwater samples will be analyzed for low concentration volatiles. Routine volatile analysis of trip blanks will not be adequate to monitor contamination of low concentration volatile samples.

Response: Comment noted. Text and tables have been revised to indicate that trip blanks used for groundwater sample shipping will be analyzed using the low concentration volatile method specified for all groundwater samples.

12. Page 4-18, Task 5: Risk Assessment

Steps outlined for the Baseline Human Health Risk Assessment seem thorough and include testing of the data distribution. The Navy has indicted that previous data will be validated and combined with new data to be collected in this study. The Navy should evaluate the size of the data set to be certain that enough samples are collected to complete the data set and to provide an adequate evaluation.

Response: Comment noted.

13. Page 4-20, Table 4-3

This section states that the future use of the site is expected to remain industrial. The Navy should elaborate on the reasons why future residential development is not expected at SJC. However, EPA recommends that both scenarios be utilized in the risk assessment process. This allows for appropriate evaluation as to whether site restrictions are necessary, i.e. whether or not long-term monitoring is required at any particular site. Additionally, the calculation of both residential and industrial scenarios is important in the development of the Feasibility Study.

Response: Comment noted. Both residential and industrial risk scenarios will be included during the risk assessment.

14. Page 4-21, Paragraph 1

The Navy is reminded that the discussion of uncertainty is to be site specific and should include a qualitative analysis of any COPC's that could not be evaluated quantitatively.

Response: A site specific discussion of uncertainty will be included in the assessment as will a qualitative analysis of any COPCs that can not be evaluated quantitatively. The Work Plan has been revised accordingly.

15. Page 4-19

Comments Related to Ecological Assessment Problem Formulation
It is recommended that the RI/FS Work Plan specify the assessment and measurement endpoints that will focus the ecological characterization.

Response: Assessment and measurement endpoints consistent with a Screening Level BERA have been added to the Work Plan.

16. The RI/FS Work Plan should either specify receptors for exposure studies or set criteria for the selection of ecological receptors.

Response: The Work Plan has been revised to include the criteria that will be utilized for the selection of ecological receptors.

17. The second and third bullets should include the collection and presentation of information on feeding habits and habitat preferences of inventoried species.

Response: The Work Plan has been revised to indicate a description of the selected receptors, including their feeding habits and habitat preferences will be provided in the appropriate phase of the BERA.

Page 4-19 Comments Related to Ecological Effects Assessment

18. The RI/FS Work Plan does not specify whether risk to ecological receptors will be assessed in a qualitative or quantitative manner. It is recommended that the eighth bullet item be expanded to specify the level of risk assessment (screening level, semi-quantitative level or quantitative level). If a tiered or phased approach is planned, then the decision points leading to the next level need to be specified in the RI/FS Work Plan.

Response: The Work Plan has been revised to indicate that a phased approach to the BERA will be implemented. The first phase will consist of a screening level assessment. The decision leading to the next level of the assessment will be based on a weight-of-evidence analysis of the data collected during the initial phase of the assessment.

19. Please clarify the fifth and sixth bullet items by clearly specifying how contaminants of potential ecological concern (COPCs) will be selected. Will the COPC selection process entail a comparison to EPA Region III BTAG screening levels, with contaminants detected at concentrations exceeding a screening level being selected as a COPC? The fifth bullet item appears to conflict with the sixth bullet item. Generally environmental effects quotients (EEQs) are calculated as part of a Tier 1 screening level ecological assessment. The sixth bullet appears to indicate that EEQs will be utilized in the COPC selection process. It is recommended that COPCs be selected by comparison with EPA Region III screening levels and that EEQs are calculated on COPCs in the first phase of the BERA. The RI/FS Work Plan should specify the denominator per medium that will be used in the EEQ calculation.

Response: The Work Plan has been revised to indicate that a screening level assessment will be completed. In this assessment, exposure point concentrations will be compared with the EPA Region III BTAG Screening Levels. Contaminants exceeding the screening levels will be considered as contaminants of potential ecological concern. The environmental effects quotients (EEQs) will be calculated for the COPCs, with the appropriate BTAG screening value being utilized as the denominator.

20. It is recommended that the work scope specify that the ecological toxicity profiles for contaminants of potential concern will be provided in the BERA. The toxicity profiles should include a recent literature review.

Response: Toxicity profiles will be prepared for compounds identified as COPCs during the screening level assessment, as well as for compounds for which screening levels have not been developed. Profiles will also be provided for select compounds present at concentrations below screening levels but are known to bioconcentrate.

21. The RI/FS Work Plan should specify if there is potential that site specific toxicity tests may be performed. It is recommended that the performance of toxicity tests be outlined in a tiered approach.

Response: As indicated in the revised Work Plan, toxicity tests may be performed in the latter phase of the assessment if warranted.

22. The methods for ecological field investigations should be specified. For example, will the 1987 Corps Method be used for wetland delineation?

Response: The methods for the ecological field investigations have been specified in the revised Work Plan.

Page 4-19 Comments Related to Ecological Risk Characterization

23. It is recommended that the RI/FS Work Plan specify that a weight of evidence approach will be taken when comparing estimated exposure point concentrations with toxicity data, toxicity reference values, and ecological observations.

Response: The revised Work Plan now indicates that a weight of evidence approach will be taken when evaluating the exposure point concentrations.

24. The RI/FS Work Plan should specify that an uncertainty section specific to the ecological assessment will be included in the ecological risk assessment report.

Response: The revised Work Plan now specifies that the ecological risk assessment will include an uncertainties section.

Draft Final Sampling and Analysis Plan

25. Table 8-1, Analytical Procedures

This table indicates SW846 Method 8330 will be used of for Total Petroleum Hydrocarbon analysis. However, this method was indicated for Nitramine (explosives) analysis in the RI/FS Work Plan for Sites 2 and 5. The Navy should verify the method to be used for TPH analysis on these sites.

Response: The correct method should have been SW846 Method 8015M however, based on recent discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), the analysis for TPH has been deleted from the Work Plan.

26. Table 2-3

This Table outlining Holding Times and Preservation Requirements is correct, but should be expanded to indicate that samples for dissolved metals must be filtered prior to preservation.

Response: Comment noted. Table 2-3 has been revised.

Draft Final Field Sampling Plan

27. Section 1.0

Though Blows Creek and the Southern branch of the Elizabeth River are adjacent to Site 4/Landfill D, no surface water or sediment sampling of Blows Creek or the Elizabeth River are proposed. It is recommended that a tiered sampling approach be specified in the RI/FS Work Plan. Such a tiered approach would outline the decision-making process. For example, if contaminants are detected in the currently proposed surface water samples at concentrations that exceed ambient water quality criteria, then surface water samples will be collected from Blows Creek.

Response: One surface water/sediment sample location is located downgradient of Site 4 and immediately upgradient of the confluence with Blows Creek. In addition, downgradient monitoring wells and surface/subsurface soil samples are also planned for Site 4. During discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), numbers of surface water/sediment sample locations were determined to be appropriate for this phase of field activities.

28. Page 1-8

The Field Sampling Plan specifies that sediment samples will be analyzed for Total Organic Carbon (TOC). However, no method reference is provided. EPA recommends that all sediment samples be analyzed for TOC with results reported as percent organic matter, and for grain size distribution by the ASTM method for hydrometer or emery tube. In addition, the laboratory reports from the TAL/TCL analyses of the sediment samples should specify percent moisture or percent solids.

Response: Comment noted. TOC analysis will be performed by EPA MCAWW Methods 415.1 / 415.2. This Method will report percent moisture as part of the analysis. Grain size distribution of sediment samples are not planned at this time.

29. Table 1-1

It is reported that burning operations were conducted at Landfill C. It is appropriate to include dioxin as an analytical parameter at sites where solvents could have been burned.

Response: During discussions with Mr. Rob Thompson (EPA) and Mr. Devlin Harris (VDEQ), the sampling and analysis of dioxins at Landfill C has not been required during this phase of field activities.

Final

Work Plan and Sampling and Analysis Plan for the Remedial Investigation and Feasibility Study Landfill C (Site 3) and Landfill D (Site 4)

St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order 0027

May 9, 1997

Prepared for

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Preface

This Work Plan (WP) and Sampling and Analysis Plan (SAP) is written for the Remedial Investigation and Feasibility Study (RI/FS) to be performed at the Landfill C (Site 3) and Landfill D (Site 4) at the St. Juliens Creek Annex, Chesapeake, Virginia. Specifically, this document focuses on the work necessary to conduct RI/FS and sampling activities associated with monitoring well installation, and sampling of soil, groundwater, surface water, and sediment. The Work Plan is a broad plan consisting of the SAP, the Quality Assurance Plan (QAPP), the Health and Safety Plan (HASP), and the Investigation Derived Waste Management Plan (IDWMP).

The Work Plan Contains the Following:

Introduction. Briefly describes the facility and the objectives of the RI/FS, provides a context for the information to follow, and offers a basis for evaluating the plan.

Site Background and Physical Setting. Provides a brief history of site uses, disposal practices, and presents an overview of the results of previous investigations. The regional topographic features and site locations are also discussed.

Initial Evaluation. Provides an evaluation of the data collected during previous investigations at the sites.

Work Plan Rationale. Provides a discussion of the rationale used to select the locations to be investigated during the RI activities.

Technical Approach. Provides a concise discussion of the RI/FS task to be performed at each site.

Staff Organization. Identifies all personnel needed to conduct the field activities including support personnel and their specific responsibilities, and details the plan for coordinating with LANTDIV, other agencies, and private interests.

Contractual Services. Identifies any contractual services needed to accomplish the field work, and includes points of contact at St. Julien's Creek Annex and Naval Base, Norfolk.

Schedule. Provides schedule of activities and due dates of deliverables.

The Sampling and Analysis Plan Contains the Following:

The Quality Assurance Project Plan —The QAPP describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve Data Quality Objectives (DQOs) as dictated by the intended use of the data.

The Field Sampling Plan —The FSP provides guidance for all fieldwork by defining in detail the sampling and data-gathering methods to be used during field activities.

The Health and Safety Plan —The HASP describes the health and safety program for field activities. The HASP identifies potentially hazardous operations and exposures and prescribes appropriate protective measures.

The Investigation-Derived Waste Management Plan —The IDWMP provides guidance and assigns responsibility for the disposal of investigation-derived waste (IDW). The IDWMP describes both well-site disposal and containerization and temporary storage of certain IDW.

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Section 1

Introduction

This work plan describes the work necessary to conduct a remedial investigation and feasibility study (RI/FS) of Landfill C and Landfill D at the St. Juliens Creek Annex, Chesapeake, Virginia. This work plan is based on a scope of work provided by Naval Facilities Engineering Command (NFEC) U.S. Naval Facilities Engineering Command, Atlantic Division (LANTDIV) on August 12, 1996 as part of Navy Contract N62470-95-D-6007 Comprehensive Long-Term Environmental Action Navy (C.L.E.A.N.), District III, Contract Task Order - 027. The technical approach is documented in CH2M HILL's implementation plan (IP), which was approved by LANTDIV on September 20, 1996.

The general background and physical setting of the St. Juliens Creek Annex facility is described in Section 2 of this work plan. Section 3 presents an initial evaluation of Landfill C and Landfill D that is based on the results of previous investigations and an initial site visit and on the rationale that supports the sampling tasks. Section 4 describes the technical approach to RI/FS work plan tasks, and Section 5 presents general information on project management and staff organization. Section 6 documents the anticipated subcontract services required for completing tasks documented in this work plan. Section 7 presents the schedule for the completion of the tasks. A list of project-related acronyms is presented in Table 1-1.

Table 1-1
St. Juliens Creek Annex
List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirement
AOC	Area Of Concern
BERA	Baseline Ecological Risk Assessment
BLRA	Baseline Risk Assessment
BOA	Basic Ordering Agreements
COMNAVBASE	Base Commander
COPC	Contaminants of Primary Concern
CERCLA	Comprehensive Environmental Response, Compensation, And Liability Act
C.L.E.A.N.	Comprehensive Long-Term Environmental Action Navy
CS	Confirmation Study
CLP	Contract Laboratory Program
DOD	Department of Defense
FSP	Field Sampling Plan
HEAST	Health Effects Assessment Summary Tables
HSP	Health and Safety Plan
IAS	Initial Assessment Study
IDW	Investigation Derived Waste
IDWMP	Investigation Derived Waste Management Plan
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
LANTDIV	U.S. Naval Facilities Engineering Command, Atlantic Division
LQAP	Laboratory Quality Assurance Plan
MCL	Maximum Contaminant Level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NACIP	Naval Assessment and Control of Installation Pollutants
NAD	Naval Ammunition Depot
NFEC	Naval Facilities Engineering Command

Table 1-1
St. Juliens Creek Annex
List of Acronyms

NPL	National Priorities List
NTR	Naval Technical Reserve
NUS	NUS Corporation
PA	Preliminary Assessment
PCB	Polychlorinated Biphenyl
PRAP	Proposed Remedial Action Plan
PRG	Preliminary Remediation Goals
PWC	Public Works Center
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAB	Restoration Advisory Board
RCRA	Resource Conservation And Recovery Act
RD	Remedial Design
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Manager
RRR	Relative Risk Ranking
SAP	Sampling and Analysis Plan
SI	Site Investigation
SOP	Standard Operating Procedures
SOW	Statement of Work
SQL	Sample Quantitation Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCE	Trichloroethene

Table 1-1
St. Juliens Creek Annex
List of Acronyms

TCL	Target Compound List
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VDEQ	Virginia Department of Environmental Quality
VSI	Visual Site Inspections
VOC	Volatile Organic Compound

Section 2

Site Background and Physical Setting

Available site background information is documented in this section. Information was obtained primarily from the St. Juliens Creek Annex Facility, Resource Conservation and Recovery Act (RCRA) facility assessment (RFA) report prepared by A.T. Kearney, Inc., 1989, and the Relative Risk Ranking (RRR) System Data Collection Report prepared by CH2M Hill Federal Group, Ltd., 1996.

Location and Surrounding Land Use

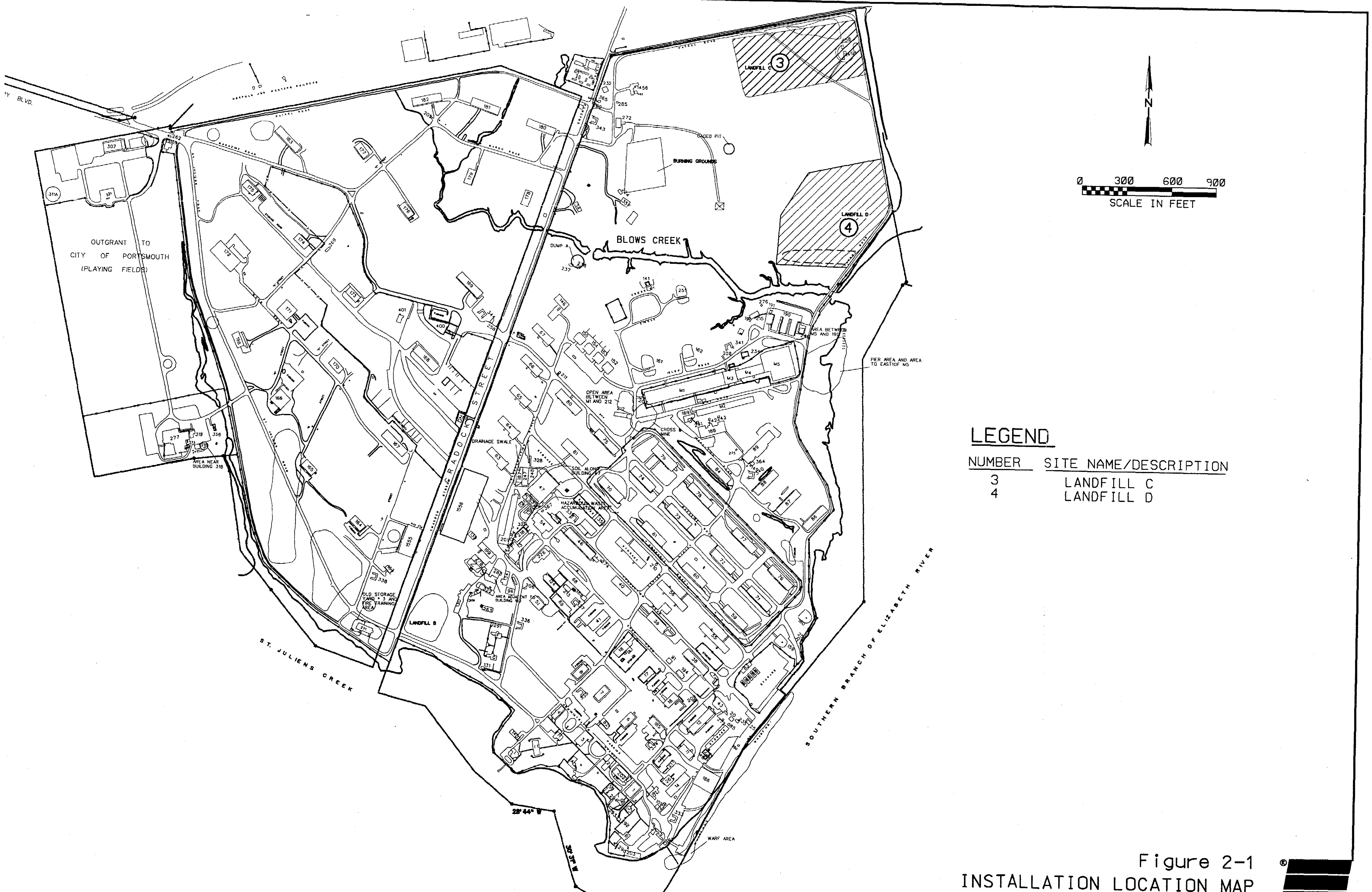
The St. Juliens Creek Annex Facility is situated at the confluence of St. Juliens Creek and the Elizabeth River in the city of Chesapeake, located in southeastern Virginia (Figure 2-1). The facility covers approximately 490 acres and includes 221 buildings, 653 feet of wharf, a central heating plant, numerous non-operational industrial facilities, and miscellaneous structures including a housing area. A Virginia Power Company power line runs diagonally across the facility in a northwest-southeast trending direction, splitting the area roughly in half. Structures northwest of the power line are predominantly used for storage and warehousing, and those southeast of the power line are light industrial and manufacturing, administrative, and housing facilities; the search radar test range for the Norfolk Naval Shipyard is also located in this area.

The facility is bordered to the north by the Norfolk and Western Railroad, the City of Portsmouth, and residential areas, to the west by residential areas, to the south by St. Juliens Creek, and to the east by the south branch of the Elizabeth River. According to the U. S. Geological Survey (USGS) Norfolk South Quadrangle topographic map, in 1982 a large industrial waste pond was located adjacent to the property boundary in the northeast portion of the Annex. Most of the surrounding areas are developed, and include residences, schools, recreational areas, and shipping facilities for several large industries. The Norfolk Naval Shipyard is located approximately three miles north. Some undeveloped areas are located in various areas surrounding the facility.

A large concentration of military installations is located within a 25-mile radius of the facility, including: Naval Base, Norfolk, Fort Monroe, Langley Air Force Base, and Norfolk Naval Shipyard on the north, Naval Amphibious Base and Fort Story on the east, Naval Air Station Oceana on the southeast, and Naval Supply Center-Craney Island Fuel Terminal on the southwest.

Facility History and Mission

The St. Juliens Creek Annex was originally an ammunitions facility. Activity at the Annex has decreased in conjunction with present national peacetime conditions. The current primary mission of the St. Juliens Creek Annex facility is to provide a radar testing range



LEGEND

NUMBER	SITE NAME/DESCRIPTION
3	LANDFILL C
4	LANDFILL D

Figure 2-1
INSTALLATION LOCATION MAP
St. Juliens Creek Annex

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and various administrative and warehousing facilities for the nearby Norfolk Naval Shipyard and other local Navy activities.

The St. Juliens Creek Annex began operations as a naval facility in 1849. At that time, the area, known as Fort Norfolk, was transferred from the War Department to the Navy Department for use as a storage facility for ordnance and materials. The facility was renamed Magazine, Fort Norfolk. In 1896, the facility gained an additional 48 acres to accommodate additional magazines, wharves, housing, and administration buildings. In 1898, ordnance material and equipment were moved from Craney Island to the Magazine; the facility was renamed U.S. Arsenal, St. Juliens Creek.

In 1902, the name was changed to U.S. Naval Magazine, St. Juliens Creek. The Magazine was at that time fully operational and provided critical support to the fleet during the end of the Spanish-American War.

In 1915, manually operated machines were replaced by modernized motor-powered machines. In 1917, the facility installed equipment for loading MARK VI mines. The facility's name was changed again, to Naval Ammunition Depot (NAD), St. Juliens Creek, and operated under the Commandant Fifth Naval District.

Between World War I and World War II, the facility assumed a peacetime mission of supplying ammunition to the fleet.

The facility operated at its peak level from 1942 to 1944, during World War II. An additional 119 acres of land were purchased, and additional magazines, filling houses, and other facilities were constructed. A fence was erected to secure the facility. The mission of NAD St. Juliens Creek during World War II included loading, assembling, issuing, and receiving naval gun ammunition. The depot also served as the principal experimental and test loading facility for new ammunition types for the Bureau of Ordnance.

The depot also supplied ammunition during the Korean War. After the war, the depot again resumed its mission of peacetime service to the fleet. In 1964, the depot was the prime source of gun ammunition for Navy and Marine Corps operations in southeast Asia.

In October 1969, after 50 years as an independent facility, NAD St. Juliens Creek was disestablished under the Department of Defense "Project 703", and was consolidated as an annex to the Naval Weapons Station, Yorktown, Virginia. On October 1, 1977, the Annex was transferred to the Norfolk Naval Shipyard.

The Norfolk Naval Shipyard transferred the Annex to Naval Base, Norfolk in July 1995. The Class II property on the Annex was transferred from Naval Base to Naval Station in April 1996.

Currently, the St. Juliens Creek Annex provides administrative offices, light industrial shops and storage facilities for tenant naval commands, and a radar testing range for the nearby Norfolk Naval Shipyard and other local Navy activities.

Processes and Operations

Processes and operations at the St. Juliens Creek Annex facility have included general ordnance operations involving wartime transfer of ammunitions to various other U.S.

Naval facilities throughout the United States and abroad. In addition, the Annex has been involved in specific ordnance operations and processes including those involving black powder operations, smokeless powder operations, projectile loading operations, mine loading, tracer mixing, testing operations, and decontamination operations.

The St. Juliens Creek Annex facility has also been involved in non-ordnance operations, including degreasing operations, paint shops, machine shops, vehicle and locomotive maintenance shops, pest control shops, battery shops, print shops, electrical shops, boiler plant operations, washrack operations, potable and salt water fire protection systems, and fire training operations. Many of these operations have been discontinued, such as locomotive maintenance, printing, and pest control.

Materials stored at the St. Juliens Creek Annex facility have included oil, ordnance materials, non-ordnance chemicals, and disaster preparedness chemicals. Various parts of the facility are used to store small amounts of waste before transfer to accumulation points.

Climate and Meteorology

The Chesapeake region is situated in a humid Mesothermal Forest climate that is characterized by long, hot summers and mild winters. Summer temperatures average in the high 80s during the day and high 60s during the night. Precipitation averages 48 inches annually and is distributed evenly over the year; relative humidity averages 72%. Thunderstorms occur approximately 40 days per year, primarily during the summer months. The average annual snowfall is 8.8 inches. Winds are generally northeasterly and moderate, averaging 10 miles per hour.

Topography, Surface Drainage, and Soil

The St. Juliens Creek Annex facility is a low-lying wedge of land between the Southern Branch of the Elizabeth River and St. Juliens Creek. Elevations range from sea level along the banks of the two bordering waterways, and along Blows Creek located in the northern part of the facility, to 15 feet above mean sea level (msl) northeast of Blows Creek. A northwest-southeast trending ridge generally bisects the area, dividing the St. Juliens Creek drainage basin to the southwest and the Blows Creek drainage basin to the northeast.

Blows Creek and St. Juliens Creek receive the majority of surface water runoff from the Annex. Both creeks flow east to empty into the Southern Branch of the Elizabeth River. The remaining runoff from the Annex flows directly into the Southern Branch of the Elizabeth River, or is diverted into storm drains that empty either into the Elizabeth River or St. Juliens Creek. The Southern Branch of the Elizabeth River flows through a highly industrialized area which includes oil storage and cresol facilities, and fertilizer plants. The river, which is part of the intracoastal waterway, is used by many recreational boaters during the summer and by larger commercial and naval craft throughout the year. The Southern Branch of the Elizabeth River flows north to discharge into the James River, which flows into the Chesapeake Bay. The entire downstream portion of surface water is tidally influenced.

The Commonwealth of Virginia has designated the watercourses in the area as IIB. This classification represents water that is contaminated. Historical releases of kepone and sediment disposal from the manufacturing activities of a private company located several miles away were a major contributor to present day contamination. Class IIB waters may be used for bathing and fishing, but taking shellfish is prohibited. A water classification of IIB indicates that the fecal coliform bacteria count should not exceed the geometric mean of 200 colonies per 100 milliliters; tidal water should have a dissolved oxygen content of at least 4.0 milligrams per liter (mg/l); and have a pH range of 6.0 to 8.5. In the past years, the Commonwealth of Virginia has noted that the concentrations of oil and grease, heavy metals, and coliform bacteria in these waters have increased.

The St. Juliens Creek Annex facility was initially placed within the boundaries of the 100-year flood plain. However, a 1984 Environmental Assessment Addendum indicated that according to the 1983 National Flood Insurance Program flood maps, the 100-year flood level for the originally proposed St. Juliens Creek Annex facility is 8.5 feet above msl. Elevations for the majority of the Annex property is above 8.5 feet msl and therefore does not lie within the 100-year flood plain. Areas within the 100-year flood plain include those adjacent to St. Juliens Creek, Blows Creek, and the southern border of the Elizabeth River.

Geology and Hydrogeology

The St. Juliens Creek Annex facility is located in the outer Atlantic Coastal Plain Physiographic Province. A sediment wedge dips and thickens to the east and extends approximately 20 miles east to the Atlantic Ocean. These sediments overlie basement rocks, which are made up of downfaulted Triassic strata and Paleozoic igneous and metamorphic rocks, similar to those in the Piedmont Province. The contact between the basement rocks and the sediments, also known as the fall line, is exposed approximately 80 miles to the west of the facility.

The Annex is underlain by over 2,000 feet of gently dipping Recent to Lower Cretaceous sandy sediments. Geologic units underlying the area, from youngest to oldest are: the Columbia Group (Sand Bridge and Norfolk Formations), the Chesapeake Group (Yorktown and Calvert Formations), the Pamunkey Group (Nanjemoy Formation), the Mattaponi Formation, transitional beds, and the Patuxent Formation. Table 2-1 shows a stratigraphic column and hydrogeologic units of southeast Virginia.

The uppermost geologic unit is the Columbia Group. The Columbia Group is approximately 60 feet thick in southeastern Virginia. The upper 20 to 40 feet make up the unconfined Columbia aquifer, and consist of unconsolidated fine sands and silts with low to moderate permeability. The lower 20 to 40 feet consist of relatively impermeable silt, clay, and sandy clay. The Sand Bridge Formation is made up of tidal channel clayey sand facies and a shoal lagoonal silty sand facies. The tidal channel facies is made up of clayey sand, silt, and clay to well sorted fine to medium sand. This facies has low to high plasticity, low to moderate permeability, good erosion resistance, fair slope stability and fair to good aquifer recharge. The shoal lagoonal facies is made up of a clean, homogeneous, fine to medium sand with silt concentrations of 10% to 35%, and a thickness of 12 to 14 feet. This facies has a low to moderate plasticity; moderate permeability, erosion resistance, and slope stability; and fair aquifer recharge. The Norfolk Formation, which underlies the Sandbridge Formation, is made up of an upper member which consists of brackish marine silty sand and fluvial-estuarine silty sand, and a lower member which consists of clean quartz sand and fine gravel.

Table 2-1
Stratigraphic and Hydrogeologic Units of Southeast Virginia

Geologic Age		Stratigraphic	Stratigraphic	Hydrogeologic
Period	Epoch	Unit/Group	Formation	Unit
Quaternary	Holocene	Alluvium and marsh sediments		Columbia Aquifer
	Pleistocene	Columbia Gr.	Sand Bridge Fm.	
Tertiary			Norfolk Fm.	
	Pliocene	Chesapeake Gr.	Yorktown Fm.	Yorktown-Eastover Aquifer
	Miocene		Eastover Fm.	
			St. Mary's Fm.	St. Mary's Confining Unit
			Choptank Fm.	St. Mary's-Choptank Aquifer
			Calvert Fm.	Calvert Confining Unit
	Oligocene		Old Church Fm.	Chickahominy-Piney Point Aquifer
	Eocene	Chickahominy		
		Piney Point Fm.		
		Pamunkey Gr.	Nanjemoy Fm.	Nanjemoy-Marlboro Clay Confining Unit
			Marlboro Clay	
	Paleocene		Aquia Fm.	Aquia Aquifer
Cretaceous		Brightseat Fm.		Brightseat-Upper Potomac Confining Unit
		Mattaponi		
	Upper Cretaceous	Potomac Gr.	Patapsco Fm.	
				Brightseat-Upper Potomac Aquifer
	Lower Cretaceous		Patuxent Fm.	Middle Potomac Confining Unit Middle Potomac Aquifer
				Lower Potomac Confining Unit Lower Potomac Aquifer
Pre-Cretaceous		Basement Rocks		Bedrock Aquifer

Surficial geology of the Annex includes the Sand Bridge Formation, alluvial sand, and marsh sediments. The clayey sand facies of the Sand Bridge Formation occurs on the eastern portion of the Annex facility, and the silty sand facies occurs on the western portion of the facility. The alluvial sand and marsh sediments occur along both Blows Creek and St. Juliens Creek. Boring logs from 1946 to 1978 indicated mostly sandy soils; silty and clayey soils were observed in the remainder of the logs. The Norfolk and Yorktown Formations underlie the surficial deposits on the Annex.

The two significant shallow aquifer systems in the area are the Columbia aquifer located in the upper 20 to 40 feet of the Columbia Group, and in the underlying Yorktown Aquifer. The Columbia aquifer, which comprises the water table aquifer, is reportedly thin and consists of discontinuous heterogeneous sand and shell lenses. The depth to the water table at the Annex is usually 5 feet or less. The Yorktown Aquifer is separated from the water table aquifer by a clay layer in the upper Yorktown. Water bearing zones in the Yorktown Aquifer consist of fine to coarse sands and gravels.

Environmental History

Information on previous and ongoing basewide hazardous waste investigations is documented below. The Installation Restoration Program (IRP) is described first. Then summary information from previous basewide hazardous waste investigations is documented. Finally, ongoing basewide hazardous waste investigations are summarized.

Installation Restoration Program

The St. Juliens Creek Annex Facility is not listed on the United States Environmental Protection Agency (USEPA) National Priorities List (NPL). Therefore, the Navy is acting as the lead agency in environmental investigations at the Base. The environmental condition of the Base is being investigated through the United States Department of Defense (DOD) IRP. The IRP at the St. Juliens Creek Annex facility has been conducted in accordance with applicable federal and state environmental regulations and requirements. In addition, the Navy has solicited involvement and comments from federal and state regulatory agencies (USEPA Region III and the Virginia Department of Environmental Quality [VDEQ]) throughout the IRP process by submitting documents for their review.

In 1975, DOD began a program for assessing past hazardous-material and toxic-material storage and disposal activities at military installations. The goals of the program, now known as the IRP, were to identify environmental contamination resulting from past hazardous-material management practices, assess the effects of the contamination on public health and the environment, and develop corrective measures as required to mitigate adverse effects on public health and the environment.

In 1976, RCRA was passed by Congress to address potentially adverse human health and environmental effects of management and disposal practices for hazardous waste. RCRA was legislated to manage the present and future disposal of hazardous wastes. In 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or "Superfund," was passed to investigate and remediate areas resulting from past hazardous-waste management practices. The program is administered by USEPA or state agencies.

In 1981, DOD's IRP was reissued, with additional responsibilities and authorities specified in CERCLA being delegated to the Secretary of Defense for DOD facilities. The Navy subsequently restructured the IRP to match the terminology and structure of the USEPA CERCLA Program. The current IRP is consistent with CERCLA and applicable state environmental laws.

Previous Basewide Investigations

Past inspections of the St. Juliens Creek Annex Facility have resulted in the identification of various inadequate waste management practices, including improper management of containers, storage of hazardous waste in areas not listed for interim status, and storage of hazardous waste in drums that were corroded, bulging, or leaking.

Previous basewide investigations completed through the IRP include the initial assessment study (IAS), dated August 1981 and a Relative Risk Ranking (RRR) System Data Collection Report, dated April 1996. In addition, USEPA Region III conducted two assessments at the Annex: a Preliminary Assessment (PA), dated 1983, and a Phase II RCRA Facility Assessment (RFA), dated March 1989.

In 1981, the U.S. Navy conducted the IAS as part of the Naval Assessment and Control of Installation Pollutants (NACIP) Program. The purpose of the IAS was to identify and assess sites that posed a potential threat to human health or the environment because of contamination from past handling of and operations involving hazardous materials. Results of this study revealed that low level concentrations of ordnance materials were determined to exist throughout the facility. However, the sites identified were determined not to pose a threat to human health and the environment, and no confirmation study was conducted. No sampling was conducted as part of the study.

In 1983, NUS Corporation, Superfund Division (NUS), conducted PA at seven sites at the facility. These sites included: Cross and Mine (Solid Waste Management Unit [SWMU] #9); Building 249 (SWMU #13); Dump A (SWMU #1); Dump B (SWMU #2); Dump B Incinerator (SWMU #3); Dump C (SWMU #5); and Dump D (SWMU #6). Each site was monitored for volatile organic compounds (VOCs) and radiation with an organic vapor meter and radiation meter, respectively. No sampling was conducted as part of the PA. NUS did not observe significant signs of contamination at the sites observed. However, the PA report mentioned that various locations on the facility were contaminated with low level residues of pesticide and herbicide materials.

In 1989, A.T. Kearney, Inc. and K.W. Brown & Associates, Inc. prepared a Phase II RFA. The RFA included a preliminary review of all available relevant documents and a visual site inspection (VSI) of the Annex, including 34 SWMUs and Areas of Concern (AOCs). Eleven of the SWMUs and AOCs were recommended for RCRA Facility Investigations (RFIs). Sampling was not conducted as part of the RFA.

In April 1996, CH2M Hill Federal Group, Ltd. submitted to the Department of the Navy an RRR System Data Collection Report for the St. Juliens Creek Annex. The report contained results from sampling conducted at 21 sites at the Annex where no sampling data had previously been available. The goal of the sampling effort was to gather data for the Navy to perform assessments of the sites using the Navy's RRR System.

Current Basewide Investigations

NFEC LANTDIV has awarded the Navy C.L.E.A.N. II Contract to CH2M HILL. As of the date of preparing this work plan, only one other contract task order (CTO) for investigations at the St. Juliens Creek Annex has been issued under the contract; CTO - 028 is the RI/FS for Landfill B and the Burning Grounds. Table 2-2 summarizes the current status of IRP sites at St. Juliens Creek Annex.

TABLE 2-2
CURRENT STATUS SUMMARY OF IRP SITES
ST. JULIENS CREEK ANNEX SITE MANAGEMENT PLAN

Site	IAS*	RRR*	PA**	RFA**	TBA	Work Plans	RI	FS	PRAP	ROD	RD	RA	Comments
1. Landfill A	1981	1996	1983	1989									RFA recommended further action.
2. Landfill B	1981	1996	1983	1989		√	√	√	0	0			RFA recommended further action.
3. Landfill B Incinerator	1981		1983	1989									RFA recommended no further action.
4. Landfill B Blast Grit				1989									RFA recommended further action, as part of Dump B.
5. Landfill C	1981	1996	1983	1989		√	√	√	0	0			RFA recommended further action.
6. Landfill D	1981	1996	1983	1989		√	√	√	0	0			RFA recommended further action.
7. Landfill D Dumpster Storage				1989									RFA recommended no further action.
8. Burning Grounds	1981	1996		1989		√	√	√	0	0			RFA recommended further action.
9. Cross and Mine		1996	1983	1989									RFA recommended further action.
10. Building 154Y Haz. Waste Storage				1989									RFA recommended no further action.
11. Building 163 Haz. Waste Storage				1989									RFA recommended no further action.
12. Building 198 PCB Storage				1989									RFA recommended no further action.
13. Building 249 Repair and Maintenance Shop	1981	1996	1983	1989									RFA recommended no further action.
14. Building 13 Haz. Waste Disposal Area				1989									RFA recommended further action.
15. Building 53 Haz. Waste Disposal Area	1981	1996		1989									RFA recommended further action.
16. Building 323 Sand Blasting Area		1996		1989									RFA recommended no further action.
17. Old Storage Yard #1		1996		1989									RFA recommended further action.
18. Old Storage Yard #2				1989									RFA recommended no further action.
19. Old Storage Yard #3				1989									RFA recommended no further action.
20. Waste Generation Area #1		1996		1989									RFA recommended further action.
21. Haz. Waste Accumulation Area				1989									RFA recommended no further action.
22. Repair Shop Satellite Storage Area				1989									RFA recommended no further action.
23. Building 249 Oil Water Separator	1981			1989									RFA recommended further action.
24. Caged (Small Items) Pit at Burning Grounds	1981			1989									RFA recommended further action.
25. Building 249 Washrack	1981			1989									RFA recommended further action.
26. Railroad Car Scrap Metal Storage	1981	1996		1989									RFA recommended no further action.
27. Building 271 Fire Training Area		1996		1989									RFA recommended further action.
28. Clearing House Storage Area (DRMO)		1996		1989									RFA recommended further action.
29. Dumpsters (throughout facility)				1989									RFA recommended no further action.
30. Landfill C Waste Disposal Pits	1981			1989									RFA recommended further action.
31. Swale Beneath Building 13				1989									RFA recommended further action.
32. Overland Drainage Ditches				1989									RFA recommended further action.
33. Sewer Drainage System				1989									RFA recommended further action.
34. Operational Waste Accumulation Areas				1989									RFA recommended no further action.
35. Building 279 Satellite Storage		1996		1989									RFA recommended secondary containment.
36. Building 47 Air Compressor		1996		1989									RFA recommended secondary containment.
37. Building 47 Blasting Grit				1989									RFA recommended secondary containment.
38. Storm Water Outfalls				1989									RFA recommended further action.
39. Temporary Pump Storage				1989									RFA recommended secondary containment.
40. Underground Storage Tanks				1989									RFA recommended integrity testing and removal if necessary.
41. Former Process Buildings				1989									RFA recommended further action.
42. Buildings M-5 and 190 Residual Ordnance	1981	1996		1989									RFA recommended further action.
43. Wharf Area Residual Ordnance	1981	1996		1989									RFA recommended further action.
44. Former Ammunition Manufacturing Areas				1989									RFA recommended further action.
45. Landfill D Old Tanks				1989									RFA recommended further action.

LEGEND:
1993 - Year Activity Completed
X - Activity Completed (date unknown)
√ - Activity In Progress
0 - Activity Planned
* NAVY-led activity
** EPA-led activity

RI - Remedial Investiagion
FS - Feasibility Study
PRAP - Proposed Remedial Action Plan
ROD - Record of Decision or Decision Document
RD - Remedial Design
TBA - To Be Addressed

RA - Remedial Action
RCRA - Resource Conservation and Recovery Act
PA - Preliminary Assessment
IAS - Initial Assessment Study
RRR - Relative Risk Ranking System Report
RFA - RCRA Facility Assessment

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Section 3

Initial Evaluation and Work Plan Rationale

This section presents an initial evaluation of available background information and existing conditions for the Landfill C and Landfill D RI/FS. The rationale for selecting sampling locations was developed by reviewing information from previous investigations and the findings from the CH2M HILL and CDM Federal visual site inspection (VSI). Sampling techniques and analytical methods proposed for the RI/FS are discussed in Section 4.

Background Information for the Landfill C and Landfill D RI/FS

Landfill C

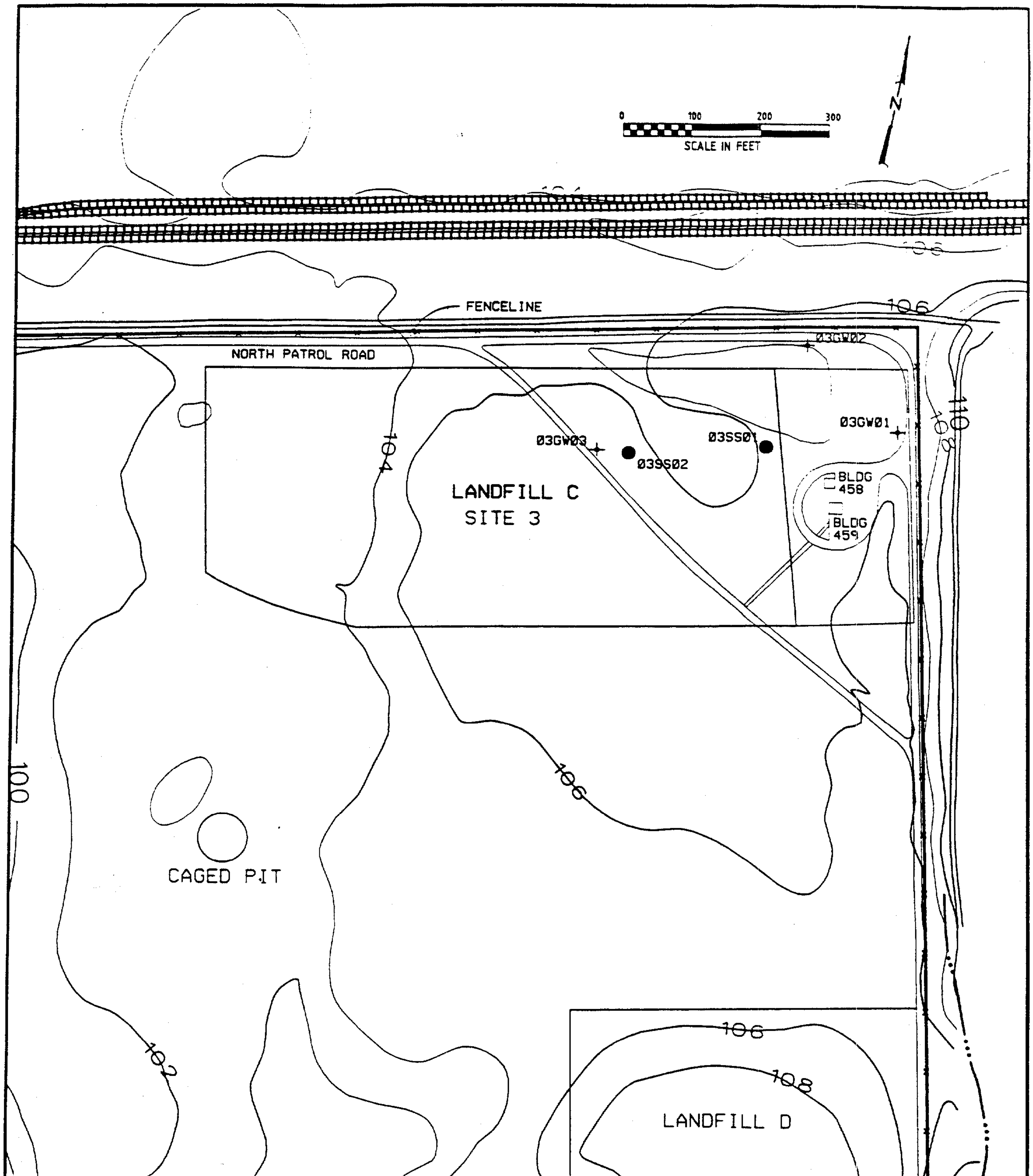
Landfill C (Site 3) covers 10 acres along the northern edge of the Annex and is accessible by way of a patrol road (Figure 3-1). The area was originally a mudflat where refuse was dumped and allowed to burn; the ash was then used to fill in the area. The landfill is unlined. Operation began in 1940 and continued until 1970. The landfill was graded level and covered with grass, but it has not been formally closed.

Refuse disposed of at Landfill C included solvents, acids, bases, and mixed municipal waste. The total volume of trichloroethene (TCE), waste oil, and oil sludge's was estimated to be 750,000 cubic feet prior to burning. Two pits reportedly used for disposal of oils and oily sludge's, as well as for periodic burning were also located at the Landfill C site. No other information is known about the sludge pits.

Landfill D

Landfill D (Site 4) covers an estimated 5 acres approximately 300 feet south of Site 3 (Figure 3-2). Site 4 was an unlined trench and fill landfill that reportedly operated from 1970 to 1981. The first trench was approximately 1,000 feet long and was located parallel to and 500 feet north of Blows Creek. Soil from subsequent trenches were used to cover previous trenches. The total number of trenches dug in the landfill is not known.

Refuse disposed of at Site 4 included drums of unknown wastes and polychlorinated biphenyls (PCBs). According to personnel at the public works department, the PCBs probably came from ballast containers for fluorescent light fixtures. The RFA indicated that several tanks with undetermined wastes were also once located in the area. Total volumes of disposal are unknown.

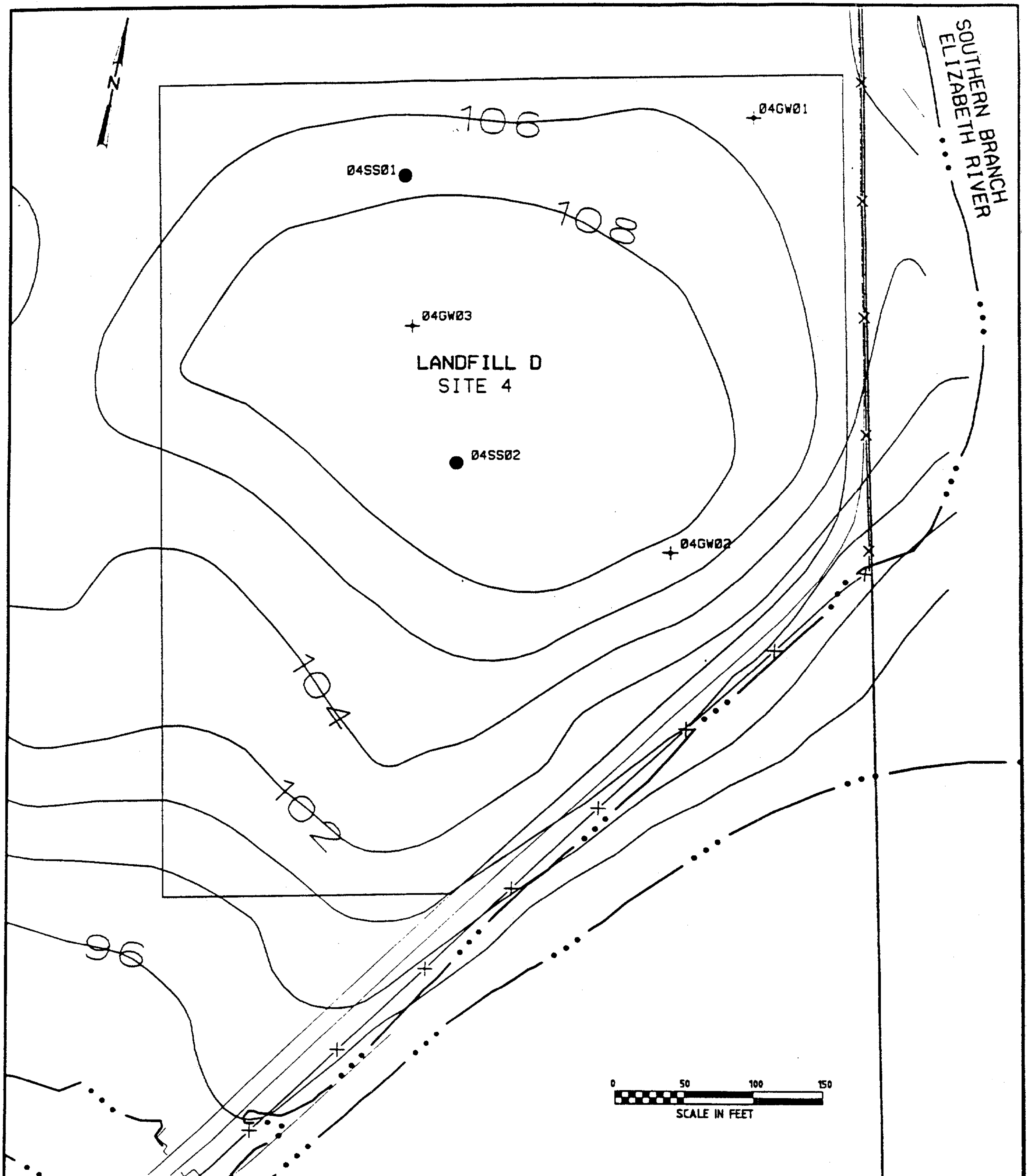


LEGEND

+ GROUNDWATER SAMPLING LOCATION

● SOIL SAMPLING LOCATION

Figure 3-1
PREVIOUS SURFACE SOIL AND GROUNDWATER
SAMPLING LOCATIONS
SITE 3 - LANDFILL C
St. Juliens Creek Annex



LEGEND

+ GROUNDWATER SAMPLING LOCATION

● SOIL SAMPLING LOCATION

Figure 3-2
PREVIOUS SURFACE SOIL AND GROUNDWATER
SAMPLING LOCATIONS
SITE 4 - LANDFILL D
St. Juliens Creek Annex

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Initial Assessment Study

Site 3 and Site 4 were included in the 1981 IAS. The purpose of the IAS was to identify and assess sites that posed a potential threat to human health or the environment because of contamination from past handling of and operations involving hazardous materials. Results of this study revealed that low level concentrations of ordnance materials were determined to exist throughout the Annex. However, it was determined that since the concentrations were low, they did not pose a threat to human health or the environment, and that no confirmation study needed to be conducted. No sampling was conducted as part of the study.

Preliminary Assessment

Site 3 and Site 4 were included in the 1983 PA conducted by NUS. Ambient air in the areas of the two landfills was monitored for VOCs and radiation with no findings reported. Sampling was not conducted as part of the PA activities.

RCRA Facility Assessment

Site 3 and Site 4 were also part of the 1989 RFA conducted by A.T. Kearney, Inc. and K.W. Brown & Associates, Inc. No sampling was conducted as part of the RFA. Although no visible evidence confirming a release of hazardous waste was noted at either site, both Site 3 and Site 4 were recommended for further investigation and sampling. Reasons given for these recommendations include: high potential for release to soils and groundwater due to the fact that both landfills are unlined and the depth to groundwater at the Annex is less than 5 feet; moderate to high potential for release to surface water via groundwater discharge and via Blows Creek; during the periods of operation at Site 3, a high potential for releases to the air from open burning of wastes, however, the potential for ongoing releases to the air is low since the landfill is no longer active; and a moderate to high potential for release of subsurface gas based on the volatile nature of wastes disposed of in the unlined landfills.

Relative Risk Ranking System Data Collection Report

Site 3 and Site 4 were two of the 21 sites sampled as part of the Relative Risk Ranking System Data Collection sampling effort. Two surface soil and three groundwater samples were collected at each of the two landfills and analyzed for Target Compound List (TCL) volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides/polychlorinated biphenyls (PCBs), Target Analyte List inorganics, total phosphorous, and nitramines. Groundwater samples were collected using Geoprobe® sampling equipment. Samples were collected to characterize the sites and determine the types of contaminants associated with each site; no background or quality control (QC) samples were collected.

Landfill C Results

Two surface soil and three groundwater samples were collected from Landfill C (Site 3) (Figure 3-1). The organic compounds, 4,4-DDE (17 parts per billion [ppb]), 4,4-DDT (7.9 ppb), fluoranthene (660 ppb), and pyrene (520 ppb) were detected in surface soil samples collected in the northeastern corner of Site 3. Aroclor-1254 (44 ppb and several inorganic compounds were detected in the surface soil sample collected in the central/northeastern corner of Site 3. Also, 1,3,5-trinitrobenzene was detected at 1.1 ppb in the groundwater sample from the center of the landfill above detection limits; 2,6-dinitrotoluene (2.4 ppb) and 4-nitrotoluene were detected in the sample located north/northeast of the landfill; and 1,3,5-trinitrobenzene (0.7 ppb) was detected in the sample located east/northeast of the landfill above detection limits. Several inorganic compounds also were detected in the groundwater samples.

Landfill D Results

Two surface soil and three groundwater samples were collected from Landfill D (Site 4) (Figure 3-2). The organic compounds, 4,4-DDD (20 ppb), 4,4-DDE (7.8 ppb), 4,4-DDT (19 P), Aroclor-1254 (190 ppb), alpha-Chlordane (34 ppb), gamma-Chlordane (45 ppb), and Dieldrin (24 ppb) were detected in the northern surface soil sample. Also, 4,4-DDT (64 ppb), 4,4-DDE (18 ppb), Aroclor-1254 (260 ppb), alpha-Chlordane (34 ppb), gamma-Chlordane (14 ppb), Dieldrin (34 ppb), and Endosulfan II (5.5 ppb) were detected in the southern surface soil sample. Acetone (25 ppb) was detected in the groundwater sample located in the northeastern corner of Site 4. No other organic compounds were detected in groundwater samples. Several inorganic analytes were also detected in both soil and groundwater samples.

CH2M Hill and CDM Federal Visual Site Inspection

Mr. Michael Tilchin of CH2M Hill and Mr. David Schroeder of CDM Federal Programs Corporation performed a visual site inspection of Site 3 and Site 4 on October 10, 1996. Mr. Tim Reisch, COMNAVBASE Program Manager and Mr. David Forsythe and Mr. Randy Jackson (Project Manager) of LANTDIV were also present.

Landfill C (Site 3) is adjacent to the northeast corner of the St. Juliens Creek Annex property boundary. The landfill area is relatively flat and as a result, fill boundaries are not easily distinguishable. The surface is grass covered and no visible signs of debris were noted. A communication and/or radar facility (Building 458 and Building 459) is located in the northeastern area of the landfill. Several low-lying areas inside the estimated boundaries were filled with water at the time of the site visit and drainage swales adjacent to the gravel perimeter road (North Patrol Road) also contained water.

Adjacent property to the north is a railroad right-of -way and to the east the property is grass covered with a slight increase in surface elevation. The downgradient direction of the site appears to be to the south towards Landfill D and Blows Creek. No sampling locations identified in this Work Plan and Field Sampling Plan were marked at the time of the site visit.

Landfill D (Site 4) is also located in the northeastern portion of the St. Juliens Creek Annex and is directly south of Landfill C. The site boundaries are somewhat more evident than Landfill C with raised surface features and areas which lack vegetation. A brush line borders the northern edge of the landfill with brush also extending beyond the western and southern edges. North Patrol Road and the adjacent property boundary borders the landfills eastern edge. A small debris pile was located in the center of the site with metal

cable and wooden posts visible and concrete debris was visible in the western part of the site. Five yellow "crane test weights" were located in southern part of the site.
Site drainage appears to be in a southern and eastern direction towards Blows Creek.
Ponded water was noted within the line of brush at the northern edge of the landfill. No sampling locations identified in this Work Plan and Field Sampling Plan were marked at the time of the site visit.

Section 4

Technical Approach

This section details the technical approach developed to perform the RI/FS activities at Site 3 and Site 4. The tasks included in the technical approach are listed below. The remainder of the section contains a detailed discussion of each task.

Task 1:	Project Planning
Task 2:	Fieldwork Support
Task 3:	Field Investigation
Task 4:	Sample Analysis and Data Validation
Task 5:	Risk Assessment
Task 6:	RI Report
Task 7 :	Feasibility Study
Task 8:	Feasibility Study Report
Task 9:	PRAP and ROD Report

Task 1: Project Planning

This task consists of the preparation of this work plan, the sampling and analysis (SAP) plan, and the health and safety plan (HSP). Meetings and project management activities also are described.

Work Plan

This task consists of developing this work plan for performing all activities associated with the RI/FS of Landfill C and Landfill D.

Sampling and Analysis Plan

This task consists of preparing a SAP, which consists of a field sampling plan (FSP), a quality assurance project plan (QAPP), and an investigation-derived waste management plan (IDWMP). The SAP will be developed in compliance with all requirements of the U.S. Navy QA/QC program manual.

The FSP will be referenced during field activities as procedural guidance for all sampling and data collection activities. The FSP includes the following sections: "Sampling Program," "Sampling Operations," and "Sample Documentation". The FSP is attached to this document.

CDM Federal has prepared a QAPP that meets the requirements specified by the Navy. The QAPP describes the quality assurance and quality control (QA/QC) procedures used for sampling soil, sediment, surface water, and groundwater at Site 3 and Site 4. The QAPP is attached to this work plan.

CDM Federal will not begin field sampling at the site until the Naval Technical Representative (NTR) receives confirmation that the requirements of the Laboratory Quality

Assurance Plan (LQAP) have been met for the site. The subcontracted analytical laboratory will be approved by the Navy and will conform to the Navy's approved LQAP. The LQAP will be submitted as soon as CH2M HILL Basic Ordering Agreements (BOAs) are in place for analytical laboratories.

The IDWMP describes the procedures used for handling and disposing of waste materials generated during the RI field program. The waste materials will include health and safety disposable items, soil, and fluids. The plan also describes the chemical analyses that will be performed to characterize the IDW materials and the potential means of disposal. The potential disposal sites also will be identified. For planning, all RI/FS-related IDW is assumed to be hazardous.

Health and Safety Plan

A site-specific HSP has been prepared and is attached to this work plan. The HSP contains guidance for the health and safety of CDM Federal employees during all RI/FS field activities. The HSP includes health and safety assessments for identifying problem areas where exposure to hazardous substances in water, soil, and air may occur. The assessments address safe working procedures, restrictions that will apply to site work, and potential human exposure to hazardous substances and the toxicological effects of those substances.

The HSP will be used by CDM Federal personnel and subcontractors during fieldwork for the project. All Site 3 and Site 4 investigations will proceed under Level D personal protection. If field conditions warrant, protection will be upgraded to Level C. Upgrade to a higher level of protection will be considered an out-of-scope cost and will not be undertaken without prior authorization.

Meetings

Four meetings are planned during which issues related Site 3 and Site 4 will be discussed. An initial onsite familiarization meeting will be attended by CDM Federal's project manager. CH2M HILL's Activity manager will also attend this meeting. One restoration advisory board (RAB) will be attended during the term of the project. One progress meeting will be held to discuss the preliminary results from the implementation of the RI/FS work plan. One meeting will be held at the mid- to later stages of the project to coordinate with regulatory agencies and discuss and resolve the comments received on the draft RI and draft FS reports or on the draft PRAP.

Project Management

The activities of project management include daily technical support and guidance, budget and schedule review and tracking, preparation and review of invoices, personnel-resource planning and allocation, subcontractor coordination, preparation of monthly progress reports, and communication and coordination of events with LANTDIV, Naval Base, Norfolk, and the Annex. Project management will occur over the duration of the project, which is estimated to be completed in 20 months.

Task 2: Fieldwork Support

This task comprises procedures for subcontractor procurement, mobilization and demobilization, and utility-clearance procedures.

Subcontractor Procurement

As part of the RI/FS fieldwork at Site 3 and Site 4, CH2M HILL will procure (for CDM Federal) drilling, surveying, analytical laboratory, data validation, and waste management services. The analytical laboratory will meet Navy Level D QC.

CH2M HILL is in the process of securing BOAs with established CLEAN I subcontractors, approved by LANTDIV. If BOAs are not in place for services required under this task order, CH2M HILL will provide subcontractor services in accordance with procedures that will be established by CH2M HILL's contract administrator and LANTDIV's contracting officer.

Mobilization and Demobilization

Mobilization includes the procurement and initial transport of field equipment to the site. Equipment and supplies will be transported during the CDM Federal field team mobilization for field activities.

Demobilization activities will include time for IDW sampling and general site restoration before the return transport of field equipment and crew. Field equipment will be recalibrated and stored after the fieldwork. IDW generated during field activities will be put in 55-gallon drums. Equipment decontamination water and development and purge water also will be put in 55-gallon drums for storage. The 55-gallon drums will be properly labeled and will be stored at a location designated by LANTDIV, Naval Base, Norfolk, and the Annex before disposal. The disposal method will depend on the results of analytical characterization.

Navy CLEAN Daily Field Reports must be completed and submitted within 7 days of the end of field activities.

Utility Clearances

Utility clearances will be performed before the start of subsurface investigation activities at the site. CDM Federal will coordinate subsurface utility clearances with the "Miss Utilities" office and the Public Works Center (PWC) at the Annex. CDM Federal will be responsible for ensuring that all appropriate contacts have been made with base personnel and that clearances have been given for proposed drilling locations, including marking of utilities near the areas of potential drilling, before field operations begin.

Task 3: Field Investigation

The field investigation includes all RI/FS activities associated with monitoring-well installation and sampling groundwater, soil, surface water, and sediment Site 3 and Site 4. This task also includes surveying sampling locations. A description of the activities follows.

Surface Geophysical Survey

A surface geophysical survey will be conducted to accurately determine subsurface conditions at Site 3 and Site 4.

Surface Geophysical Survey Techniques

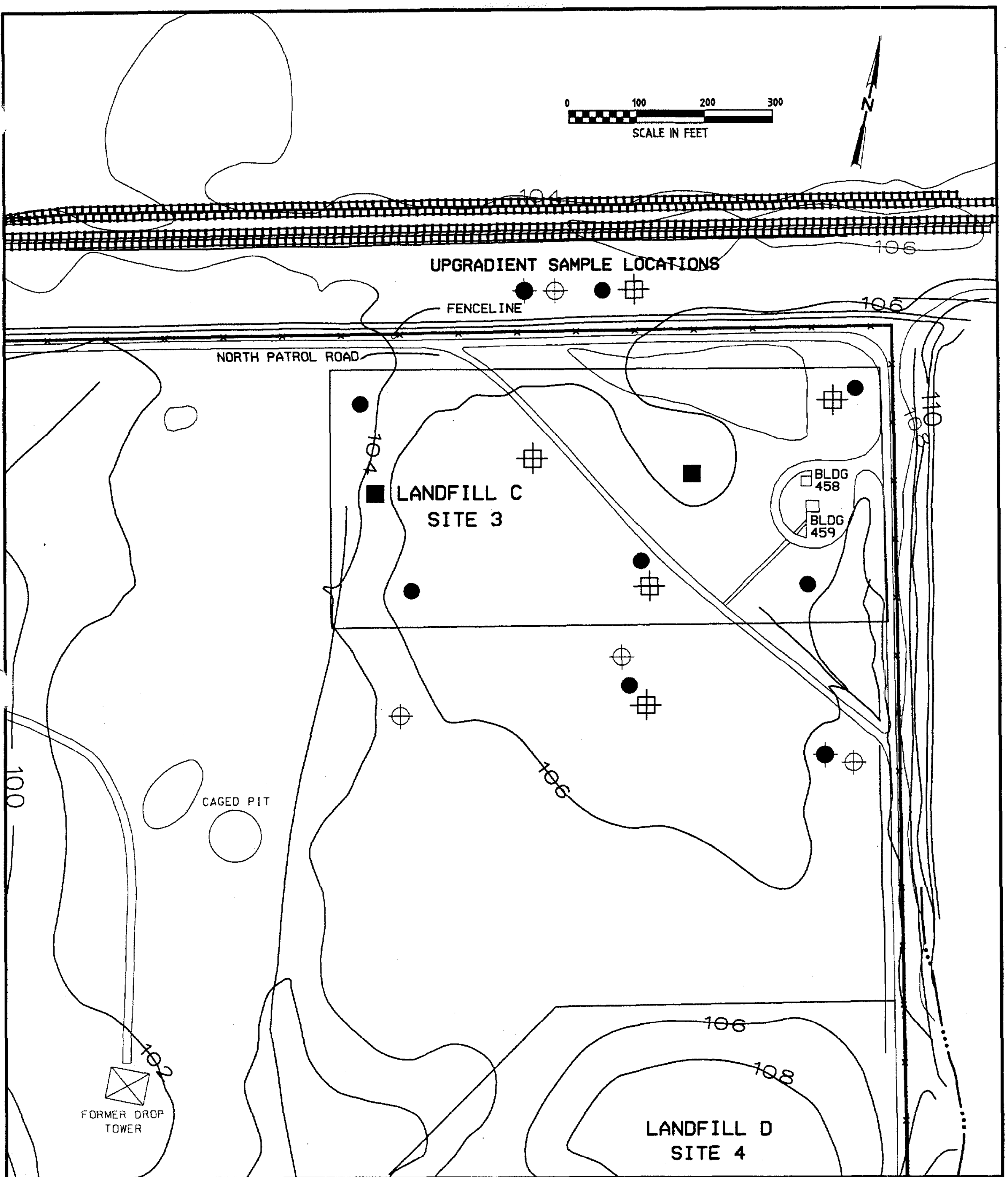
The electromagnetic survey method EM-31 will be used at both sites as part of the surface geophysical survey. This method measures the electromagnetic properties of the subsurface while generating its own signal source, and is suited to delineate site boundaries. EM-31 geophysical data will be used to estimate the boundaries and fill acreage for each landfill and characterize the soil profile above the water table. An EM-61 magnatometer survey and ground penetrating radar (GPR) survey will also be performed at Site 4. The EM-61 will be used to identify any buried metallic objects (e.g., steel drums and metallic construction debris). The survey traverses of the sites will be conducted on a perpendicular grid pattern with 100-foot centers. Based on EM-31 and EM-61 surveys, GPR will focus on areas which may indicate the presence of buried drums.

Monitoring Well Installation

A total of eight shallow alluvial monitoring wells (four at each site) and four deep alluvial monitoring wells (two at each site) will be constructed, developed, and sampled. Both upgradient and downgradient wells will be located around each site, and will be placed outside of the landfill boundaries. The exact placement of the monitoring wells will be determined in the field, based on the results of the geophysical survey. Figures 4-1 and 4-2 show the proposed general locations of the wells for Site 3 and Site 4, respectively. Where possible, the shallow and deep alluvial monitoring wells will be paired to provide a vertical profile of groundwater quality. All wells will be constructed with 2-inch PVC risers with 10-foot screens. Shallow wells will be screened from 10 - 20 feet bgs with screens spanning the water table. The deep wells will be screened from 50 - 60 feet bgs. Where a confining unit is detected, the deep wells will be constructed using a 30-foot length of surface casing to isolate the unconfined water table aquifer from the underlying Yorktown Aquifer; no surface casing will be required if no confining unit is detected in the upper 60 foot stratigraphic interval. For planning purposes the assumption is that surface casing will be needed in two deep wells. Geologic and well-construction logs will be prepared for each well.

The newly installed monitoring wells will be developed after the annular grout has cured for at least 24 hours. Wells will be developed by removing multiple well volumes (3-5) of groundwater until turbidity is absent from the development water or until the well has been pumped or bailed dry multiple times.

Monitoring well locations identified in this work plan are subject to change in the event of utility clearance or unexploded ordnance problems or other unforeseen circumstances.



LEGEND

- Surface soil sample location
- Composite soil sample location (0-3')
- Subsurface soil sample location
- Shallow monitoring well location
- Deep monitoring well location

Figure 4-1
PROPOSED MONITORING WELL AND SOIL SAMPLING LOCATIONS
SITE 3 - LANDFILL C
St. Juliens Creek Annex

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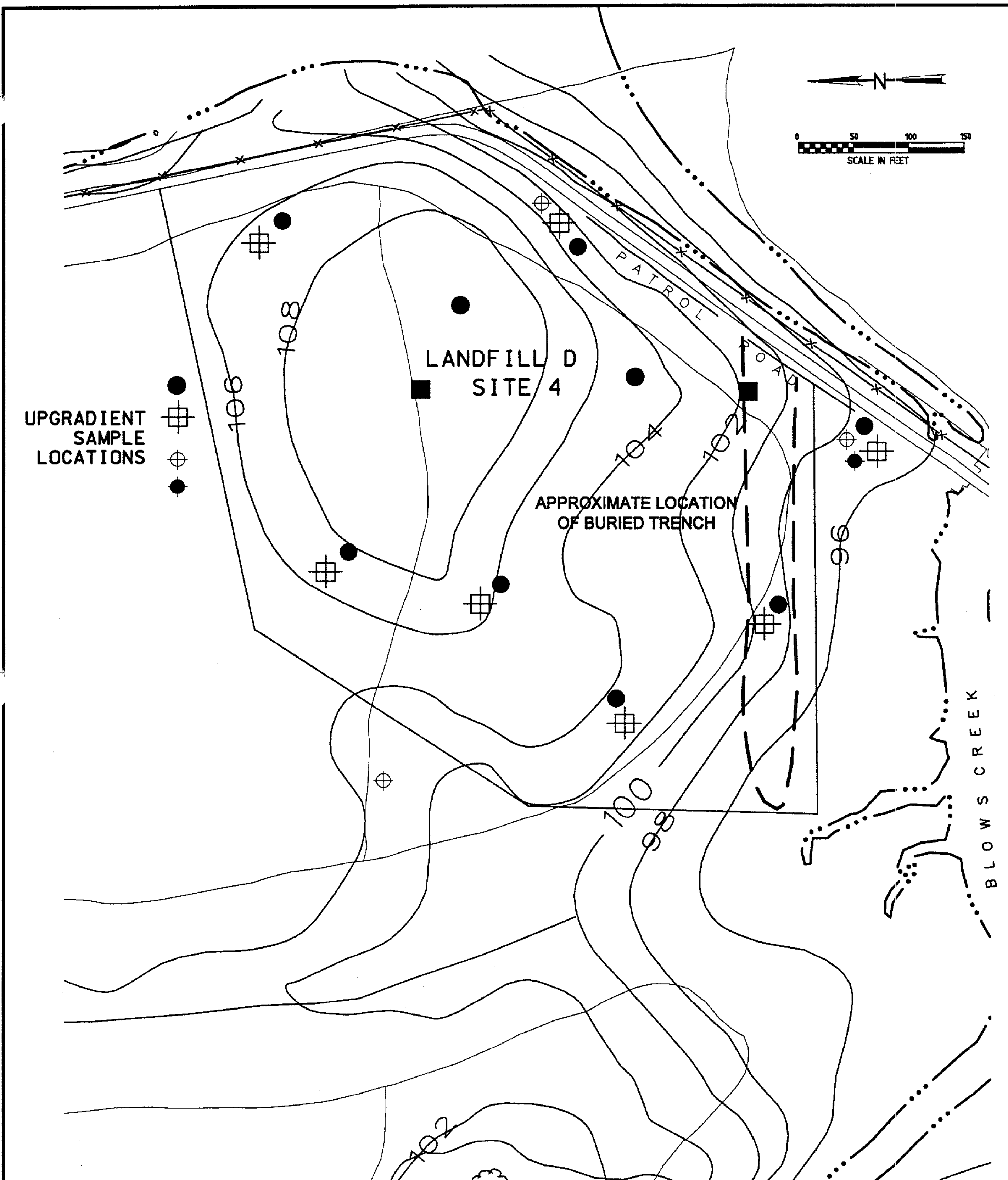

LEGEND

- Surface soil sample location
- Composite soil sample location (0–3')
- Subsurface soil sample location
- Shallow monitoring well location
- Deep monitoring well location

Figure 4-2
PROPOSED MONITORING WELL AND SOIL SAMPLING LOCATIONS
SITE 4 – LANDFILL D
St. Juliens Creek Annex

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Monitoring well installation is described in detail in a standard operating procedure (SOP) in Attachment A of the FSP.

Groundwater Sampling

Groundwater will be sampled from the 12 newly installed upgradient and downgradient monitoring wells at Site 3 and Site 4. Groundwater sampling methods are described below. The locations and numbers of groundwater samples and sample analytical methods are specified as well as proposed groundwater sampling techniques.

Groundwater Sample Numbers and Locations

Groundwater from the 12 newly installed monitoring wells will be sampled twice, on a quarterly basis. The first sampling event will follow well construction and development. The second sampling event will be conducted three months after the first.

The new monitoring wells will be sampled and analyzed for Target Compound List (TCL) organics (including volatiles, semivolatiles, pesticides, and PCBs) , Target Analyte List (TAL) inorganics (including total and dissolved metals and cyanide), and total phosphorous. The dissolved metals sample will be filtered in the field using a 0.45-micron membrane filter. In order to achieve the lower detection limits required for the risk assessment associated with the Landfill C and Landfill D RI/FS, the volatile fraction of the organic sample will be analyzed by the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Low Concentration Water for drinking water.

Temperature, pH, conductivity, and dissolved oxygen will be measured in the field.

Standard EPA methods will be followed during sample analysis. Table 4-1 identifies the groundwater samples to be collected and the analyses to be performed for samples at Landfill C and Landfill D. Figures 4-1 and 4-2 show the proposed locations of the wells to be sampled.

Groundwater Sampling Techniques

Before sampling, groundwater will be purged from each well. The volume of groundwater in the monitoring well will be calculated by using values for the depth of the well, the depth to water, and the well diameter. Purging will be performed until a minimum of three well volumes of water have been removed and the temperature, specific conductance, dissolved oxygen, and pH have stabilized within 10 percent for three consecutive readings. Sampling will begin when the parameter measurements have stabilized. The IDWMP discusses handling and disposal of purge water. Wells that are pumped dry during purging will be allowed to recover before being sampled. The sample will be obtained as soon as a volume of groundwater sufficient to fill all sample containers has entered the well. Unfiltered and filtered groundwater samples will be collected using a Grundfos® Redi-Flo 2 sampling pump. In the event that the sampling pump is not able to be used, the sample will be collected using a Teflon® bailer. Groundwater samples on which metals analysis will be conducted will be split into two portions. One portion will be filtered through a 0.45-micron membrane filter, transferred to a bottle and analyzed for dissolved metals. The remaining portion will be transferred to a bottle and analyzed for total metals.

Table 4-1
SITE 3 AND SITE 4 SUMMARY OF AQUEOUS SAMPLES TO BE SUBMITTED FOR ANALYSIS

Matrix	Laboratory Parameter	Samples Site 3	Samples Site 4	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
Groundwater *	Low Concentration Volatiles	12	12	3	2	6	2	6	43
	TCL Semivolatiles	12	12	3	2	0	2	6	37
	TCL Pesticides/PCBs	12	12	3	2	0	2	6	37
	TAL Metals (filtered)	12	12	3	2	0	2	6	37
	TAL Metals (unfiltered)	12	12	3	2	0	2	6	37
	TAL Cyanide	12	12	3	2	0	2	6	37
	Total Phosphorous	12	12	3	2	0	2	6	37
Surface Water	TCL Volatiles	3	3	1	1	1	1	1	11
	TCL Semivolatiles	3	3	1	1	0	1	1	10
	TCL Pesticides/PCBs	3	3	1	1	0	1	1	10
	TAL Metals	3	3	1	1	0	1	1	10
	TAL Cyanide	3	3	1	1	0	1	1	10
	Total Phosphorous	3	3	1	1	0	1	1	10
	Alkalinity	3	3	1	0	0	0	0	7
	BOD/COD	3	3	1	0	0	0	0	7
	TDS/TSS	3	3	1	0	0	0	0	7
	Hardness	3	3	1	1	0	1	1	10

Notes:
* Groundwater samples will be collected in two rounds: 6 samples per landfill per sampling round. This table summarizes the total number of groundwater samples to be collected.
[1]Field duplicates are collected at a frequency of 1 per 10 per matrix.
[2]Field blanks are collected at a frequency of 1 per source water per event.
[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples. Trip blanks shipped with groundwater samples will be analyzed using the low concentration volatiles method.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20 per matrix. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. The amount of extra volumes will be determined once the laboratories have been procured.
[5]Equipment blanks are collected at a frequency of 1 per day per matrix.
This table is based on Navy Level D QA/QC requirements.

Samples will be placed in containers and will be preserved according to Navy Level D protocol and will be analyzed within the proper holding time. For volatile organic analysis (VOA), the bottles will be filled to minimize aeration of the samples. Sample vials will be filled completely and capped to prevent entrapment of air bubbles in the vial.

The bottle cap should be removed carefully from the laboratory-cleaned sample bottle. The cap should not be laid down, and the inside should not be touched. At no time should the inside of the bottle come into contact with anything other than the sample.

All appropriate preservatives will be added to the sample containers by the contracted laboratory before the samples are shipped to the CDM Federal field team. TCL VOA samples will be preserved with hydrochloric acid (HCl), TAL metals samples will be preserved with nitric acid (HNO_3), and cyanide samples will be preserved with sodium hydroxide (NaOH). All samples will be kept cool at 4°C, using bagged ice.

The appropriate number of field QA/QC samples, including field blanks, equipment blanks, and duplicates, will be analyzed in addition to laboratory QA/QC samples, which will include matrix spike and matrix spike duplicate samples.

Soil Sampling

A total of 17 surface soil and 17 subsurface soil samples will be collected from Site 3 and Site 4. Locations, numbers, and depths of soil samples and sample analytical methods are specified below. Then, soil-sampling techniques are described. Sample locations depicted in this work plan are subject to change in the event of utility clearance problems or other unforeseen circumstances.

Soil Sample Numbers and Locations

A total of 17 surface soil and 17 subsurface soil samples will be collected from Site 3 and Site 4. Surface soil samples (seven at Site 3 and ten at Site 4, includes one upgradient at each site) will be collected at depths of 0 - 0.25 feet bgs for use in the risk assessment. Sixteen of the subsurface soil samples (five at Site 3 and eight at Site 4, includes one upgradient at each site) will be collected just above the water table at depths of 3 - 5 feet bgs. The remaining four subsurface soil samples (two at each site) will be composite samples of soil from 0 - 3 feet bgs. The composite samples will be used for ecological evaluation; no upgradient composite samples will be collected. Where possible, surface and subsurface samples will be collected from the same locations (not including composite samples). Figures 4-1 and 4-2 show the proposed locations of soil samples for Site 3 and Site 4, respectively.

All soil samples will be analyzed for TCL organics, TAL inorganics and total phosphorous. Standard EPA methods will be followed. Analysis of the soil samples will be performed in accordance with Navy guidance for Level D. The designations of soil samples collected at Site 3 and Site 4 and specific analyses to be performed are shown in Table 4-2.

Soil Sampling Techniques

Both surface and subsurface soil samples will be collected. Two sampling techniques will be used during the soil sampling phase of this investigation: manual sampling with a stainless steel trowel will be used for surface soil sampling, and split-spoon sampling using a Geoprobe® will be used for subsurface soil sampling. Both sampling techniques are

Table 4-2
SITE 3 AND SITE 4 SUMMARY OF SOIL AND SEDIMENT SAMPLES TO BE SUBMITTED FOR ANALYSIS

Matrix	Laboratory Parameter	Samples Site 3	Samples Site 4	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
Soil	TCL Volatiles	14	20	4	1	3	2	3	40
	TCL Semivolatiles	14	20	4	1	0	2	3	40
	TCL Pesticides/PCBs	14	20	4	1	0	2	3	40
	TAL Metals and Cyanide	14	20	4	1	0	2	3	40
	Total Phosphorous	14	20	4	1	0	2	3	40
Sediment	TCL Volatiles	4	4	1	1	1	1	1	10
	TCL Semivolatiles	4	4	1	1	0	1	1	10
	TCL Pesticides/PCBs	4	4	1	1	0	1	1	10
	TAL Metals and Cyanide	4	4	1	1	0	1	1	10
	Total Phosphorous	4	4	1	1	0	1	1	10
	TOC	4	4	1	1	0	1	1	10

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10 per matrix.
[2]Field blanks are collected at a frequency of 1 per source water per event.
[3]Trip blanks are shipped with samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20 per matrix. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. The amount of extra volumes will be determined once the laboratories have been procured.
[5]Equipment blanks are collected at a frequency of 1 per day per matrix.
Aqueous field QC samples associated with the solid samples are provided for informational purposes only and are not included in matrix total. In addition, these samples will be analyzed by the TCL organics method (not low concentration).
This table is based on Navy Level D QA/QC requirements.

described briefly below. The standard operating procedures (SOPs) for collecting soil samples are included in Attachment A of the FSP.

Stainless Steel Trowel

A stainless steel trowel will be used to collect surface soil samples in areas where manual soil sampling is appropriate. The trowel will be used to transfer the soil or sediment from the sampling location to the sample containers. The VOC sample containers will be filled first. The sample will be placed directly in the VOC sample container (without mixing) to minimize volatilization of organic compounds. The remaining sample volume will be placed in a stainless steel bowl and will be mixed thoroughly. After mixing, all other sample containers will be filled.

All soil samples will be placed in clean glass containers provided by the laboratory. Samples that are split for duplicate analysis will be mixed thoroughly before being split (except for VOCs).

Split-Spoon and Geoprobe® Sampling

Direct push sampling techniques will be used at locations where samples are being collected from several different depths or where compaction of the soil has made sample collection using manual sampling techniques impractical. A Geoprobe® rig will be used to advance a drive point to the top of the desired sampling interval. The drive point will then be removed, and a stainless steel split-spoon sampling device will be used to collect the sample. If necessary, several samples within a 1-foot diameter will be collected at each location to acquire the volume of sample needed to fill all sample containers. The sampler then will be retrieved, and the sample will be extruded. The VOC sample containers will be filled with soil first. The soil sample will be placed directly into the VOC sample container to minimize volatilization of organic compounds. The remaining soil-sample volume will be placed in a stainless steel bowl and mixed thoroughly. After mixing, all other soil sample containers will be filled. For the composite soil samples, the VOC sample containers will be filled prior to homogenization. The appropriate number of field QA/QC samples, including field blanks, equipment blanks, and duplicates, will be analyzed in addition to laboratory QA/QC samples, which will include matrix spike and matrix spike duplicate samples.

Split-spoon sampling (lithologic logging) will be performed during the installation of monitoring wells; however, no samples collected during monitoring well installation will be submitted for laboratory analysis.

Surface Water and Sediment Sampling

Six surface water samples and eight sediment samples will be collected to further characterize the nature and extent of contamination at Site 3 and Site 4. The locations and numbers of surface water and sediment samples and analytical methods are specified below. Surface water and sediment sampling techniques also are described.

Surface Water and Sediment Sample Numbers and Locations

Six surface water and eight sediment samples will be collected in the areas of surface water runoff (ponded water, drainage ditches, or streams) at Site 3 and Site 4. Locations of surface water and sediment samples are depicted in Figure 4-3 for Site 3 and in Figure 4-4 for Site 4, and are described below.

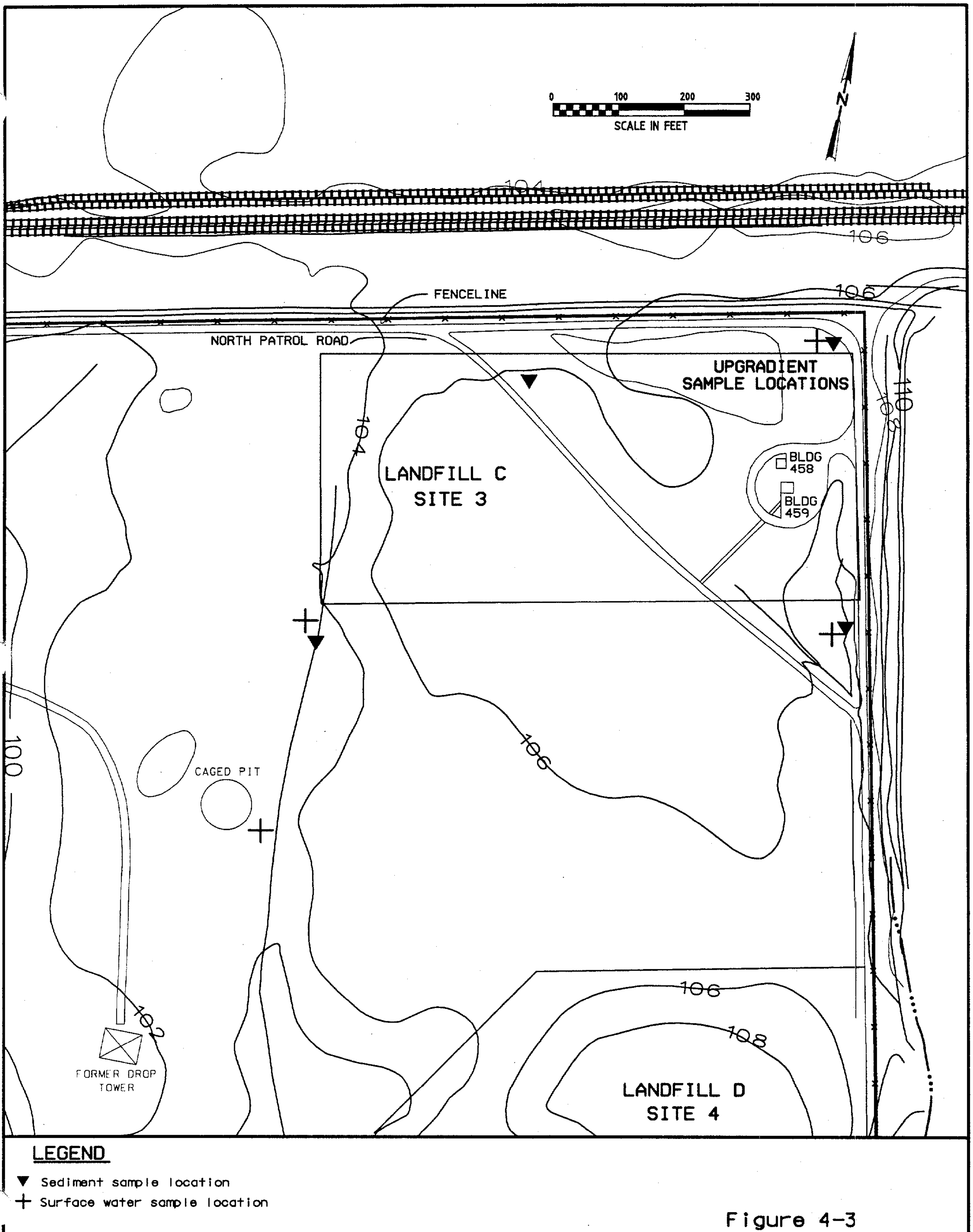

Figure 4-3
PROPOSED SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
SITE 3 - LANDFILL C
St. Juliens Creek Annex

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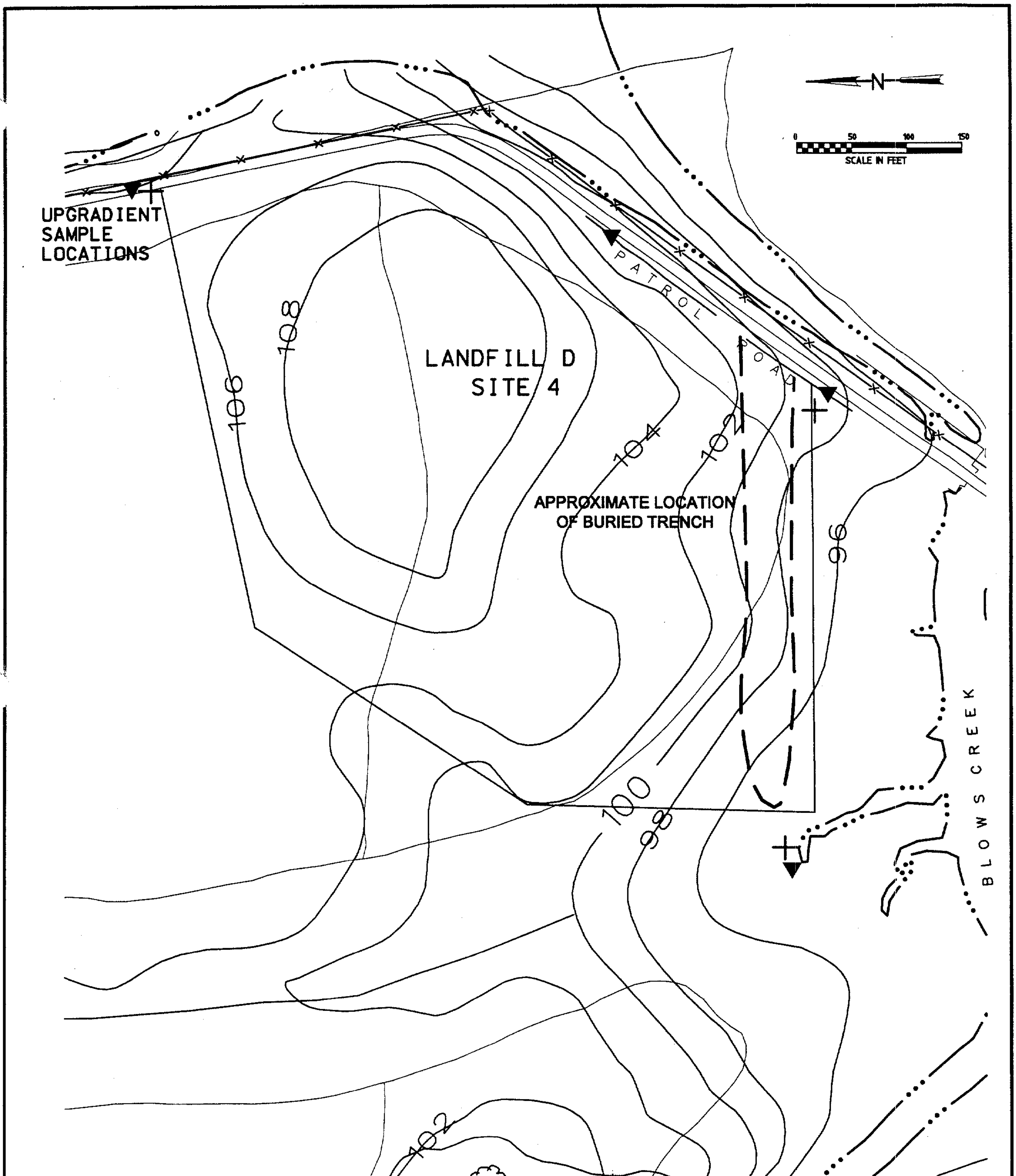

LEGEND

▼ Sediment sample location

+ Surface water sample location

Figure 4-4
PROPOSED SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
SITE 4 - LANDFILL D
St. Juliens Creek Annex

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Surface Water Sampling

Three surface water samples will be collected at each site from areas of ponded water, drainage ditches, or streams adjacent to each site. Two surface water samples will be collected proximal to each landfill, where possible, at locations considered to represent upgradient conditions. One of the surface water sampling locations is proposed at the confluence of a drainage way and St. Juliens Creek. This sample will represent contaminants in the surface water leaving the site. Conditions in St. Juliens Creek will not be investigated at this time.

All surface water samples will be analyzed for TCL organics, TAL inorganics, total phosphorous, alkalinity, hardness, BOD, COD, total suspended solids, and total dissolved solids. Standard EPA methods will be followed. Temperature, pH, conductivity, and dissolved oxygen will be measured and recorded in the field. Analysis of surface water samples will be performed in accordance with Navy guidance for Level D. Proposed samples and specific analyses to be performed are listed in Table 4-1.

Sediment Sampling

Eight sediment samples will be collected (four from each site) . Six samples will be collected at corresponding surface water sampling locations, and the two additional sediment sampling locations will be located within and downgradient of the site. Two sediment samples will be collected proximal to each landfill, where possible, at locations considered to represent upgradient conditions. One of the sediment sampling locations is proposed at the confluence of a drainage way and St. Juliens Creek. This sample will represent contaminants in the sediment leaving the site. Conditions in St. Juliens Creek will not be investigated at this time.

All sediment samples will be analyzed for TCL organics, TAL inorganics, total phosphorous, total organic carbon, pH, Eh, temperature, and conductivity. Standard EPA methods will be followed. Analysis of sediment samples will be performed in accordance with Navy guidance for Level D. Proposed samples and specific analyses to be performed are listed in Tables 4-3 and 4-4.

Surface Water and Sediment Sampling Techniques

Surface water and sediment sampling techniques are described below.

Surface Water Sampling Techniques

Surface water samples will be collected by submerging the sampling container directly into the surface water body. Care will be taken to ensure that the body of the sampling container is facing downstream so that sediment disturbed during the immersion of the container does not enter the sampling vessel. If the volume of surface water encountered is insufficient to allow the direct submersion of the sampling containers, a glass interim vessel will be used to transfer the surface water sample to the sample containers. The glass interim vessel will be laboratory-cleaned to the same specifications as the sample containers.

Samples will be placed in containers and preserved according to Navy Level D protocol and will be analyzed within the proper holding time. For VOC samples, the bottles will be filled to minimize aeration of the samples. During the collection of surface water samples, care will be taken to ensure that pre-added preservative is not rinsed from the sampling container. Sample vials will be filled completely and capped to prevent the entrapment of air bubbles in the vial.

The bottle cap should be removed carefully from the laboratory-cleaned sample bottle. The cap should not be laid down or touched inside. At no time should the inside of the bottle come into contact with anything other than the sample.

All appropriate preservatives will be added to the sample containers by the contracted laboratory before the containers are shipped to the CDM Federal field team. TCL VOA samples will be preserved with HCl, TAL metal samples will be preserved with HNO_3, and cyanide samples will be preserved with NaOH. All samples will be kept cool at 4°C, using bagged ice.

Sediment Sampling Techniques

A Ponar Dredge will be used to collect sediment samples from beneath any surface water greater than 1-foot in depth. The ponar dredge is a "clamshell" type sampling device consisting of the bucket/jaws and the sampler arms. During sampling activities, a length of rope is attached to a ring on the top of the sampler arms. The sampler arms are then pushed towards the bucket to open the sampler jaws. The jaws are locked in the open position by inserting a spring-loaded steel pin through a small hole in the arms. The sampler is lifted by the rope, with the sampler's weight creating the tension which holds the locking pin in place. The sampler is lowered until the sediments are encountered, pulled up approximately 6-inches, and allowed to free fall. With the tension relieved, the spring on the locking pin forces the pin out of the hole in the arms. As the sampler is retrieved, the jaws close trapping the sediment sample inside. Any surface water entrapped in the sampler is slowly decanted through a screened port on the top of the ponar. A stainless steel trowel will be used to collect shallow sediment samples in areas where this method is appropriate.

Sediment samples will be collected from downstream to upstream locations so as not to disturb downstream sediments and to prevent contamination of unsampled areas. Samples will be collected using a hand-held sediment auger with a 3-foot extension and will be transferred into appropriate jars with a stainless steel spoon or utensil. A stainless steel trowel will be used to collect shallow sediment samples in areas where this method is appropriate.

The VOC sample containers will be filled first. The sample will be placed directly in the VOC sample container to minimize volatilization of organic compounds. The remaining sample volume will be placed in a stainless steel bowl and will be mixed thoroughly. After mixing, all other sample containers will be filled.

All samples will be placed in clean glass containers provided by the laboratory. Samples that are split for duplicate analysis will be mixed thoroughly before being split (except for VOCs).

Surveying

A subcontracted surveyor licensed in the Commonwealth of Virginia will provide horizontal and vertical coordinates for the newly installed monitoring wells and horizontal coordinates for the soil, surface water, and sediment sampling locations.

The top of the PVC casing in the monitoring wells and ground-surface elevations will be established during this task. If necessary, the survey contractor will convert the base sea-level datum to the U.S. Geological Survey (USGS) mean sea-level datum. In addition, permanent landmarks (e.g., building corners) will be surveyed as appropriate.

Task 4: Sample Analysis and Data Validation

CDM Federal will be responsible for tracking sample analyses and obtaining results from the laboratory. The analytical data generated during the RI/FS field program will be validated by an independent data validation subcontractor according to EPA standard procedures.

Sample Analysis

All analyses of soil, groundwater, surface water, and sediment will be conducted at a contracted laboratory that fulfills all requirements of the U.S. Navy's QA/QC Program Manual and EPA's Contract Laboratory Program. A signed certificate of analysis will be provided with each laboratory analysis, along with a certificate of compliance certifying that all work was performed in accordance with the applicable federal, state, and local regulations. All analyses will be performed following Navy guidance for Level D.

Field Quality Control Procedures

Quality control duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and to provide an estimate of the components of variance and the bias in the analytical process. Tables 4-1 and 4-2 provides a summary of the collection frequencies of the field QC samples.

Blanks

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. ASTM Type II water will be used for blanks. Three types of blanks will be generated during sampling activities: trip blanks, field blanks, and equipment blanks.

One trip blank will be included in each cooler containing samples for VOC analysis. Pre-prepared trip blanks will be obtained from the laboratory, if possible. Otherwise, the trip blanks will be prepared prior to each sampling event, shipped or transported to the field with the sampling bottles, and sent to the laboratory unopened for analysis. Trip blanks will not be prepared or handled in the field. Trip blanks will indicate if any contamination occurred during shipment to the field, field storage, or during shipment from the field to the analytical laboratory.

One field blank will be collected per source, per sampling event. The field blanks will indicate if any contaminants were introduced during the handling of the sample containers in the field or during sample analysis at the laboratory. The sample container will be filled with ASTM Type II water in the field at the time of sampling. Pre-preserved bottles will be obtained from the laboratory, if possible, otherwise, preservatives will be added in the field. Field blank sample containers will be capped, packed, and shipped with the samples.

One equipment blank per matrix will be collected and analyzed every day during sampling activities. The equipment blanks will indicate the efficiency of equipment decontamination procedures. Pre-preserved bottles will be obtained from the laboratory, if possible; otherwise, preservatives will be added in the field. Field blank sample containers will be capped, packed, and shipped with the samples.

Duplicates

Field duplicate samples will be collected at a frequency of 1 per 10 field samples per matrix. The location from which the duplicates are taken will be randomly selected. The duplicate sample will be submitted for analysis as an independent sample. The sample and its duplicate will be numbered non-sequentially.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of 1 per 20 field samples. Analytical results of these samples indicate the impact the matrix (water, soil, sediment) has on extracting the analyte for analysis. Data validators will use these results to evaluate the accuracy of the analytical data.

Data Validation

All data will be validated before the project staff performs an interpretation. The data validation will be performed by an independent subcontractor, and will conform to the Navy guidance for Level D. Data that should be qualified will be flagged with the appropriate symbol. Results for QA/QC samples will be reviewed and the data will be qualified further, if necessary. Finally, the data set as a whole will be examined for consistency, anomalous results, and reasonableness.

Task 5: Risk Assessment

This task includes the preparation of a baseline risk assessment (BLRA) and a baseline ecological risk assessment (BERA). The risk assessments will be conducted in accordance with current EPA national and Region III guidance.

Baseline Human Health Risk Assessment

A BLRA will be performed for the RI of Site 3 and Site 4 to assess the potential human health risks posed by the sites. The risk assessment will evaluate the potential effects of existing site contamination on both current and potential future exposed populations. Future risks will be based on current site conditions, assuming no additional remedial action is conducted at the site. The future use of the site is unknown at this time; however, the Navy is investigating the possibility of excessing the Annex for lease for private ventures.

The risk assessment will be completed in accordance with EPA s *Risk Assessment Guidance for Superfund (RAGS), Volume I - Human Health Evaluation Manual (Part A),* dated December 1989, *RAGS* Parts B and C dated December 1989, and EPA Region III guidance. The exposure factors in RAGS have been superseded by OSWER Directive 9285.6-03, *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors,* dated March 1991. Dermal permeability coefficients will be taken from *EPA s Interim Guidance for Dermal Exposure Assessment,* dated January 1992. Other required exposure factors may be taken from *Exposure Factors Handbook* (EPA, 1989) and the American Industrial Health Council s *Exposure Factors Sourcebook* (AIHC, May 1994). The risk assessment will contain the following major components:

- Data evaluation and identification of contaminants of potential concern
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

The first step of the risk assessment will be to select contaminants of potential concern (COPCs). The selection criteria in EPA Region III s *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening,* January 1993, will be followed to determine which chemicals will be evaluated quantitatively. This methodology includes evaluating data quality, reducing the data set using risk-based concentrations (based on a target cancer risk of 1×10^{-6} and a target hazard index of 0.1), and further reducing the data set according to frequency of detection, comparison to background, and evaluation as human nutrients. Data collected during this investigation and data collected during the *Relative Risk Ranking System Data Collection Report, St. Juliens Creek Annex to the Norfolk Naval Base, Chesapeake, VA,* dated April 23, 1996 will be evaluated for use in the risk assessment. All data will be validated.

The second step of the risk assessment will be to identify actual or potential exposure pathways and to determine the probable magnitude of human exposure. Both residential and industrial risk scenarios will be included during the risk assessment. Only plausible and complete pathways will be carried through the exposure-quantification section to the risk characterization. A complete pathway contains a source of chemical release, a medium for environmental transport, a point of contact with the contaminated medium, and an exposure route at the point of contact. The pathways that are anticipated to be complete at Site 3 and Site 4 are those listed in Table 4-3. Exposure to surface soil, subsurface soil, sediment, surface water, and groundwater will be evaluated in the risk assessment. Quantification of exposure involves determining the exposure concentration and exposure parameters. The sources that will be consulted for the exposure parameters are discussed above. The exposure concentrations will be calculated for each scenario. The 95 percent upper confidence limit of the mean (95UCL) will be used as the exposure concentration for soil, sediment, and surface water. For comparative purposes, the calculation of average exposure concentrations will also be performed. The 95UCL calculation is dependent on the distribution of the data. A W-test will be used to determine if the data are lognormally or normally distributed. If the 95UCL is greater than the maximum detected concentration, the maximum detected concentration will be used as the exposure concentration. The exposure concentration for groundwater will be the concentration of each constituent detected in the well or group of wells that are the most contaminated or are located in the center of the plume.

TABLE 4-3
Site 3 and Site 4, St. Julien's Creek Annex
Summary of Exposure Pathways and Potentially Exposed Populations

Scenario Timeframe	Land use	Receptor Population	Medium	Receptor Age	Exposure Route	Evaluate Scenario?
Current	Industrial	Trespasser	Surface Soil	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
			Sediment	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	No
			Surface Water	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
		Worker (Site Worker)	Surface Soil	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
			Sediment	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	No
			Surface Water	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
Future	Residential	Homeowner	Surface Soil	Adult/Child	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
			Sediment	Adult/Child	Dermal	Yes
					Ingestion	Yes
					Inhalation	No
			Surface Water	Adult/Child	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
	Industrial	Worker (Construction Worker)	Surface/Subsurface Soil	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
			Sediment	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	No
			Surface Water	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
		Trespasser	Surface/Subsurface Soil	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
			Sediment	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes
			Surface Water	Adult	Dermal	Yes
					Ingestion	Yes
					Inhalation	Yes

For the purpose of calculating the exposure concentrations for the risk assessment, the following data handling methodology will be used. When a primary and duplicate sample are collected, the maximum concentration will be used as the sample concentration. One-half the sample quantitation limit (SQL) or sample detection limit (DL) will be used for cases where no detectable contaminant quantities were found in that specific sample, but the contaminant was detected in that medium for that group of samples. Data that have been qualified with a J (estimated value) during data validation will be treated as unqualified detected concentrations. Data qualified with an R (rejected) will not be used for risk assessment and will not be included in the total count of samples analyzed for a constituent. It will be assumed that the blank-related concentration of a constituent qualified with a B is the sample quantitation limit.

The next step of the risk assessment is the toxicity assessment. The primary source of toxicological data to be used in the analysis will be EPA s Integrated Risk Information System (IRIS) database. If toxicological data for a particular constituent are not available in IRIS, EPA s Health Effects Assessment Summary Tables (HEAST) will be consulted. This section will include a brief discussion of the toxicological characteristics of the major site contaminants and the quantitative approach used to assess the potential effects of the carcinogenic and noncarcinogenic effects on human health.

Risk characterization is the next step in the baseline human health risk assessment. It combines the results of the exposure assessment with the critical toxicity values in the appropriate media for each COPC. For quantitative risk estimation from carcinogenic chemicals, excess lifetime cancer risks will be estimated. Potential risks from noncarcinogenic chemicals will be presented using the hazard index approach. If estimated risks approach the EPA threshold values (i.e., 10^{-4} and 10^{-6}), a Monte Carlo uncertainty analysis will be performed.

The last section will be a discussion of uncertainty that provides the limits and assumptions for the results of the risk characterization. The discussion will include a qualitative sensitivity analysis of the exposure assumptions. A site specific discussion of uncertainty will be included in the assessment as will a qualitative analysis of any COPCs that cannot be evaluated quantitatively. Upgradient sample results will also be discussed in this section.

The results of the BLRA will be documented in the RI report. The risk assessment will be used to help determine whether remediation is necessary and to aid in the development of preliminary remediation goals for the media of concern. If risk-based concentrations (based on a target cancer risk of 1×10^{-6} and a target hazard index of 0.1) are exceeded site remediation will be recommended.

RI Baseline Ecological Risk Assessment

A BERA will be performed for the RI of Site 3 and Site 4. The BERA, which will be conducted utilizing a phased approach, will identify and evaluate the potential effects of the contamination on biota in the area. The characterization of environmental risks will involve identifying potential exposures to the surrounding ecological receptors and evaluating potential effects associated with such exposures. The BERA will be conducted in accordance with *Risk Assessment Guidance for Superfund Volume II: Environmental Evaluation*

Manual (EPA, 1989), *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1994), Region III s supplementary risk assessment guidance, and other appropriate guidance.

The BERA for Sites 3 and 4 will be implemented in phases. The first phase of the BERA will be a Screening Level Assessment (SLA). In this assessment, preliminary problem formulation will occur and a site conceptual model will be developed. The ecological effects analysis will consist of comparing site contaminant levels with EPA Region III BTAG Screening Levels. Details pertaining to the Screening Level Assessment process for Sites 2 and 5 are provided below.

The scope of the subsequent phase of the BERA, a semi-quantitative assessment, will be determined by the outcome of the Screening Level Assessment. The Contaminants of Potential Concern (COPCs), as identified in the SLA, will be further evaluated, assessment and measurement endpoints will be developed, appropriate exposure models will be developed, and the modeled doses will be compared with screening / benchmark values derived from the literature.

If necessary, the final phase of the BERA will consist of a quantitative assessment. The need for a quantitative assessment will be evaluated based on the results of the preceding phase. This phase will rely on site-specific toxicity or bioaccumulation data to further refine the semi-quantitative assessment. It is currently envisioned that this final phase will only be conducted if the level of ecological risk cannot be reasonably established with an acceptable level of uncertainty during the semi-quantitative assessment or if site-specific data is deemed necessary to establish clean-up levels.

BERA - Screening Level Assessment

The focus of the BERA SLA will be the evaluation of available site data, preliminary problem formulation, the development of a site conceptual model, and the screening of site contaminant data against the August 9, 1995 Revised Region III BTAG Screening Levels (effects analysis).

The preliminary problem formulation will consist of:

- A description of the ecological and environmental setting
- Identification of the known sources and types of contaminants at the sites
- Identification of known and suspected contaminant exposure pathways
- Identification of receptor species

The BERA - specific activities that will be completed to facilitate problem formulation include:

- Collection of existing data for use in the characterization of land use, soil, topography, and flora and fauna
- Preliminary identification of habitats in potentially contaminated areas or along potential exposure pathways through review of reports, aerial photography, and

contacts with resource agencies having knowledge of environmental resources in the vicinity of the site

- Collection of existing information to determine the presence of either state or federal rare, threatened or endangered species
- Field identification of habitats and a qualitative identification of potential receptor species

The field identification of habitats and identification of potential receptor species will be accomplished during an ecological reconnaissance of the site. Utilizing the information obtained during the preliminary habitat identification activities, approximate habitat boundaries and approximate wetland boundaries will be identified and transects through representative areas of each habitat will be defined. During the ecological reconnaissance, the transects will be surveyed with the dominant vegetative species being noted. Any fauna or signs of fauna (tracks, scat, etc.) will also be noted. Based on the field observations and the results of the data collection activities, a list of potential receptor species will be developed. Delineation of the boundaries of the jurisdictional wetlands onsite will not be performed at this time.

As the final stage of problem formulation, a site conceptual model will be developed. The conceptual model will establish the exposure pathways that will be evaluated in the effects analysis. The model will also define the assessment and measurement endpoints of the BERA. Consistent with an SLA, it is anticipated that the assessment endpoint will be the survival, growth, and reproduction of all onsite species. The measurement endpoint will be the response of the most sensitive species, as reported in the literature, in a medium to exposure to each contaminant present onsite.

Upon completion of the problem formulation and the development of the site conceptual model, the ecological effects of the site contaminants will be evaluated. For each habitat and media potentially effected by site contaminants (e.g., palustrine wetland sediment, emergent wetland surface water, scrub/shrub upland soil, etc.), contaminant levels and effects will be evaluated by comparing maximum observed concentrations against the EPA Region III BTAG Screening Levels. Utilizing the appropriate BTAG Screening Value as the denominator, an environmental effects quotient will be calculated for each of the site contaminants in each potentially effected media and habitat. Those contaminants whose concentrations exceed the screening levels (i.e., EEQ > 1) will be retained as Contaminants of Potential Concern (COPC).

For each COPC, a toxicity profile will be developed utilizing information gathered during a literature review. The toxicity profile will present available information pertinent to the contaminant s toxicity, including target tissue and dose-response relationships, and toxic mechanisms. This information will facilitate an evaluation of the likelihood of toxic effects. Toxicity profiles will also be developed for contaminants whose EEQ is greater than 0.1 and have a tendency to bioconcentrate (i.e., bioconcentration factor > 1). In addition, profiles will be developed for those compounds where screening values are not available in order to facilitate a qualitative assessment of the effects of exposure to the compound(s).

The BERA SLA will also include an uncertainties section. This discussion will identify the key factors and assumptions made during the assessment that effect the level of uncertainty associated with the analysis.

The final stage of the BERA SLA will be a weight-of-evidence analysis in which all of the available data will be evaluated and conclusions and recommendations will be drawn. This analysis will consider the type and quality of environmental data evaluated, the available toxicity and reference values to which the environmental data was compared, the type of analysis or comparison that was completed, and the level and type of uncertainty associated with the analyses. As the final step of this analysis, the need for subsequent phases of ecological risk assessment will be evaluated. Toxicity profiles will be prepared for compounds identified as COPCs during the screening level assessment, as well as for compounds for which screening levels have not been developed. Profiles will also be provided for select compounds present at concentrations below screening levels but are known to bioconcentrate. If it is believed that additional phases are required, the discussion will include a definition of issues, identification of exposure pathways, selection of ecological receptors, and potential effects that might need to be addressed in future assessments. Recommendations pertaining to the selection of ecological receptor species will be supported by species descriptions which will include the feeding habits and habitat preferences of each receptor species. Receptor species will be selected based on its known or reported presence on site in the types of habitat(s) being evaluated, its similarity to species known to occur onsite, and the availability of appropriate ecotoxicological data for the selected species or a closely related species. The assessment and measurement endpoints of the subsequent phase of the assessment will be also be proposed.

Task 6: RI Report

This task documents activities associated with RI report preparation. The results of the investigation and the human health and ecological risk assessment will be compiled in an RI report. This report will include the following items:

- History and background of the site, including previous studies
- Features and environmental setting
- RI field activities
- Sampling and analytical methods
- Presentation and evaluation of the analytical data
- Discussion of the nature and extent of contamination
- Results of the BLRA and the BERA

The RI report will include, as appropriate, site maps with sampling locations, boring logs, cross sections, raw and validated analytical data, and figures that depict the extent of soil and groundwater contamination.

The report will document recommendations and supporting information to justify the recommendations. The information collected and presented in the RI report will be used to prepare the FS. A draft, draft final, and final RI document will be prepared as part of this task.

Task 7: Feasibility Study

CDM Federal will conduct an FS for Site 3 and Site 4. The FS will involve remedial alternatives screening and remedial alternatives evaluation. A description of the FS follows.

Remedial Alternatives Screening

CDM Federal will develop a range of distinct alternatives for waste management that, if implemented, would potentially remediate or control contaminated media (e.g., soil, groundwater) as deemed necessary in the RI to provide adequate protection of human health and the environment. On the basis of existing information and information obtained from the RI, site-specific remedial objectives to protect human health and the environment will be developed. The objectives will specify the contaminants and media of concern, the exposure routes and receptors, and an acceptable contaminant level or range of levels for each exposure route (e.g., preliminary remediation goals, or PRGs). The PRGs will be based on readily available information, such as reference doses or chemical-specific ARARs, such as maximum contaminant levels (MCLs), and the results of the risk assessment.

General-response actions will be developed for each medium of concern. Volumes or areas to which general-response actions may apply will be identified, taking into account the requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characteristics of the site.

CDM Federal will identify and screen alternative remedial actions that will address the general-response actions. This will be a two-step process that entails identifying and screening individual technologies on the basis of a technology's ability to address contaminants at the site effectively, as well as implementability and relative cost. The identification and screening step will be followed by the conversion of applicable technologies into alternatives and screening those alternatives on a general basis for their effectiveness, implementability, and relative cost.

The cost of technologies and remedial action alternatives developed at this stage of the FS will be evaluated to facilitate the development of both RA alternatives applicable to site problems and relative order-of-magnitude costs by which the technologies or alternatives may be screened. Candidate technologies that might be applicable to site conditions will be considered in developing RA alternatives. For these technologies, means such as contacting technology vendors or previous experience on other projects will be used to generate relative order-of-magnitude costs for screening alternatives.

The following soil/sediment remediation alternatives will be developed:

- No action
- Institutional controls
- *In situ* treatment
- Excavation and onsite or offsite treatment
- Containment and/or capping

The following groundwater remediation alternatives will be developed:

- No action
- Institutional controls with monitoring
- Air sparging or other appropriate *in situ* treatment method
- Extraction and treatment

Remedial Alternatives Evaluation

A detailed analysis will be performed on soil and groundwater remedial alternatives that pass the screening process. The analysis will consist of individual and comparative evaluations based on the criteria given on USEPA guidance 540/G-89/004, EPA Region III guidance, and other appropriate guidance, including the following:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

The results of the detailed alternatives analysis will be the formulation and documentation of recommendations for one or more feasible actions that might be implemented to address contamination at Site 3 and Site 4.

Task 8: Feasibility Study Report

A report will be prepared that documents the results of the FS. All steps taken during the screening and evaluation of remedial alternatives will be described. Several remedial alternatives and their estimated costs will be provided to cover a wide range of technologies and costs.

A draft and a final FS report will be submitted as separate documents from the RI report.

Task 9: PRAP and ROD Reporting

A draft, draft final, and final proposed remedial action plan (PRAP) will be prepared as part of this task. The plan will include appropriate components, as described in *Guidance for Preparing Superfund Decision Documents*, EPA/540/G-89/007, July 1989; EPA Region III guidance; and other appropriate guidance.

A draft, draft final, and final record of decision (ROD) will be prepared in accordance with USEPA guidance, as noted above. The public notice on the proposed PRAP also will be prepared.

Section 5

Staff Organization

Project Management

Project management will include overall coordination of all work to be performed at the site. The management structure for CH2M HILL is designed so that there is one central administrative point of contact, the Activity Manager, and multiple technical project managers who will manage the technical tasks as their expertise is required. The Activity Manager will maintain close contact with the LANTDIV NTR.

The Activity Manager will oversee and coordinate each project to maintain overall project schedule and will coordinate the monthly progress report effort. In addition, the activity manager and the technical project managers will conduct weekly internal program-review meetings to update all team members on individual project status and upcoming technical needs and to discuss technical issues that might affect the course, or completion of other technical tasks. After the weekly internal review meetings, the Activity Manager will relay pertinent issues to the LANTDIV NTR. The Activity Manager also will provide general program support, interaction with client and regulatory agencies, and documentation of decisions on technical issues that might affect future work at the Base.

The responsibilities of the technical project managers include such activities as the preparation and submittal of Navy CLEAN daily reports, daily technical support and oversight, budget and schedule review and tracking, preparation and review of invoices, personnel-resource planning and allocation, and project-specific coordination with LANTDIV, the Activity, and subcontractors.

Project-Specific Organization

The Activity Manager, Mr. Michael Tilchin, will be the primary point of contact for the project and will provide guidance to the Project Manager. The Project Manager, Mr. Dave Schroeder of CDM Federal, will be responsible for such activities as budget and schedule review and tracking, preparation and review of invoices, personnel-resource planning and allocation, and coordination with LANTDIV, Naval Base, Norfolk, the Annex, and subcontractors. The RI/FS field investigation tasks (soil, sediment, surface water, and groundwater sampling) will be performed by supporting field personnel. In addition, Dr. Robert Root, of CH2M HILL, and Ms. Joan Knapp, of CDM Federal, will perform senior review during the project. The project organization is depicted in Figure 5-1.

CH2M HILL and CDM Federal will notify LANTDIV and the Annex about which CDM Federal personnel will mobilize to the site before initiating field activities. CDM Federal also will notify appropriate Annex personnel to acquire site access and utility clearances. The LANTDIV NTR, Mr. Randy Jackson, and the COMNAVBASE Program Manager, Mr. Tim Reisch will be advised of all site activities and schedules before site operations begin. St. Juliens Creek Annex contacts are listed below in Table 5-1.

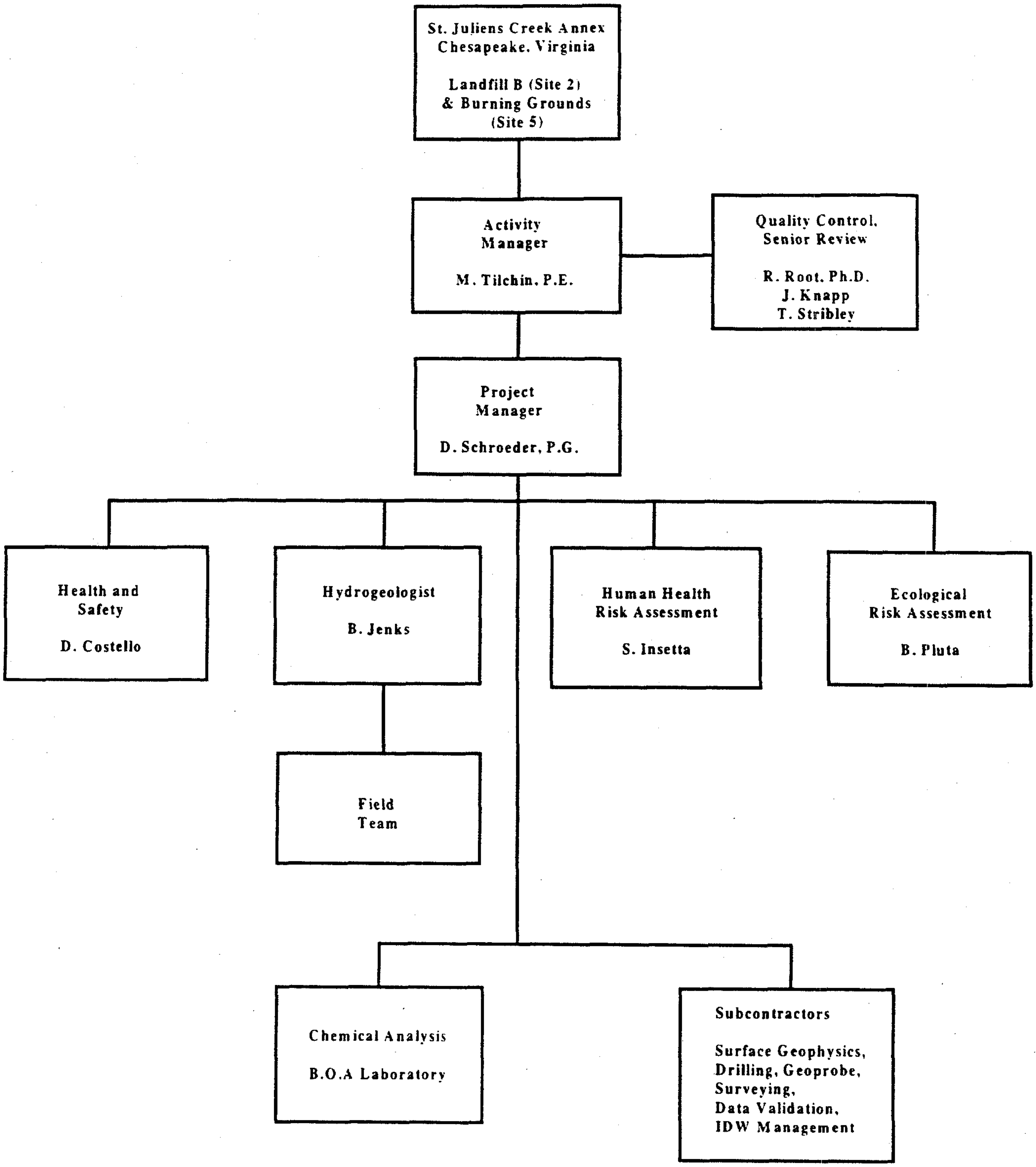


Figure 5-1
PROJECT ORGANIZATION
SITE 3-LANDFILL C AND SITE 4-LANDFILL D
St. Juliens Creek Annex, Chesapeake

CH2M HILL

Table 5-1
ST. JULIENS CREEK ANNEX CONTACT LIST

Contact Person	Responsibility	Department	Phone Number	Fax Number	Location on Base
Mr. Randy Jackson	Environmental Engineer and NTR	Installation Restoration Section, LANTDIV	757-322-4587	757-322-4805	1510 Gilbert Street Norfolk, VA 23511-2699
Mr. Tim Reisch	Program Manager, COMNAVBASE	Norfolk Naval Base Environmental	757-322-2900	757-444-3000	Suite 200 1520 Gilbert Street Norfolk, VA 23511-2979
Mr. Roger Hillers (or Mr. Rusty Carter)	Water, steam, sewage, electrical, and natural gas lines	Public Works	757-445-8558	757-445-9316	Building P71 9742 Maryland Ave. Norfolk, VA 23511-3095
Mr. Meryl Kauffman	Digging permits	Public Works	757-445-8558	757-445-9316	Building P71 9742 Maryland Ave. Norfolk, VA 23511-3095
Mr. Jerry Fly	Communications lines	Communications	757-322-2045 757-475-6090 (Beeper)	757-445-6803	Building M51, Room 149
Mr. Paul Kidd	Survey monumentation	Code 405 (Civil/Survey)	757-322-4405	757-322-4415	Building N26, 3rd Floor

Note: The base phone numbers are in the process of being changed from 444- and 445- prefixes to a 322- prefix

Section 6

Contractual Services

This section documents the anticipated subcontract services required for completing the tasks documented in this work plan. CH2M HILL is in the process of acquiring BOAs with existing Navy Clean subcontractors used under the CLEAN I contract. BOAs will be negotiated with new subcontractors as needed.

The RI/FS will require subcontract services from the following:

- Surface Geophysics Contractor
- Geoprobe Contractor
- Drilling Contractor
- Surveyor
- Analytical Laboratory
- Data Validation
- IDW Disposal Services

Section 7

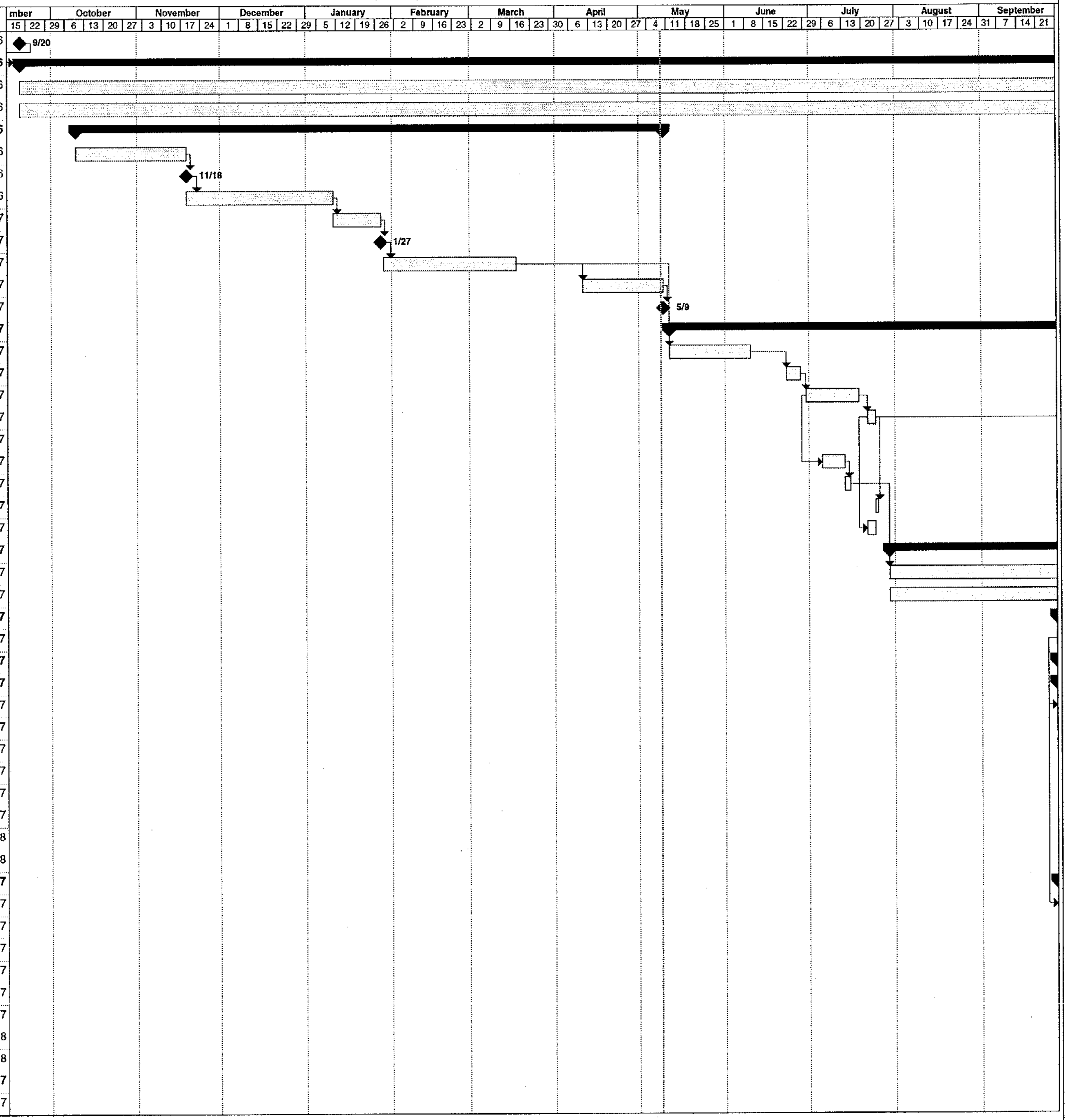
Project Schedule

This section describes the project schedule and the due dates of deliverables.

The project will be performed in accordance with the schedule and milestones presented in Figure 7-1. Table 7-1 shows a breakdown of primary task deliverables and milestones with their respective due dates. Government review periods also are tabulated. Longer periods of review will result in an extended schedule.

CH2M HILL NAVY C.L.E.A.N. CONTRACT
CTO-0027
RI/FS of Landfill C and Landfill D at St. Julien's Creek Annex, Chesapeake, Virginia

ID	Task Name	Duration	Start
1	Notice to Proceed	0d	9/20/96
2	**Project Planning (PP)**	**617d**	**9/20/96**
3	Project Mnaagement (PP.PM)	617d	9/20/96
4	Meetings (PP.MG)	617d	9/20/96
5	**Workplan Preparation (PP.WP)**	**207d**	**10/10/96**
6	Prepare Draft Workplan	40d	10/10/96
7	Submit Draft Workplan	0d	11/18/96
8	Navy Review	48d	11/19/96
9	Prepare Draft Final Workplan and Executive Summary	17d	1/11/97
10	Submit Draft Final Workplan	0d	1/27/97
11	Navy and Regulatory Review	48d	1/29/97
12	Prepare Final Workplan	29d	4/11/97
13	Submit Final Workplan	0d	5/9/97
14	**RI Field Investigation (FI)**	**168d**	**5/12/97**
15	Fieldwork Support/Subcontractor Procurement (FI.FK)	29d	5/12/97
16	Surface Geophysical Surveying	5d	6/23/97
17	Monitoring Well Installation (FI.FI)	19d	6/30/97
18	Groundwater Sampling - First Round (FI.FQ)	3d	7/22/97
19	Groundwater Sampling - Second Round (FI.FQ)	4d	10/23/97
20	Soil Sampling (FI.FS)	8d	7/6/97
21	Sediment/Surface Water Sampling (FI.FW)	2d	7/14/97
22	RI-Derived Waste Disposal (FI.FF)	1d	7/25/97
23	Surveying (FI.FM)	3d	7/22/97
24	**Sample Analysis and Validation (SA)**	**70d**	**7/30/97**
25	Sample Management (SA.SM)	70d	7/30/97
26	Data Validation (SA.DV)	60d	7/30/97
27	**Data Evaluation (DE)**	**30d**	**9/28/97**
28	Data Evaluation (DE.DE)	30d	9/28/97
29	**RA Reports (AR)**	**135d**	**9/28/97**
30	**Prepare HHRA and ERA Reports (AR.HH) & (AR.ER)**	**135d**	**9/28/97**
31	Prepare Draft HHRA and ERA Reports	60d	9/28/97
32	Submit Draft HHRA and ERA Reports	0d	11/26/97
33	Navy Review	15d	11/27/97
34	Prepare Draft Final HHRA and ERA Reports and Executive Summ:	15d	12/12/97
35	Submit Draft Final HHRA and ERA Reports and Executive Summa	0d	12/26/97
36	Navy and Regulatory Review	30d	12/27/97
37	Prepare Final HHRA and ERA Reports and Executive Summary	15d	1/26/98
38	Submit Final HHRA and ERA Reports	0d	2/9/98
39	**RI Report (RI)**	**135d**	**9/28/97**
40	Prepare Draft RI Reports (RI.DR)	60d	9/28/97
41	Submit Draft RI Reports	0d	11/26/97
42	Navy Review	15d	11/27/97
43	Prepare Draft Final RI Reports and Executive Summary (RI.DF)	15d	12/12/97
44	Submit Draft Final RI Reports and Executive Summary	0d	12/26/97
45	Navy and Regulatory Review	30d	12/27/97
46	Prepare Final RI Reports and Executive Summary (RI.FR)	15d	1/26/98
47	Submit Final RI Reports	0d	2/9/98
48	**Remedial Alternatives Screening (AS)**	**34d**	**12/19/97**
49	AlternativesDevelopment and Screening (AS.AD)	14d	12/19/97



Date: 5/9/97 | Task | Milestone | Summary

ID	Task Name	Duration	Start
50	Technology Screening (AS.AT)	14d	12/29/97
51	General Response Actions (AS.GR)	14d	1/8/98
52	**Alternatives Evaluation (AE)**	**28d**	**1/18/98**
53	Alternative Evaluations (AE.AE)	14d	1/18/98
54	Cost Estimate (AE.EC)	14d	2/1/98
55	**FS Report (FS)**	**147d**	**12/19/97**
56	Prepare Draft FS Reports (FS.DR)	60d	12/19/97
57	Submit Draft FS Reports	0d	2/16/98
58	Navy Review	15d	2/17/98
59	Prepare Draft Final FS Reports (FS.DF)	27d	3/4/98
60	Submit Draft Final FS Reports	0d	3/30/98
61	Navy and Regulatory Review	30d	3/31/98
62	Prepare Final FS Report (FS.FR)	15d	4/30/98
63	Submit Final FS Report	0d	5/14/98
64	**Post RI/FS Support (PS)**	**180d**	**5/15/98**
65	**Prepare PRAPs and RODs (PS.PS)**	**180d**	**5/15/98**
66	Prepare Draft PRAPs	15d	5/15/98
67	Submit Draft PRAPs	0d	5/29/98
68	Navy Review of PRAPs	10d	5/30/98
69	Prepare Draft Final PRAPs	15d	6/9/98
70	Submit Draft Final PRAPs	0d	6/23/98
71	Navy and Regulatory Review of PRAPs	20d	6/24/98
72	Prepare Final PRAPs	10d	7/14/98
73	Public Notice (PS.PN)	45d	7/24/98
74	Prepare Draft RODs	15d	9/7/98
75	Navy Review of RODs	15d	9/22/98
76	Prepare Draft Final ROD	15d	10/7/98
77	Navy and Regulatory Review of RODs	20d	10/22/98
78	Submit Final PRAPs and RODs	0d	11/10/98

Timeline columns: mber (15, 22, 29) | October (6, 13, 20, 27) | November (3, 10, 17, 24) | December (1, 8, 15, 22, 29) | January (5, 12, 19, 26) | February (2, 9, 16, 23) | March (2, 9, 16, 23, 30) | April (6, 13, 20, 27) | May (4, 11, 18, 25) | June (1, 8, 15, 22, 29) | July (6, 13, 20, 27) | August (3, 10, 17, 24, 31) | September (7, 14, 21)

Date: 5/9/97 | Task | Milestone ◆ | Summary

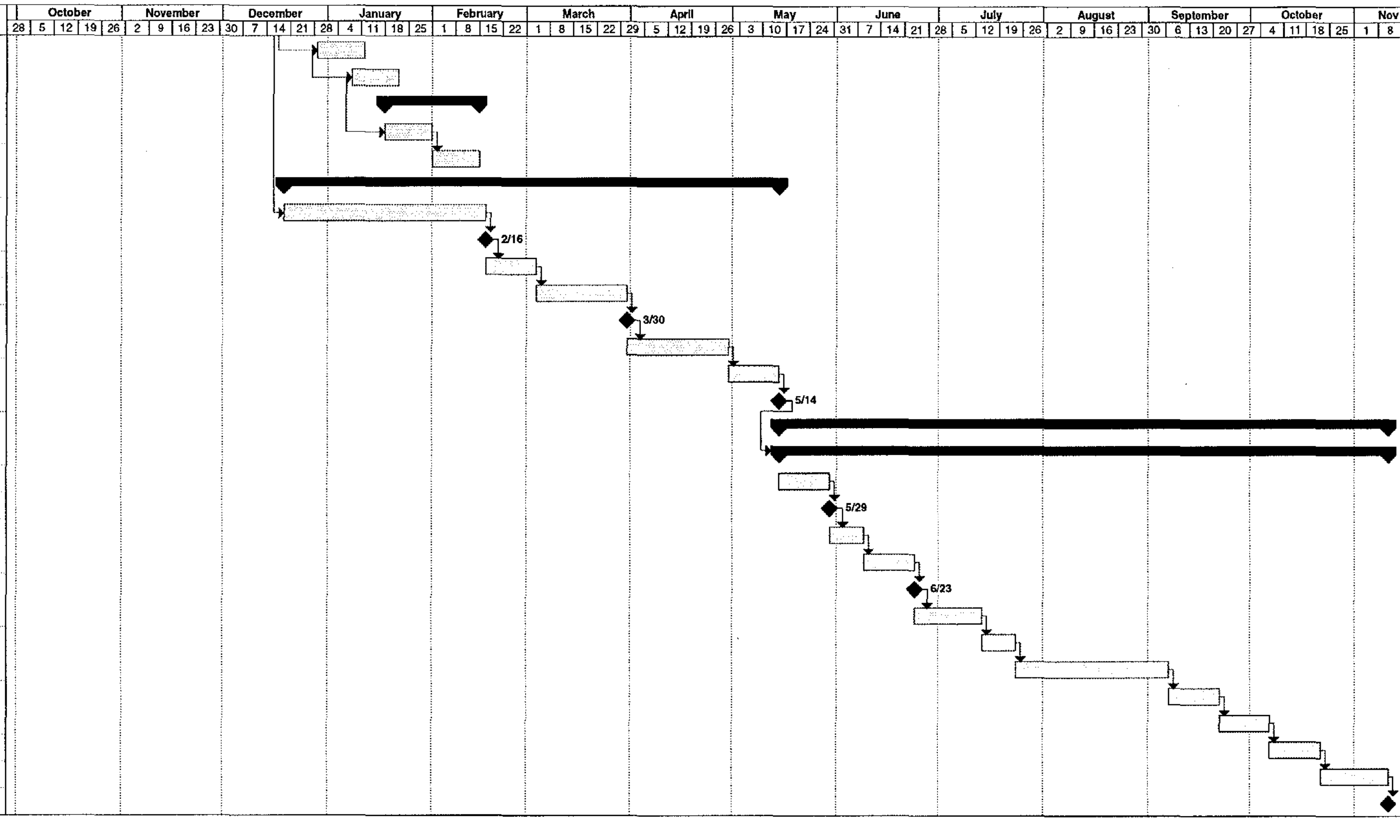
CH2M HILL NAVY C.L.E.A.N. CONTRACT
CTO-0027
RI/FS of Landfill C and Landfill D at St. Julien's Creek Annex, Chesapeake, Virginia

ID	Task Name	Milestone
1	Notice to Proceed	
2	**Project Planning (PP)**	
3	Project Mnaagement (PP.PM)	
4	Meetings (PP.MG)	
5	**Workplan Preparation (PP.WP)**	
6	Prepare Draft Workplan	
7	Submit Draft Workplan	
8	Navy Review	
9	Prepare Draft Final Workplan and Executive Summary	
10	Submit Draft Final Workplan	
11	Navy and Regulatory Review	
12	Prepare Final Workplan	
13	Submit Final Workplan	
14	**RI Field Investigation (FI)**	
15	Fieldwork Support/Subcontractor Procurement (FI.FK)	
16	Surface Geophysical Surveying	
17	Monitoring Well Installation (FI.FI)	
18	Groundwater Sampling - First Round (FI.FQ)	
19	Groundwater Sampling - Second Round (FI.FQ)	
20	Soil Sampling (FI.FS)	
21	Sediment/Surface Water Sampling (FI.FW)	
22	RI-Derived Waste Disposal (FI.FF)	
23	Surveying (FI.FM)	
24	**Sample Analysis and Validation (SA)**	
25	Sample Management (SA.SM)	
26	Data Validation (SA.DV)	
27	**Data Evaluation (DE)**	
28	Data Evaluation (DE.DE)	
29	**RA Reports (AR)**	
30	**Prepare HHRA and ERA Reports (AR.HH) & (AR.ER)**	
31	Prepare Draft HHRA and ERA Reports	
32	Submit Draft HHRA and ERA Reports	11/26
33	Navy Review	
34	Prepare Draft Final HHRA and ERA Reports and Executive Summ:	
35	Submit Draft Final HHRA and ERA Reports and Executive Summa	12/26
36	Navy and Regulatory Review	
37	Prepare Final HHRA and ERA Reports and Executive Summary	
38	Submit Final HHRA and ERA Reports	2/9
39	**RI Report (RI)**	
40	Prepare Draft RI Reports (RI.DR)	
41	Submit Draft RI Reports	11/26
42	Navy Review	
43	Prepare Draft Final RI Reports and Executive Summary (RI.DF)	
44	Submit Draft Final RI Reports and Executive Summary	12/26
45	Navy and Regulatory Review	
46	Prepare Final RI Reports and Executive Summary (RI.FR)	
47	Submit Final RI Reports	2/9
48	**Remedial Alternatives Screening (AS)**	
49	AlternativesDevelopment and Screening (AS.AD)	

Timescale: October (28, 5, 12, 19, 26), November (2, 9, 16, 23), December (30, 7, 14, 21), January (28, 4, 11, 18, 25), February (1, 8, 15, 22), March (1, 8, 15, 22), April (29, 5, 12, 19, 26), May (3, 10, 17, 24), June (31, 7, 14, 21), July (28, 5, 12, 19, 26), August (2, 9, 16, 23), September (30, 6, 13, 20), October (27, 4, 11, 18, 25), Nov (1, 8)

Date: 5/9/97 | Task | Milestone | Summary

ID	Task Name
50	Technology Screening (AS.AT)
51	General Response Actions (AS.GR)
52	**Alternatives Evaluation (AE)**
53	Alternative Evaluations (AE.AE)
54	Cost Estimate (AE.EC)
55	**FS Report (FS)**
56	Prepare Draft FS Reports (FS.DR)
57	Submit Draft FS Reports
58	Navy Review
59	Prepare Draft Final FS Reports (FS.DF)
60	Submit Draft Final FS Reports
61	Navy and Regulatory Review
62	Prepare Final FS Report (FS.FR)
63	Submit Final FS Report
64	**Post RI/FS Support (PS)**
65	**Prepare PRAPs and RODs (PS.PS)**
66	Prepare Draft PRAPs
67	Submit Draft PRAPs
68	Navy Review of PRAPs
69	Prepare Draft Final PRAPs
70	Submit Draft Final PRAPs
71	Navy and Regulatory Review of PRAPs
72	Prepare Final PRAPs
73	Public Notice (PS.PN)
74	Prepare Draft RODs
75	Navy Review of RODs
76	Prepare Draft Final ROD
77	Navy and Regulatory Review of RODs
78	Submit Final PRAPs and RODs



Date: 5/9/97 | Task | Milestone ◆ | Summary

Table 7-1
PROPOSED PROJECT MILESTONES
RI/FS Landfill C (Site 3) and Landfill D (Site 4)
CONTRACT TASK ORDER 0027

Key Project Milestones	Number of Days From Award	Interval	Date of Completion
Notice to Proceed	1	1	9/20/96
Kick Off Meeting and Visual Site Inspection	21	1	10/10/96
Submit Draft WP and SAP	59	1	11/18/96
Submit Draft Final WP and SAP	73	1	1/29/97
Submit Final WP and SAP	119	1	5/9/97
RI Fieldwork	134	44	6/23/97
Laboratory Analyses	173	60	8/25/97
Data Validation/Management	173	80	9/27/97
Submit Draft HHRA and ERA Report	292	1	11/29/97
Submit Draft Final HHRA and ERA Report	322	1	12/29/97
Submit Draft RI Report	292	1	11/26/97
Submit Draft Final RI Report	322	1	12/26/97
Submit Final HHRA and ERA Report	366	1	2/12/98
Submit Final RI Report	366	1	2/9/98
Submit Draft FS Report	373	1	2/16/98
Submit Draft Final FS Report	417	1	3/30/98
Submit Final FS Report	461	1	5/14/98
Submit Draft PRAP	476	1	5/29/98
Submit Draft Final PRAP	501	1	6/23/98
Submit Final PRAP and ROD	641	1	11/10/98

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Final

Sampling and Analysis Plan
Remedial Investigation and Feasibility Study
Landfill C (Site 3) and Landfill D (Site 4)

St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order 0027

May 9, 1997

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CDM Federal Programs Corporation

Fairfax, Virginia

Submitted by

CH2M HILL

Herndon, Virginia

Preface

This Sampling and Analysis Plan (SAP) is written for the Remedial Investigation and Feasibility Study (RI/FS) to be performed at the Landfill C (Site 3) and the Landfill D (Site 4) at the St. Juliens Creek Annex, Chesapeake, Virginia. Specifically, this SAP focuses on the sampling activities associated with monitoring well installation, and sampling of soil, groundwater, surface water, and sediment. The SAP is comprised of four separate plans.

1. The Quality Assurance Project Plan (QAPP)—The QAPP describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve Data Quality Objectives (DQOs) as dictated by the intended use of the data.

2. The Field Sampling Plan (FSP)—The FSP provides guidance for all fieldwork by defining in detail the sampling and data-gathering methods to be used during field activities.

3. The Health and Safety Plan (HASP)—The HASP describes the health and safety program for field activities. The HASP identifies potentially hazardous operations and exposures and prescribes appropriate protective measures.

4. The Investigation-Derived Waste Management Plan (IDWMP)—The IDWMP provides guidance and assigns responsibility for the disposal of investigation-derived waste (IDW). The IDWMP describes both well-site disposal and containerization and temporary storage of certain IDW.

Final
Quality Assurance Project Plan
Landfill C (Site 3) and Landfill D (Site 4)
Remedial Investigation and Feasibility Study

St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order 0027

May 9, 1997

Prepared for

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Acronyms and Abbreviations

BOD	Biochemical Oxygen Demand
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
CofC	Chain-of-Custody
DQOs	Data Quality Objectives
EPA	Environmental Protection Agency
FSP	Field Sampling Plan
GPR	Ground Penetrating Radar
HASP	Health and Safety Plan
LANTDIV	U.S. Navy Naval Facilities Engineering Command, Atlantic Division
LQAP	Laboratory Quality Assurance Plan
MS	Matrix Spike
MSD	Matrix Spike Duplicate
µg/l	Micrograms per liter
NFESC	Navy Facilities Engineering Services Command
OLC02	EPA analytical method for Organic Low Concentration Water
OVM	Organic Vapor Monitor
%R	Percent Recovery
PCB	Polychlorinated biphenyl
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RSD	Relative Standard Deviation
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SOW	Statement of Work
SVOCs	Semivolatile Organic Compounds
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds

Section 1

Introduction

This plan describes the Quality Assurance and Quality Control (QA/QC) procedures used for conducting soil, groundwater, surface water, and sediment sampling activities at Landfill C (Site 3) and Landfill D (Site 4) at St. Juliens Creek Annex, Chesapeake, Virginia. The Quality Assurance Project Plan (QAPP) focuses on the sampling activities for the RI/FS. All field sampling and laboratory analyses will be conducted in accordance with the *Navy Installation Restoration Laboratory Quality Assurance Guide*, February 1996.

Section 2

Project Description

Landfill C and Landfill D are located in the northeast corner of St. Juliens Creek Annex in Chesapeake, Virginia. Landfill C was an unlined landfill that operated from 1940 to 1970. Refuse disposed of at the landfill included solvents (TCE), acids, bases, and mixed municipal waste; the total volume of disposal was estimated to be 750,000 cubic feet prior to burning. The 10 acre area was originally a mudflat where refuse was dumped and allowed to burn. The ash was then used to fill in the area. Two pits reportedly used for disposal of oils and oily sludge's and for periodic burning were also located at the Landfill C site. The exact locations of the sludge pits are unknown. The landfill has been graded level and covered with grass.

Landfill D covers an estimated 5 acres approximately 300 feet south of Landfill C. Landfill D was an unlined trench and fill landfill that operated from 1970 to 1981. Refuse disposed of at Landfill D included drums of unknown wastes and polychlorinated biphenyls (PCBs). According to personnel at the public works department, the PCBs probably came from ballast containers for fluorescent light fixtures. The RFA indicated that several tanks with undetermined wastes were also once located in the area. Total volumes of disposal are unknown. The first trench was approximately 1,000 feet long and was located parallel to and 500 feet north of Blows Creek. The total number of trenches dug in the landfill is not known.

The work plan for the Site 3 and Site 4 RI/FS provides a more detailed history of the use and disposal practices at the landfills, an evaluation of the data collected during previous investigations at the site, and a description of activities to be performed.

The objectives of the sampling work to be performed in relation to Site 3 and Site 4 are to:

- Conduct a surface geophysical survey to estimate the fill acreage for each landfill and characterize the soil profile above the water table. The electromagnetic survey method EM-31 will be used to delineate site boundaries. Landfill D will also be surveyed by method EM-61 and ground penetrating radar (GPR). The survey traverses of the sites will be conducted on a perpendicular grid pattern with 100-foot centers. Continuous EM readings will be collected along each traverse.

- Install and develop a total of eight shallow (20 foot) and four deep (60 foot) alluvial monitoring wells (five at each site), including both upgradient and downgradient wells. Where possible, the shallow and deep alluvial monitoring wells will be paired to provide a vertical profile of groundwater quality. If a confining unit is detected, the deep wells will be constructed to isolate the unconfined water table aquifer from the underlying confined aquifer.

- Collect two rounds of groundwater samples from the newly installed monitoring wells (12 wells per sampling event) to characterize the groundwater quality and the nature and extent of groundwater contamination.

- Collect 17 surface soil and 17 subsurface soil samples from Site 3 and Site 4 to characterize the nature and extent of surface and subsurface soil contamination. All surface soil samples will be collected at depths of 0 - 0.25 feet bgs. Sixteen of the subsurface soil samples will be collected just above the water table at depths of 3 - 5 feet bgs and four of the subsurface soil samples will be composite samples of soil from 0 - 3 feet bgs. Two surface and two subsurface soil samples will be collected proximal to each landfill at locations considered to represent upgradient conditions. Where possible, surface and subsurface samples will be collected from the same locations (not including composite samples).

- Collect six (three at each site) surface water samples to assess the horizontal distribution of surface water contamination. Surface water samples will be collected at each site from areas of ponded water, drainage ditches, or streams adjacent to each site. Two surface water samples will be collected proximal to each landfill, where possible, at locations considered to represent upgradient conditions.

- Collect eight (four at each site) sediment samples to assess the horizontal distribution of surface water contamination. Six sediment samples will be located at corresponding surface water locations. The two additional sediment sample locations will be located within and downgradient of the site. Two sediment samples will be collected proximal to each landfill, where possible, at locations considered to represent upgradient conditions.

- All solid samples will be analyzed for EPA's Target Compound List (TCL) organics (volatiles, semivolatiles, pesticide/PCBs),, Target Analyte List (TAL) inorganics (metals and cyanide), and total phosphorous. In addition, sediment samples will also be analyzed for total organic carbon (TOC). Aqueous samples will be analyzed for TCL volatiles, semivolatiles, pesticide/PCBs, TAL inorganics, and total phosphorous. The volatile fraction of the groundwater and surface water samples will be analyzed by EPA's Contract Laboratory Program (CLP) Statement of Work (SOW) for Low Concentration Water (OLC02) in order to achieve the lower detection limits necessary for risk assessment. Surface water samples will be additionally analyzed for hardness, alkalinity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), and total suspended solids (TSS). The compound list is found in Table 1-1 of the Field Sampling Plan. All analytical results to be used in risk assessment will require Navy Level D QA/QC.

Section 3

Project Organization

Mr. Michael Tilchin will serve as the activity manager and the primary contact at CH2M HILL. Mr. Tilchin will assume primary responsibility for ensuring that the work is performed in a manner that is acceptable to LANTDIV. With the activity manager's oversight, the project manager, Mr. Dave Schroeder, of CDM Federal, will be responsible for such activities as budget and schedule review and tracking, preparation and review of invoices, personnel resources planning and allocation, and coordination with LANTDIV, the Naval Base, and subcontractors. Dr. Robert Root, of CH2M HILL and Ms. Joan Knapp, of CDM Federal will provide senior review. Figure 3-1 represents a chart view of the project organization.

The RI/FS field investigation tasks (soil, groundwater, surface water, and sediment) will be performed by the CDM Federal supporting field personnel. CH2M HILL will notify LANTDIV and St. Juliens Creek Annex which CDM Federal personnel will mobilize to the site prior to initiating field activities. A field task manager will be assigned to lead all field activities. This person will be responsible for assuring that the SAP is being followed, maintaining the field log book, monitoring the site for all releases, and other activities. The field staff will be responsible for collecting the samples, supervising subcontractors, completing sample paperwork, shipping samples, etc.

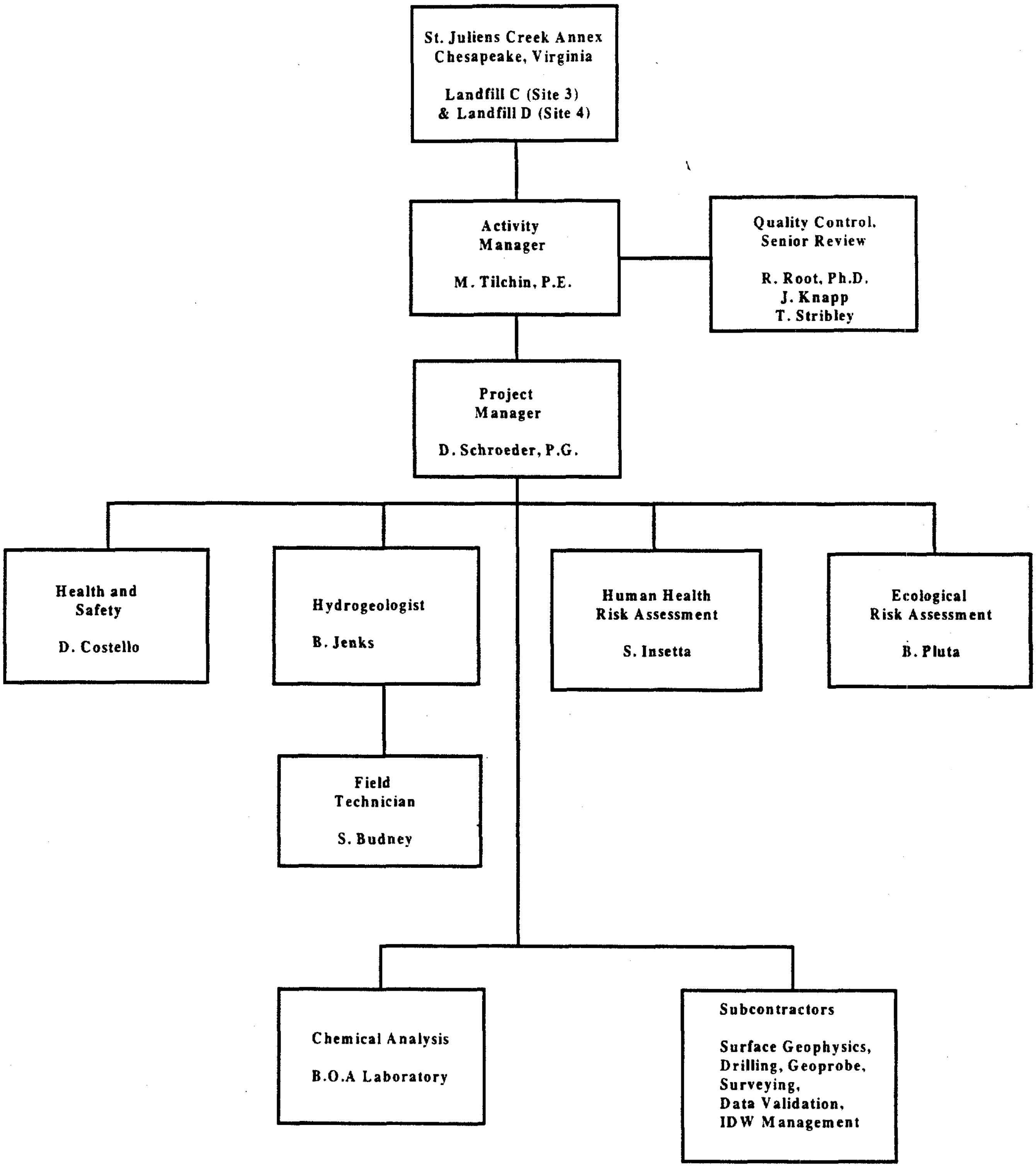

Figure 3-1
PROJECT ORGANIZATION
SITE 3-LANDFILL C AND SITE 4-LANDFILL D
St. Juliens Creek Annex, Chesapeake

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Section 4

Quality Assurance Objectives

Data Quality Objectives (DQOs) will be established for each major sample collection effort as specified in the *Data Quality Objectives for Remedial Response Activities*, March 1987. DQOs are the quantitative and qualitative descriptions of the quality of data required to support an environmental decision or action. As target values for data quality, they are not necessarily criteria for acceptance or rejection of data. DQOs for a site vary according to the end use of the data. Everyone from the data gatherer to the analytical laboratory is involved in the DQO development process from the beginning.

The fundamental mechanisms that will be employed to achieve quality goals are:

- prevention of errors through planning, documented instructions and procedures, and careful selection and training of personnel
- assessment of data through field and laboratory audits and data validation of the analytical results
- correction of errors through a corrective action program.

The four documents in the SAP (QAPP, FSP, HASP, and IDWMP) contain the plans and procedures for safe, competent sampling and for effective management of the data. Each laboratory providing analytical data for the RI/FS has developed its own Laboratory Quality Assurance Plan (LQAP). The SAP and the LQAP must address the elements of the Navy QA Program.

Audits in the field and in the laboratories will determine how the QA/QC procedures are being implemented. Any discrepancies will be addressed through the corrective action programs described in the SAP and LQAP.

The detection limits achieved by the EPA's TCL organics and TAL inorganics analyses for soil are adequate to meet the DQOs for this project. Groundwater and surface water samples will be analyzed for TCL volatiles, semivolatiles and pesticide/PCBs, TAL inorganics, and total phosphorous. Groundwater samples will be analyzed by OLC02 to meet the low detection limit requirements of risk assessment. Navy D Level data validation for this project will ensure that the data obtained with the EPA protocols will be acceptable.

DQOs are measured by the degree of precision, accuracy, representativeness, completeness, and comparability of the data that is required for the project. The project precision and accuracy objectives for laboratory analysis are included in Table 4-1. The quality objectives for field parameters are included in Appendix A of the FSP (i.e., Standard Operating Procedures for pH, conductivity, OVM).

Table 4-1 PRECISION and ACCURACY OBJECTIVES			
Parameter	**Precision (Relative Percent Difference)**	**Accuracy (% Spike Recovery)**	**Intended Data Use**
Groundwater and Surface Water			
TCL Volatiles	< ±20	80-120	Determine extent of contamination Risk assessment
Low Concentration Volatiles	< ±20	80-120	Determine extent of contamination Risk assessment
TCL Semivolatiles	< ±20	80-120	Determine extent of contamination Risk assessment
TCL Pesticides/PCBs	< ±20	80-120	Determine extent of contamination Risk assessment
TAL Metals and Cyanide	< ±20	80-120	Determine extent of contamination Risk assessment
Soil and Sediment			
TCL Volatiles	< ±25	75-125	Determine extent of contamination Risk assessment
TCL Semivolatiles	< ±25	75-125	Determine extent of contamination Risk assessment
TCL Pesticides/PCBs	< ±25	75-125	Determine extent of contamination Risk assessment
TAL Metals and Cyanide	< ±25	75-125	Determine extent of contamination Risk assessment

Accuracy and Precision

Accuracy is a measure of the agreement between an experimental result and the true value of the parameter. Analytical accuracy can be determined using known reference materials or matrix spikes. Spiking of reference materials into the actual sample matrix is the preferred technique because it quantifies the effects of the matrix on the analytical accuracy. Accuracy can be expressed as the percent recovery (%R) as determined by the following equation:

$$\%R = \frac{SSR - SR}{SA} \times 100$$

where:

SSR = spiked sample result
SR = sample result (native)
SA = spike added

Precision is the measure of the agreement or repeatability of a set of duplicate results obtained from repeat determinations made under the same conditions. The precision of a duplicate determination can be expressed as the relative percent difference (RPD) which is determined by the following equation:

$$RPD = \frac{|X1 - X2|}{X1 + X2} \times 200$$

where:

X1 = first duplicate value

X2 = second duplicate value

For a given laboratory analysis, the duplicate RPD values are tabulated, and the mean and standard deviation of the RPD are calculated. Control limits for precision are usually plus or minus two standard deviations from the mean.

Accuracy and precision will be monitored by using field duplicate, matrix spike, and matrix spike duplicate samples. These data alone cannot be used to evaluate accuracy and precision of individual samples but will be used to assess the long-term accuracy and precision of the analytical method.

Completeness

Completeness is defined as the percentage of analytical measurements made that are judged to be valid, with validity being defined by the DQOs. Percent completeness is calculated as the number of valid analyses divided by the total number of analyses performed multiplied by 100. The completeness goal for the project is 85 percent.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent parameter variations at a sampling point. Representativeness is a measure of how closely the measured results reflect the actual distribution and concentration of certain chemical compounds in the medium sampled. The FSP describes the procedures to be used to collect samples. This process will generate samples that are as representative as possible. Documentation of laboratory and field procedures, as described in the FSP, will be used to establish that protocols have been followed and that sample identification and integrity have been maintained.

Comparability

Comparability is the term that describes the confidence with which one data set can be compared to another. Comparability refers to such issues as using standard field and analytical techniques, following the same QA/QC procedures, and reporting data in the same units. This criterion becomes important if more than one field team is collecting samples or more than one laboratory is analyzing the samples. Consistency in sampling and laboratory procedures will be maintained throughout the project. (See the FSP for a discussion of sampling procedures.) In addition, accepted methodologies will be used for sample analysis, and these methods will not be changed during the project.

Section 5

Sample Collection Procedures

A detailed description of sampling procedures is provided in the attached FSP and Appendix A of the FSP. Procedures are included that describe, at a minimum:

- Sample plan design considerations
- Sampling point selection
- Sample packing, handling, and shipment (including time considerations)
- Special conditions for sample container preparation and time requirements (tabulated)
- Preparation and use of trip blanks and field blanks
- Documentation of sampling activities

The composite samples sent for volatile analysis will require special handling during sample collection so that the sample will be exposed to the least amount of air. The aliquots from each depth will be layered directly into the volatile jar, and the jar will be tightly capped between additions, as detailed in the FSP. The laboratory will be instructed to mix the sample before analysis.

Section 6

Sample Custody

Essential to any sampling and analytical program is maintaining the integrity of the sample from collection to data reporting. This requires tracking the possession and handling of samples from the time of collection, through analysis, to final disposal. This documentation is referred to as chain-of-custody (CofC). Figure 6-1 shows an example of a CofC form. The essential components of this CofC are described in the FSP and summarized below.

Field Custody

The sample coordinator is responsible for the care and custody of samples until they are shipped or otherwise delivered to the laboratory custodian.

Transfer of Custody

The CofC form must be completed before samples are shipped. The persons involved in relinquishing and receiving the samples will sign, date, and note the time of sample receipt on the CofC form. The first such transfer may occur between the field sampler and the sample carrier. Another transfer may occur between the sample carrier and the laboratory sample custodian. Each sample shipment will be accompanied by a CofC record that identifies the contents of the shipment.

Laboratory Custody

Laboratory custody procedures are detailed in each laboratory's Quality Assurance Plan (LQAP). The laboratory custodian will verify that the custody seals on the sample shipment or the containers are intact and that the information on the CofC matches the actual contents. The laboratory custodian will also note any anomalies, such as broken bottles, elevated temperatures, and missing labels. The project-specific procedures for sample custody are described fully in the FSP.

Sample Disposal

Unless otherwise instructed, the analytical laboratory will dispose of unused sample portions, according to Resource Conservation and Recovery Act (RCRA) regulations and the LQAP, after the analyses have been completed and any outstanding issues between the contractor and the laboratory have been resolved.

CDM FEDERAL PROGRAMS CORPORATION

13135 Lee Jackson Memorial Highway, Suite 200
Fairfax, Virginia 22033
703-968-0900

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT LEADER	REMARKS
PROJECT NAME/LOCATION		

ESD SAMPLE TYPES

1. SURFACE WATER
2. GROUND WATER
3. POTABLE WATER
4. WASTEWATER
5. LEACHATE
6. SOIL/SEDIMENT
7. SLUDGE
8. WASTE
9. AIR
10. FISH
11. OTHER ______

SAMPLERS (SIGN)

CIRCLE/ADD parameters desired. List no. of containers submitted

ANALYSES

STATION NO.	SAMPLE TYPE	19__ DATE	TIME	COMP	GRAB	STATION LOCATION/DESCRIPTION	TOTAL CONTAINERS	METALS	EXT ORG/PEST/PCBs	VOA	CYANIDE					TAG NO./REMARKS	LAB USE ONLY

RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)
(SIGN)		(SIGN)	(SIGN)		(SIGN)
RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)
(SIGN)		(SIGN)	(SIGN)		(SIGN)

DISTRIBUTION: White and Pink copies accompany sample shipment to laboratory Pink copy retained by laboratory

Figure 6-1

Example of a Chain of Custody Record

Section 7

Equipment Calibration

Various instruments will be used in the field and in the laboratory to collect data and monitor site conditions. Proper calibration, maintenance, and use of these instruments is important for collecting quality data. A record of calibration and maintenance activities is as important as the data record itself in order to verify the delivery of quality data.

Field Equipment Calibration

The field equipment to be used during this investigation that will require calibration includes:

- pH Meter
- Conductivity Meter
- Organic Vapor Monitor (OVM)
- Dissolved Oxygen (DO) Meter
- Oxidation/Reduction Potential Meter
- Explosimeter

These instruments will be calibrated before and during each day's use according to procedures and schedules outlined in the Health and Safety Plan (HASP) and in the FSP. The standards which will be used to calibrate these instruments are shown in Table 7-1. Standards will be purchased as necessary from appropriate vendors.

If an individual suspects an equipment malfunction, the device shall be removed from service and tagged so that it is not inadvertently used, and the equipment manager notified so that a substitute piece of equipment can be used. Backup equipment will be available in the field for use in the event of a malfunction.

Equipment that fails calibration or becomes inoperable during use shall be removed from service and tagged so that it is not inadvertently used. Such equipment shall be repaired and satisfactorily recalibrated. Equipment that cannot be repaired will be replaced.

Results of activities performed using equipment that has failed recalibration shall be evaluated. If the results are adversely affected, the outcome of the evaluation will be documented and the task manager will be notified.

Laboratory Equipment Calibration

The laboratory itself is responsible for equipment and instrument calibration and maintenance. Manufacturer's guidance shall be followed for general upkeep. Laboratory calibration procedures are outlined in the LQAP and will be provided by the accepted laboratory.

Table 7-1

CALIBRATION STANDARDS

Instrument	Calibration Standard	Span	Reading	Method
OVM	100 ppm isobutylene	RF = 0.55	100 ppm	1.5 l/m reg: T-tubing
pH Meter	pH 4 and 7 Buffers	N/A	N/A	N/A
Conductivity Meter	EC 225 and 1,000 µs/cm	N/A	N/A	N/A

Section 8

Analytical Procedures

All laboratory analyses will be performed by an approved laboratory meeting U.S. Navy Level D quality control. The laboratories will be procured using the Basic Ordering Agreements (BOAs). Until the BOAs with CH2M HILL are in place, the BOA laboratories from Baker will be utilized. Laboratory procedures to be used for the project are listed in Table 8-1.

Table 8-1
ANALYTICAL PROCEDURES

Analysis	Methodology
TCL Volatiles, Semivolatiles, and Pesticides/PCBs	U.S. EPA CLP SOW for Organic Analysis OLMOL7 (7/91) or most recent revision
Low Concentration Volatiles (for groundwater samples)	U.S. EPA CLP SOW for Low Concentration Water OLC02 (8/94)
TAL Metals and Cyanide	U.S. EPA CLP SOW for Inorganic Analysis (9/91) or most recent revision
Total Phosphorous	SM 4500 ③
TOC (sediment samples)	EPA MCAWW Methods 415.1 / 415.2 ②
Alkalinity (surface water samples)	EPA MCAWW Method 310 ②
BOD/COD (surface water samples)	EPA MCAWW Methods 405.1/410 ②
TDS/TSS (surface water samples)	EPA MCAWW Methods 160.1/160.2 ②
Hardness (for surface water samples)	EPA MCAWW Method 130.1 ②

① = U.S. EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846. (11/90).

② = U.S. EPA Methods for the Chemical Analysis of Water and Wastes (MCAWW). (1983).

③ = Standard Methods for the Examination of Water and Wastewater. 17th Edition. (1989).

Section 9

Data Reduction, Validation, and Record Keeping

Data reduction and reporting are steps in the overall management and use of both field and laboratory data, and data validation is a step in the overall management and use of laboratory data. Figure 9-1 shows the flow of information and sample tracking forms.

Data Reduction

Data reduction, validation, and reporting will ensure that all documents for the investigations can be accounted for when they are completed. Accountable documents include items such as logbooks, field data records, correspondence, CofC records, analytical reports, data packages, and reports.

Definition

Analytical data collected will be computerized. Electronic data will be requested for all analyses from the laboratory in a format agreed upon by the data manager. Other types of analytical data will be entered and then verified by spot-checking procedures. The sample manager will handle data entries that are unverified.

Background Data

Background data produced for internal records and not reported as part of the analytical data include the following: laboratory worksheets, laboratory notebooks, sample tracking system forms, maintenance records, calibration records, and associated quality control. These sources will be available for inspection and to determine the validity of data.

Data Validation

Validation of analytical data will be contracted by CH2M HILL in accordance with Navy Level D QA/QC requirements. The project, its objectives, and the intended use of the data will be discussed with the data validation personnel.

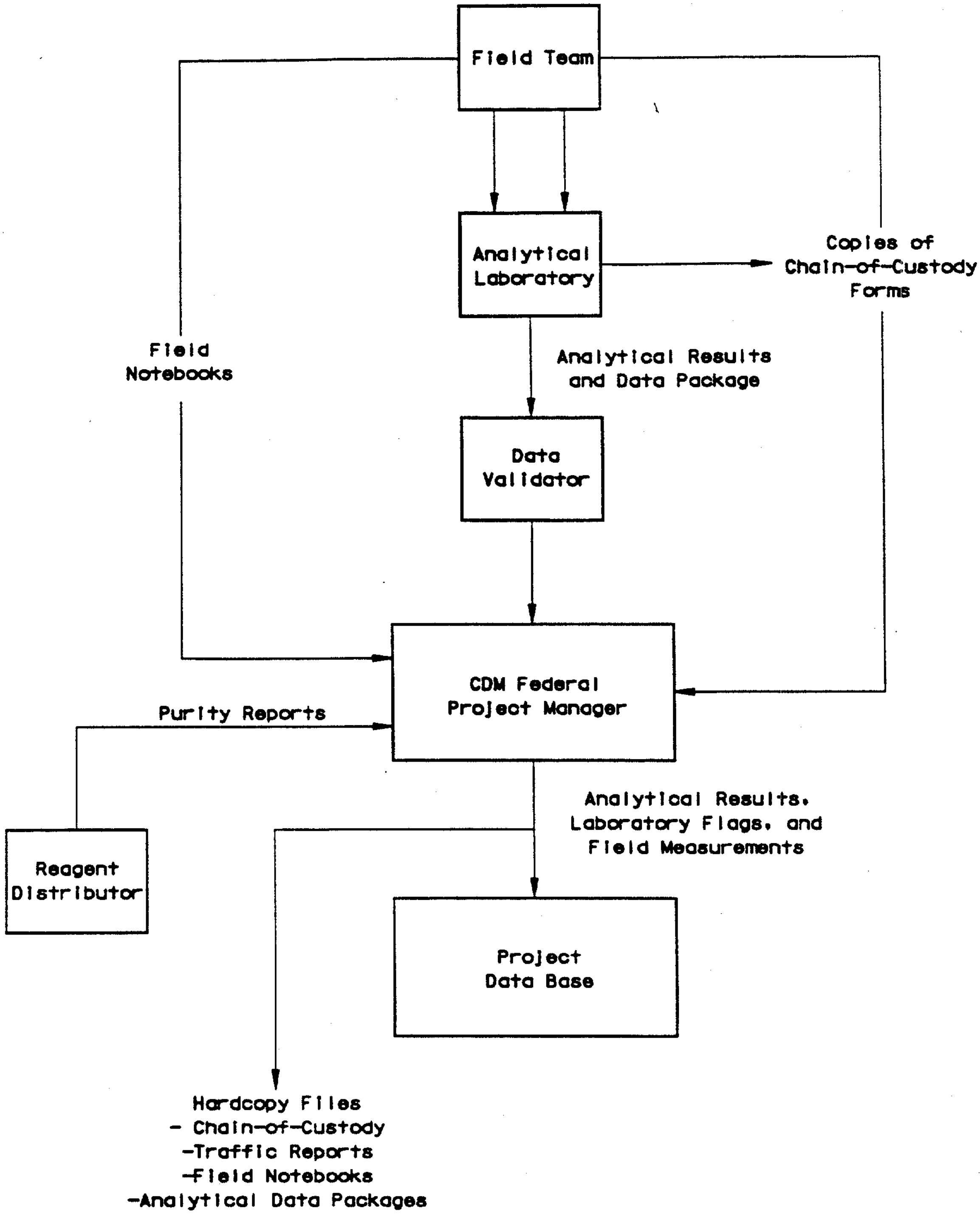

Figure 9-1
FLOW OF FORMS AND SAMPLE AND ANALYSIS INFORMATION

CH2M HILL

Data Records

The following describes procedures for maintaining the project's records:

- The task manager shall determine the records to be generated before the start of work. These records will be listed in the site-specific FSP.
- Records of field activities that support the integrity of samples shall be entered on bound and numbered pages. Such records shall be dated and signed or otherwise authenticated on the day of entry.
- Records retained on file shall be indexed. The indexing system shall include the location of records within the indexing system. (The indexing system shall be in alphabetical, chronological or numerical order, or as otherwise indicated in written procedures.)
- There shall be sufficient information in records to permit identification between the record and the item(s) or activity to which it applies. Identification of records will be by means that permit traceability.
- The records storage system shall provide for accurate retrieval of records without undue delay.

Section 10

Quality Control Checks

A number of QA/QC samples will be collected to check the adequacy of sample collection and analysis and to monitor laboratory performance. Duplicates, blanks, and spiked samples are used to determine if the sampling technique affects the analytical results, to measure the internal consistency of the samples, and to estimate any variance or bias in the analytical process. The field and laboratory QA/QC sampling procedures are described below.

Field Sampling Quality Control Procedures

Quality control duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and an estimate of variance and bias. . Table 10-1 shows the number of each type of field QC sample that should be collected for the number of investigative samples collected. Table 10-2 and Table 10-3 are summaries of the solid and aqueous samples (respectively) that will be collected and submitted to the laboratory. The tables show the collection frequencies of the field QC samples.

Table 10-1
QC COLLECTION FREQUENCIES

Type of QC Sample	Frequency Collected
Field Duplicate	One per 10 samples per matrix.
Trip Blank	One per cooler containing samples for volatile analysis.
Field Blank	One per source water per event.
Equipment Blank	One per day per matrix.
Matrix Spike/Matrix Spike Duplicate	One per matrix for each group of up to 20 samples sent to a single laboratory. MS/MSD is not required for low concentration organic samples.

One duplicate sample will be obtained for every 10 field samples collected. The sampling station from which the duplicate is taken will be randomly selected for each event. Each duplicate sample will be split evenly into two sample containers and submitted for analysis as two independent samples.

Table 10-2
SITE 3 AND SITE 4 SUMMARY OF SOLID SAMPLES TO BE SUBMITTED FOR ANALYSIS

Matrix	Laboratory Parameter	Samples		Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
		Site 3	Site 4						
Soil	TCL Volatiles	14	20	4	1	3	2	3	40
	TCL Semivolatiles	14	20	4	1	0	2	3	40
	TCL Pesticides/PCBs	14	20	4	1	0	2	3	40
	TAL Metals and Cyanide	14	20	4	1	0	2	3	40
	Total Phosphorous	14	20	4	1	0	2	1	40
Sediment	TCL Volatiles	4	4	1	1	1	1	1	10
	TCL Semivolatiles	4	4	1	1	0	1	1	10
	TCL Pesticides/PCBs	4	4	1	1	0	1	1	10
	TAL Metals and Cyanide	4	4	1	1	0	1	1	10
	Total Phosphorous	4	4	1	1	0	1	1	10
	TOC	4	4	1	1	0	1	1	10

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10 per matrix.
[2]Field blanks are collected at a frequency of 1 per source water per event.
[3]Trip blanks are shipped with samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20 per matrix. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. The amount of extra volumes will be determined once the laboratories have been procured.
[5]Equipment blanks are collected at a frequency of 1 per day per matrix.
Aqueous field QC samples associated with the solid samples are provided for informational purposes only and are not included in matrix total. In addition, these samples will be analyzed by the TCL organics method (not low concentration).
This table is based on Navy Level D QA/QC requirements.

Table 10-3
SITE 3 AND SITE 4 SUMMARY OF AQUEOUS SAMPLES TO BE SUBMITTED FOR ANALYSIS

Matrix	Laboratory Parameter	Samples		Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
		Site 3	Site 4						
Groundwater *	Low Concentration Volatiles	12	12	3	2	6	2	6	43
	TCL Semivolatiles	12	12	3	2	0	2	6	37
	TCL Pesticides/PCBs	12	12	3	2	0	2	6	37
	TAL Metals (filtered)	12	12	3	2	0	2	6	37
	TAL Metals (unfiltered)	12	12	3	2	0	2	6	37
	TAL Cyanide	12	12	3	2	0	2	6	37
	Total Phosphorous	12	12	3	2	0	2	6	37
Surface Water	TCL Volatiles	3	3	1	1	1	1	1	11
	TCL Semivolatiles	3	3	1	1	0	1	1	10
	TCL Pesticides/PCBs	3	3	1	1	0	1	1	10
	TAL Metals	3	3	1	1	0	1	1	10
	TAL Cyanide	3	3	1	1	0	1	1	10
	Total Phosphorous	3	3	1	1	0	1	1	10
	Alkalinity	3	3	1	0	0	0	0	7
	BOD/COD	3	3	1	0	0	0	0	7
	TDS/TSS	3	3	1	0	0	0	0	7
	Hardness	3	3	1	1	0	1	1	10

Notes:
* Groundwater samples will be collected in two rounds: 6 samples per landfill per sampling round. This table summarizes the total number of groundwater samples to be collected.
[1]Field duplicates are collected at a frequency of 1 per 10 per matrix.
[2]Field blanks are collected at a frequency of 1 per source water per event.
[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20 per matrix. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. The amount of extra volumes will be determined once the laboratories have been procured.
[5]Equipment blanks are collected at a frequency of 1 per day per matrix.
This table is based on Navy Level D QA/QC requirements.

Matrix spike/matrix spike duplicates (MS/MSD) will be collected at the rate of one for every 20 field samples collected per matrix. MS/MSD samples give an indication of laboratory analysis accuracy and precision within the sample matrix.

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. Three types of blanks can be generated during sampling activities: trip blanks, field blanks, and equipment rinsate blanks.

One trip blank will be included in each cooler used for the daily shipment of Volatile Organic Analysis (VOA) samples. If more than one cooler is being sent on a given day, all of the VOA samples should be placed in one cooler, if possible, to minimize the number of trip blanks needed. The trip blanks will be prepared before each sampling event, shipped or transported to the field with the sampling bottles, and returned unopened for analysis. Trip blanks will indicate if there is any contamination during shipment to the field, from storage in the field, or from shipment from the field to the analytical laboratory.

One equipment blank per sample media will be obtained for each day of sampling. Equipment blanks will give an indication of the efficiency of decontamination procedures.

One field blank will be collected for each sampling event Field blanks are used to determine the chemical quality of water used for such procedures as decontamination and blank collection.

Laboratory Analytical Quality Control Procedures

The analytical laboratory will use the quality control elements including matrix spikes, matrix spike duplicates, and laboratory blanks as specified in the *Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Guidance Document*, February, 1996. Field quality control procedures are provided in Appendix A of the FSP.

Matrix Spike/Matrix Spike Duplicate

Matrix spike/matrix spike duplicates will be spiked by the laboratory in two separate aliquots of a sample selected by the sampler from each batch of 20 field samples per matrix. The MS/MSDs will be used to assess accuracy and precision. The MSD is identical to the MS; both are analyzed to determine the reproducibility of the results. The sampler will collect triple volume (for aqueous matrices) of one sample to provide the laboratory with enough material to analyze the sample, the spiked sample, and the spiked sample duplicate. MS/MSDs are not required for the low concentration method, as the laboratory performs other QC (lab control samples) with this method.

Section 11

Performance and Systems Audits

Both field and laboratory audits will be conducted.

Laboratory Performance and Systems Audits

The analytical laboratories will conduct internal quality control checks as indicated in each laboratory's LQAP. The laboratories are subject to external audits by the Navy and CH2M HILL.

Field Team Performance and Systems Audits

A performance audit will be conducted on an as-needed basis by the project manager during the sampling activities to verify that proper sampling and documentation procedures presented in the QAPP and the FSP are followed and that subsequent sample data are valid. The audit will focus on the details of the QA program. The audit checklist, which will serve as the guide for performing audits for field procedures, is shown in Figure 11-1. The audit will evaluate the following:

- Project responsibilities
- Sample collection and preservation procedures
- Equipment decontamination procedures
- Field equipment calibration procedures
- Sample custody procedures
- Document control
- Sample identification system
- QC corrective action procedures

An audit report summarizing any results and corrections will be prepared and filed in the project files. Significant variances from established procedures will be reported to the project manager.

Section 12

Preventive Maintenance

Routine maintenance procedures and schedules for sampling equipment are described in the manufacturer's instruction manuals. All records of inspection and maintenance will be dated and documented in the field notebook.

Maintenance procedures and schedules for all field and laboratory analytical instruments will follow the recommendations of the equipment manufacturers. Routine laboratory equipment maintenance will be performed by laboratory personnel as needed or as indicated in the LQAP. All records of inspection and maintenance will be dated and documented in laboratory record books.

Critical spare parts for the pH, OVM, conductivity meter, and explosimeter include batteries, electrodes, and membranes. They will be included in the sampling kits to minimize downtime. In addition, back-up meters will be available, if needed. Spare parts will be purchased from accepted vendors.

Section 13

Data Assessment Procedures

The precision and accuracy of data will be routinely assessed to ensure that they meet the requirements of the DQOs.

All data will be validated before interpretation by a subcontractor. The validation will be performed according to *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Organic Analysis 1988,* and the *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses,* 1988 or most recent revision.

Data validation will be performed by an independent contractor, as it would not be appropriate for CH2M HILL or CDM Federal to validate data collected by their staff. Data that should be qualified will be flagged with the appropriate symbol. Results for field and equipment blanks will be reviewed, and the data will be qualified further, if necessary. Finally, the data set as a whole will be examined for consistency, anomalous results, and reasonableness.

Section 14

Corrective Actions

The project manager is responsible for initiating corrective actions. Corrective action steps will include problem identification, investigation responsibility assignment, action to eliminate the problem, increased monitoring of the effectiveness of the corrective action, and verification that the problem has been eliminated.

Examples of corrective actions include, but are not limited to, correcting CofC forms, analysis reruns (if holding time criteria permit), recalibration with fresh standards, replacement of sources of blank contamination, examination of calculation procedures, additional training in sample preparation and analysis, reassignment of analytical responsibilities using a different batch of containers, or recommending an audit of laboratory procedures. Additional approaches may include:

- Resampling and analyzing
- Evaluating and amending sampling and analytical procedures
- Accepting the data and acknowledging the level of uncertainty or inaccuracy by flagging the data and providing an explanation for the qualification.

Section 15

Quality Assurance Reports

A QA report will be completed at the end of the field activity to summarize the QA/QC status of the project and any problems. The report will be an assessment of the measured QA parameters (for example, precision and accuracy), results of performance audits, any reported non-conformance, and any significant QA problems and the recommended solutions. Any change in the QAPP will be summarized in a report or letter and sent to LANTDIV and distributed to the CH2M HILL and CDM Federal project teams.

Final

Field Sampling Plan
Remedial Investigation/Feasibility Study
Landfill C (Site 3) and Landfill D (Site 4)

St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order 0027

May 9, 1997

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

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Prepared By

CDM Federal Programs Corporation

Fairfax, Virginia

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Appendix

A Standard Operating Procedures

Section 1

Sampling Program

This Field Sampling Plan (FSP) documents procedures and practices to be followed during the Remedial Investigation (RI) and Feasibility Study (FS) at Landfill C (Site 3) and the Landfill D (Site 4) at the St. Juliens Creek Annex, Chesapeake, Virginia. Samples will be collected from various media, including soil, groundwater, sediment, and surface water. The location of Site 3 and Site 4 are depicted on Figure 1-1. The following sections document the sampling program for each media. All sample analyses will be performed in accordance with standard EPA methods and procedures by a contracted laboratory that fulfills all requirements of the U.S. Navy's QA/QC Program Manual and EPA's Contract Laboratory Program. A signed certificate of analysis will be provided with each laboratory analysis, along with a certificate of compliance certifying that all work was performed in accordance with the applicable federal, state, and local regulations. All analyses will be performed following the Navy's guidance for Level D. Table 1-1 lists the analytical parameters included on EPA's Target Compound List (TCL) and Target Analyte List (TAL).

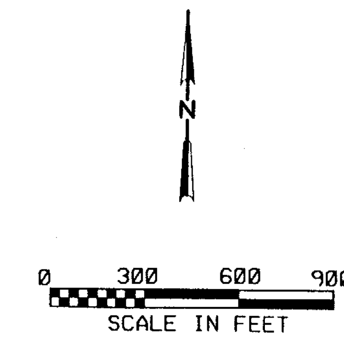
Soil and Sediment Investigation

The soil and sediment sampling program includes the collection of surface soil samples using a trowel and sub-surface and composite sub-surface soil samples during Geoprobe® direct push collection activities. Sediment sampling will also be performed at both sites. The number of samples and specific analyses performed are outlined below. Table 1-2 and Table 1-3 summarize the soil and sediment sampling program for each site giving the sampling location and analyses to be performed for each sample.

Split-spoon sampling (lithologic logging) will be performed during the installation of monitoring wells, however, samples collected during monitoring well installation will not be submitted for laboratory analysis.

Soil Sampling

A total of 17 surface soil samples and 17 subsurface soil samples will be collected during the Site 3 and Site 4 RI/FS field activities. One surface soil and one subsurface soil sample will be collected from each of the sites at locations representative of upgradient conditions. Five subsurface soil samples from Site 3 and eight subsurface soil samples from Site 4 will be collected just above the water table from a depth of approximately 3-5 feet. The remaining two subsurface soil samples at each site will be composited from soil collected between 0-3 feet. The composite samples will be used for ecological evaluation; no upgradient composite samples will be collected. Seventeen surface soil samples (seven at Site 3 and ten at Site 4) will be collected at depths of 0 - 0.25 feet bgs for use in the risk assessment.



LEGEND

NUMBER	SITE NAME/DESCRIPTION
3	LANDFILL C
4	LANDFILL D

Figure 1-1
INSTALLATION LOCATION MAP
St. Juliens Creek Annex

CH2M HILL

098A032

Table 1-1 ANALYTICAL PARAMETERS	
Volatile Organic Compounds on Target Compound List (TCL) (Soil Samples)	
Acetone	1,2-Dichloropropane
Benzene	cis-1,3-Dichloropropene
Bromoform	trans-1,3-Dichloropropene
Bromodichloromethane	Ethylbenzene
Bromomethane	2-Hexanone
2-Butanone	4-Methyl-2-Pentanone
Carbon Disulfide	Methylene Chloride
Carbon Tetrachloride	Styrene
Chlorobenzene	1,1,2,2-Tetrachloroethane
Chloroethane	Tetrachloroethene
Chloroform	Toluene
Chloromethane	1,1,1-Trichloroethane
Dibromochloromethane	1,1,2-Trichloroethane
1,1-Dichloroethane	Trichloroethene
1,2-Dichloroethane	Vinyl Chloride
1,1-Dichloroethene	Xylenes (total)
1,2-Dichloroethene (total)	
Volatile Organic Compounds Under Low Concentration Method OLC02 (Aqueous Samples)	
Acetone	1,1-Dichloroethene
Benzene	1,2-Dichloroethene (total)
Bromoform	cis-1,2-Dichloroethane
Bromochloromethane	trans-1,2-Dichloroethene
Bromodichloromethane	1,2-Dichloropropane
Bromomethane	cis-1,3-Dichloropropene
2-Butanone	trans-1,3-Dichloropropene
Carbon Disulfide	1,2,4-Trichlorobenzene
Carbon Tetrachloride	Ethylbenzene
Chlorobenzene	2-Hexanone
Chloroethane	4-Methyl-2-Pentanone
Chloroform	Methylene Chloride
Chloromethane	Styrene
1,2-Dibromo-3-chloropropane	1,1,2,2-Tetrachloroethane
Dibromochloromethane	Tetrachloroethene
1,2-Dibromoethane	Toluene
1,2-Dichlorobenzene	1,1,1-Trichloroethane
1,3-Dichlorobenzene	1,1,2-Trichloroethane
1,4-Dichlorobenzene	Trichloroethene
1,1-Dichloroethane	Vinyl Chloride
1,2-Dichloroethane	Xylenes (total)

Table 1-1
ANALYTICAL PARAMETERS

Semivolatile Organic Compounds on Target Compound List (TCL)	
1,2-Dichlorobenzene	2,4-Dinitrophenol
1,3-Dichlorobenzene	4-Nitrophenol
1,4-Dichlorobenzene	Dibenzofuran
Phenol	2,4-Dinitrotoluene
bis-(2-Chloroethyl)ether	Diethylphthalate
2-Chlorophenol	4-Chlorophenyl-phenylether
2-Methylphenol	Fluorene
2,2′-oxybis(1-Chloropropane)	4-Nitroaniline
4-Methylphenol	4,6-Dinitro-2-methylphenol
N-Nitroso-di-n-propylamine	N-Nitrosodiphenylamine
Hexachloroethane	4-Bromophenyl-phenylether
Nitrobenzene	Hexachlorobenzene
Isophorone	Pentachlorophenol
2-Nitrophenol	Phenanthrene
2,4-Dimethylphenol	Anthracene
bis-(2-Chloroethoxy)methane	Di-n-butylphthalate
2,4-Dichlorophenol	Carbazole
1,2,4-Trichlorobenzene	Fluoranthene
Naphthalene	Pyrene
4-Chloroaniline	Butylbenzylphthalate
Hexachlorobutadiene	3,3′-Dichlorobenzidine
4-Chloro-3-methylphenol	Benzo(a)anthracene
2-Methylnaphthalene	Chrysene
Hexachlorocyclopentadiene	bis-(2-Ethylhexyl)phthalate
2,4,6-Trichlorophenol	Di-n-octylphthalate
2,4,5-Trichlorophenol	Benzo(b)fluoranthene
2-Chloronaphthalene	Benzo(k)fluoranthene
2-Nitroaniline	Benzo(a)pyrene
Dimethylphthalate	Indeno(1,2,3-cd)pyrene
Acenaphthylene	Dibenz(a,h)anthracene
2,6-Dinitrotoluene	Benzo(g,h,i)perylene
3-Nitroaniline	
Acenaphthene	

Dioxin Analysis List	
2,3,7,8- TCDD	1,2,3,7,8,9- HxCDD
1,2,3,7,8- PeCDD	1,2,3,4,6,7,8- HpCDD
1,2,3,6,7,8- HxCDD	1,2,3,4,6,7,8,9- OCDD
1,2,3,4,7,8- HxCDD	

Table 1-1 ANALYTICAL PARAMETERS	
Pesticides and PCBs on Target Compound List (TCL)	
alpha-BHC	4,4-DDT
beta-BHC	Methoxychlor
delta-BHC	Endrin ketone
gamma-BHC (Lindane)	Endrin aldehyde
Heptachlor	alpha-Chlordane
Aldrin	gamma-Chlordane
Heptachlor epoxide	Toxaphene
Endosulfan I	Aroclor-1016
Dieldrin	Aroclor-1221
4,4′-DDE	Aroclor-1232
Endrin	Aroclor-1242
Endosulfan II	Aroclor-1248
4,4′-DDD	Aroclor-1254
Endosulfan sulfate	Aroclor-1260
Inorganics on Target Analyte List (TAL)	
Aluminum	Lead
Antimony	Magnesium
Arsenic	Manganese
Barium	Mercury
Beryllium	Nickel
Cadmium	Potassium
Calcium	Selenium
Chromium	Silver
Cobalt	Sodium
Copper	Thallium
Cyanide	Vanadium
Iron	Zinc

Table 1-2
SOIL AND SEDIMENT SAMPLING PROGRAM FOR SITE 3 (LANDFILL C) RI/FS

Site	Sampling Location	TCL VOC	TCL SVOC	TCL Pest/PCB	TAL Metals and Cyanide (total)
Site 3	SJS3-SS01	X	X	X	X
Site 3	SJS3-SS02	X	X	X	X
Site 3	SJS3-SS03	X	X	X	X
Site 3	SJS3-SS04	X	X	X	X
Site 3	SJS3-SS05	X	X	X	X
Site 3	SJS3-SS06	X	X	X	X
Site 3	SJS3-SS07	X	X	X	X
Site 3	SJS3-SB01	X	X	X	X
Site 3	SJS3-SB02	X	X	X	X
Site 3	SJS3-SB03	X	X	X	X
Site 3	SJS3-SB04	X	X	X	X
Site 3	SJS3-SB05	X	X	X	X
Site 3	SJS3-SB06	X	X	X	X
Site 3	SJS3-SB07	X	X	X	X
Site 3	SJS3-SD01①	X	X	X	X
Site 3	SJS3-SD02①	X	X	X	X
Site 3	SJS3-SD03①	X	X	X	X
Site 3	SJS3-SD04①	X	X	X	X

① = Sediment samples will also be analyzed for total organic carbon.
②= All samples will be analyzed for total phosphorus

Table 1-3
SOIL AND SEDIMENT SAMPLING PROGRAM FOR SITE 4 (LANDFILL D) RI/FS

Site	Sampling Location	TCL VOC	TCL SVOC	TCL Pest/PCB	TAL Metals and Cyanide (total)
Site 4	SJS4-SS01	X	X	X	X
Site 4	SJS4-SS02	X	X	X	X
Site 4	SJS4-SS03	X	X	X	X
Site 4	SJS4-SS04	X	X	X	X
Site 4	SJS4-SS05	X	X	X	X
Site 4	SJS4-SS06	X	X	X	X
Site 4	SJS4-SS07	X	X	X	X
Site 4	SJS4-SS08	X	X	X	X
Site 4	SJS4-SS09	X	X	X	X
Site 4	SJS4-SS10	X	X	X	X
Site 4	SJS4-SB01	X	X	X	X
Site 4	SJS4-SB02	X	X	X	X
Site 4	SJS4-SB03	X	X	X	X
Site 4	SJS4-SB04	X	X	X	X
Site 4	SJS4-SB05	X	X	X	X
Site 4	SJS4-SB06	X	X	X	X
Site 4	SJS4-SB07	X	X	X	X
Site 4	SJS4-SB08	X	X	X	X
Site 4	SJS4-SB09	X	X	X	X
Site 4	SJS4-SB10	X	X	X	X
Site 4	SJS4-SD01①	X	X	X	X
Site 4	SJS4-SD02①	X	X	X	X
Site 4	SJS4-SD03①	X	X	X	X
Site 4	SJS4-SD04①	X	X	X	X

① = Sediment samples will also be analyzed for total organic carbon.
②= All samples will be analyzed for total phosphorus

Surface soil samples and subsurface soil samples (except composite samples) will be collected from the same locations. All surface soil samples will be collected with the use of a stainless steel hand trowel and all subsurface soil samples will be collected with the use of a Geoprobe® type sampling rig. Figure 1-2 and Figure 1-3 depict the soil and sediment sampling locations for Site 3 and Site 4, respectively.

All soil samples will be analyzed for TCL organics (volatiles, semivolatiles, and pesticides/PCBs), TAL inorganics (metals and cyanide), and total phosphorous.

Sediment Sampling

A total of eight sediment samples will be collected during the RI/FS field activities. Two sediment samples will be collected at each site from an area which represents upgradient conditions. The remaining sediment samples (two from each site) will be collected from surface water drainage ditches and low lying areas located within and downgradient of the sites. It is anticipated that sediment samples at Site 3 will be collected in the areas of the sites where standing water was observed during the site visit. These areas are typically linear, topographically lower land depressions, outside the sites estimated boundaries. Other areas noted during the site visit that are proposed sediment sample locations are surface depressions within and outside the site boundaries. The sediment sampling locations for Site 3 are shown on Figure 1-2 and Site 4 sampling locations are shown on Figure 1-3. Sampling locations will be selected in the field based on areas of observed surface water pooling in drainage ditches and low lying areas. One of the sediment sampling locations is proposed at the confluence of a drainage way and St. Juliens Creek. This sample will represent contaminants in the sediment leaving the site. Conditions in St. Juliens Creek will not be investigated at this time. In the event that no standing water is visible at the time of the RI/FS field activities, sampling locations will be randomly selected to provide an overall assessment of the horizontal distribution of sediment contamination derived from the erosion and deposition of contaminated site soil. Four of the sediment sample locations will be co-located with surface water locations as described below. All sediment samples will be analyzed for TCL organics, TAL inorganics, total phosphorous, and total organic carbon. Field measurements of temperature, conductivity, Eh, pH, and Munsell color will also be collected.

Groundwater and Surface Water Investigation

Groundwater and surface water samples will be collected during the RI/FS field activities. The groundwater and surface water investigation activities are discussed below. Table 1-4 and Table 1-5 summarize the number of samples and specific analyses to be performed during the Site 3 and Site 4 RI/FS, respectively.

In order to achieve the lower detection limits required for risk assessment, the volatile fraction of the groundwater sample will be analyzed by the EPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Low Concentration Water (OLC02).

Table 1-4
GROUNDWATER AND SURFACE WATER SAMPLING PROGRAM FOR SITE 3 - LANDFILL C

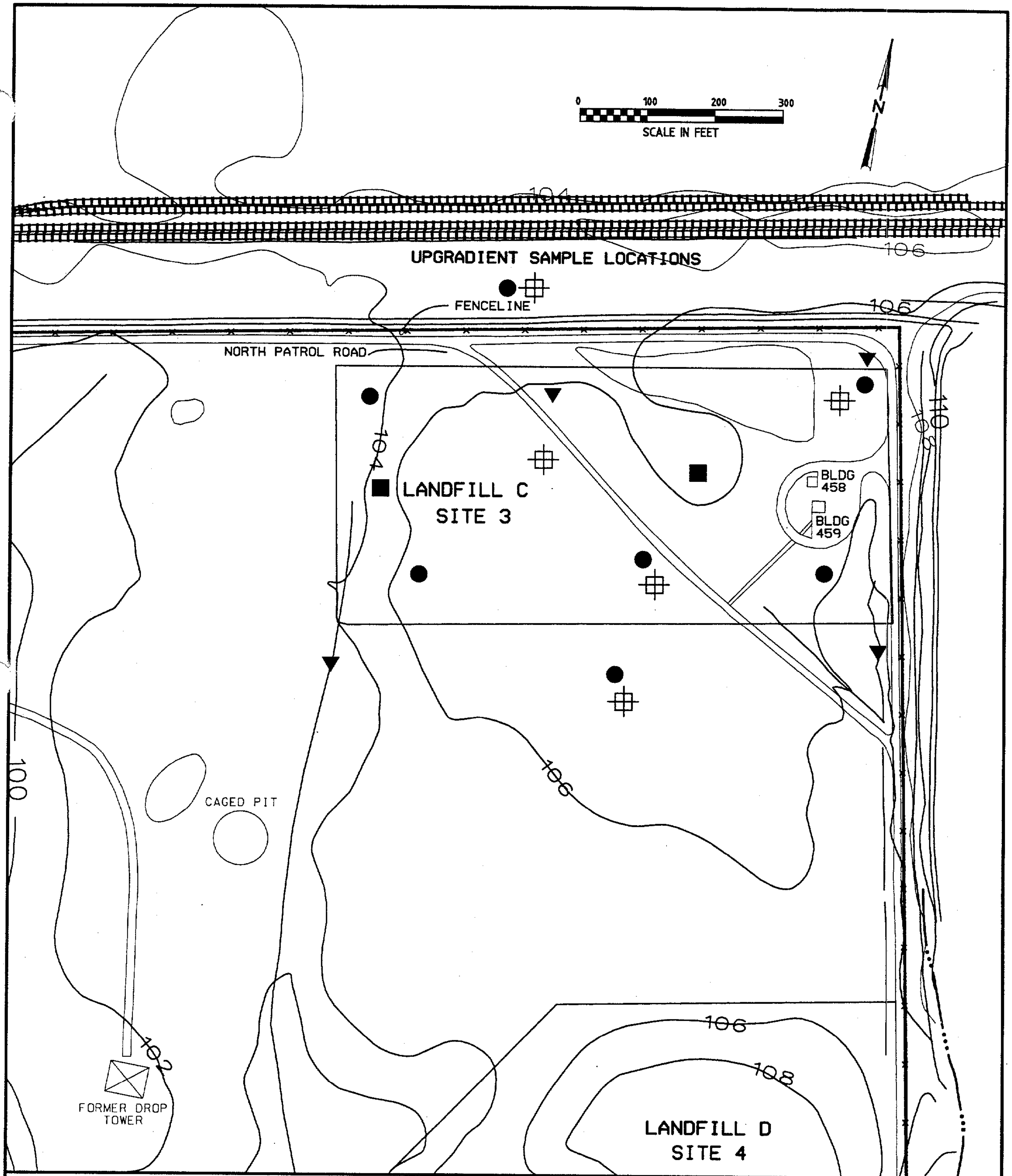
Site	Sampling① Location	TCL VOC	TCL SVOC	TCL Pest/PCB	TAL Metals (total and dissolved)	Cyanide
Site 3	SCS3-GW01	X	X	X	X	X
Site 3	SCS3-GW02	X	X	X	X	X
Site 3	SCS3-GW03	X	X	X	X	X
Site 3	SCS3-GW04	X	X	X	X	X
Site 3	SCS3-GW05	X	X	X	X	X
Site 3	SCS3-GW06	X	X	X	X	X
Site 3	SCS3-GW07	X	X	X	X	X
Site 3	SCS3-GW08	X	X	X	X	X
Site 3	SCS3-GW09	X	X	X	X	X
Site 3	SCS3-GW10	X	X	X	X	X
Site 3	SCS3-GW11	X	X	X	X	X
Site 3	SCS3-GW12	X	X	X	X	X
Site 3	SCS3-SW01②	X	X	X	X	X
Site 3	SCS3-SW02②	X	X	X	X	X
Site 3	SCS3-SW03②	X	X	X	X	X

Notes:
① Groundwater Samples will be analyzed for VOAs using low concentration method. Groundwater samples SCS3-GW07 through SCS3-GW12 will be collected during the second round of groundwater sampling.
② Surface water samples will also be analyzed for water quality parameters including hardness, alkalinity, BOD, COD, TDS, and TSS.
②= All samples will be analyzed for total phosphorus

Table 1-5
GROUNDWATER AND SURFACE WATER SAMPLING PROGRAM FOR SITE 4 - LANDFILL D

Site	Sampling① Location	TCL VOC	TCL SVOC	TCL Pest/PCB	TAL Metals (total and dissolved)	Cyanide
Site 4	SCS4-GW01	X	X	X	X	X
Site 4	SCS4-GW02	X	X	X	X	X
Site 4	SCS4-GW03	X	X	X	X	X
Site 4	SCS4-GW04	X	X	X	X	X
Site 4	SCS4-GW05	X	X	X	X	X
Site 4	SCS4-GW06	X	X	X	X	X
Site 4	SCS4-GW07	X	X	X	X	X
Site 4	SCS4-GW08	X	X	X	X	X
Site 4	SCS4-GW09	X	X	X	X	X
Site 4	SCS4-GW10	X	X	X	X	X
Site 4	SCS4-GW11	X	X	X	X	X
Site 4	SCS4-GW12	X	X	X	X	X
Site 4	SCS4-SW01②	X	X	X	X	X
Site 4	SCS4-SW02②	X	X	X	X	X
Site 4	SCS4-SW03②	X	X	X	X	X

① = Groundwater samples will be analyzed for VOA's using low concentration method. Groundwater samples SCS4-GW07 thruSCS4-GW12 will be collected during the second round of groundwater sampling.
② = Surface water samples will also be analyzed for water quality parameters including hardness, alkalinity, BOD, COD, TDS, and TSS.
②= All samples will be analyzed for total phosphorus



LEGEND

- ● Surface soil sample location
- ■ Composite soil sample location (0-3')
- ⊕ Subsurface soil sample location
- ▼ Sediment sample location

Figure 1-2
PROPOSED SOIL AND SEDIMENT
SAMPLING LOCATIONS
SITE 3 – LANDFILL C
St. Juliens Creek Annex

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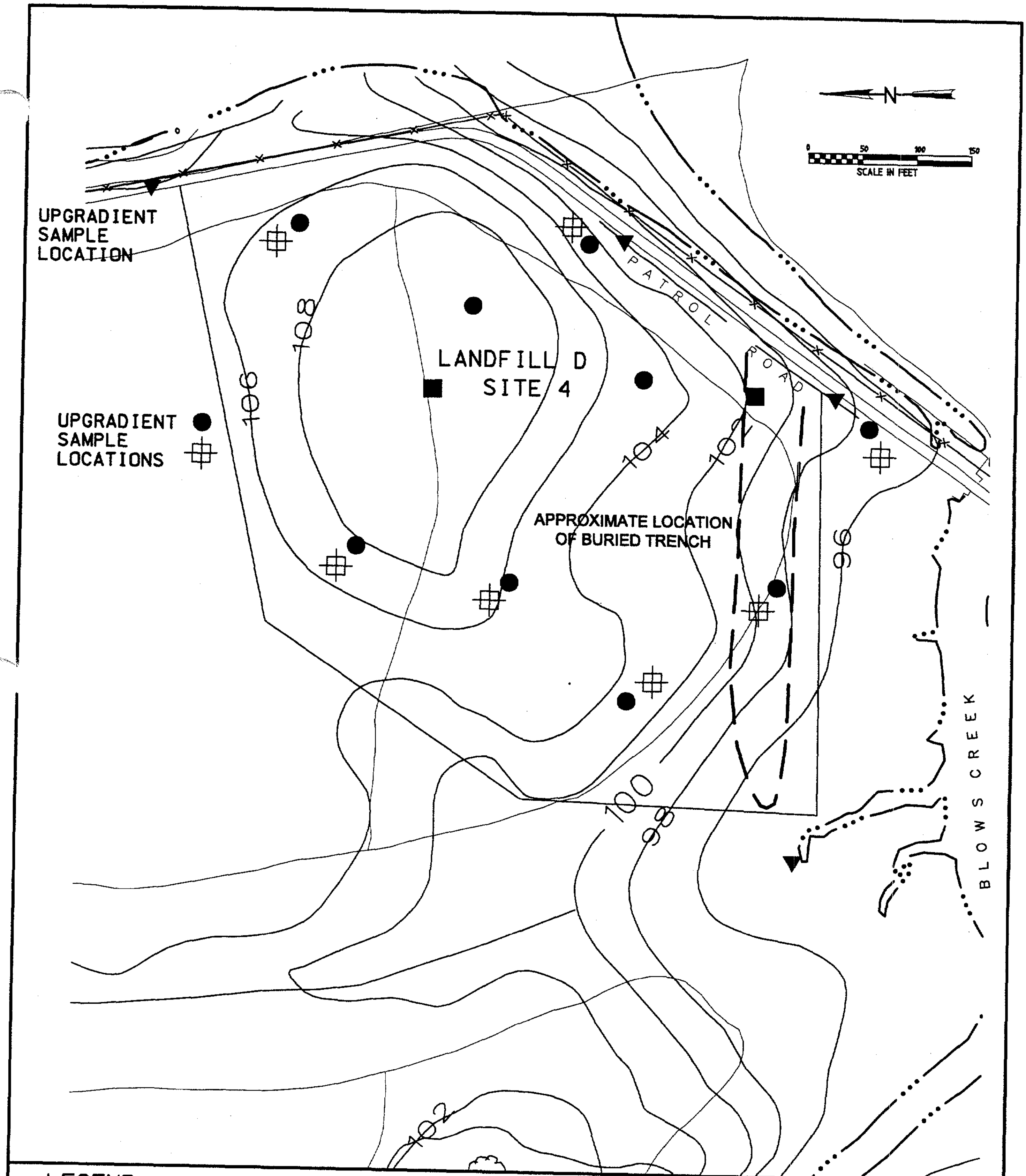


LEGEND

- ● Surface soil sample location
- ■ Composite soil sample location (0-3')
- ⊕ Subsurface soil sample location
- ▼ Sediment sample location

Figure 1-3
PROPOSED SOIL AND SEDIMENT SAMPLING LOCATIONS
SITE-4 LANDFILL D
St. Juliens Creek Annex

CH2M HILL

Groundwater Sampling

Unfiltered and filtered groundwater samples will be collected from the 12 newly installed monitoring wells using a Grundfos® Redi-Flo 2 sampling pump. In the event that the sampling pump is not able to be used, the sample will be collected using a Teflon® bailer.

Groundwater samples on which metals analysis will be conducted will be split into two portions. One portion will be filtered through a 0.45-micron membrane filter, transferred to a bottle and analyzed for dissolved metals. The remaining portion will be transferred to a bottle and analyzed for total metals. The dissolved metals portion will be preserved after filtration.

Figure 1-4 and Figure 1-5 illustrate the monitoring well locations for Site 3 and Site 4 respectively. All groundwater samples will be analyzed for TCL organics, TAL inorganics, and total phosphorous. The volatile fraction of the organic groundwater sample will be analyzed using the EPA low concentration water method OLC02.

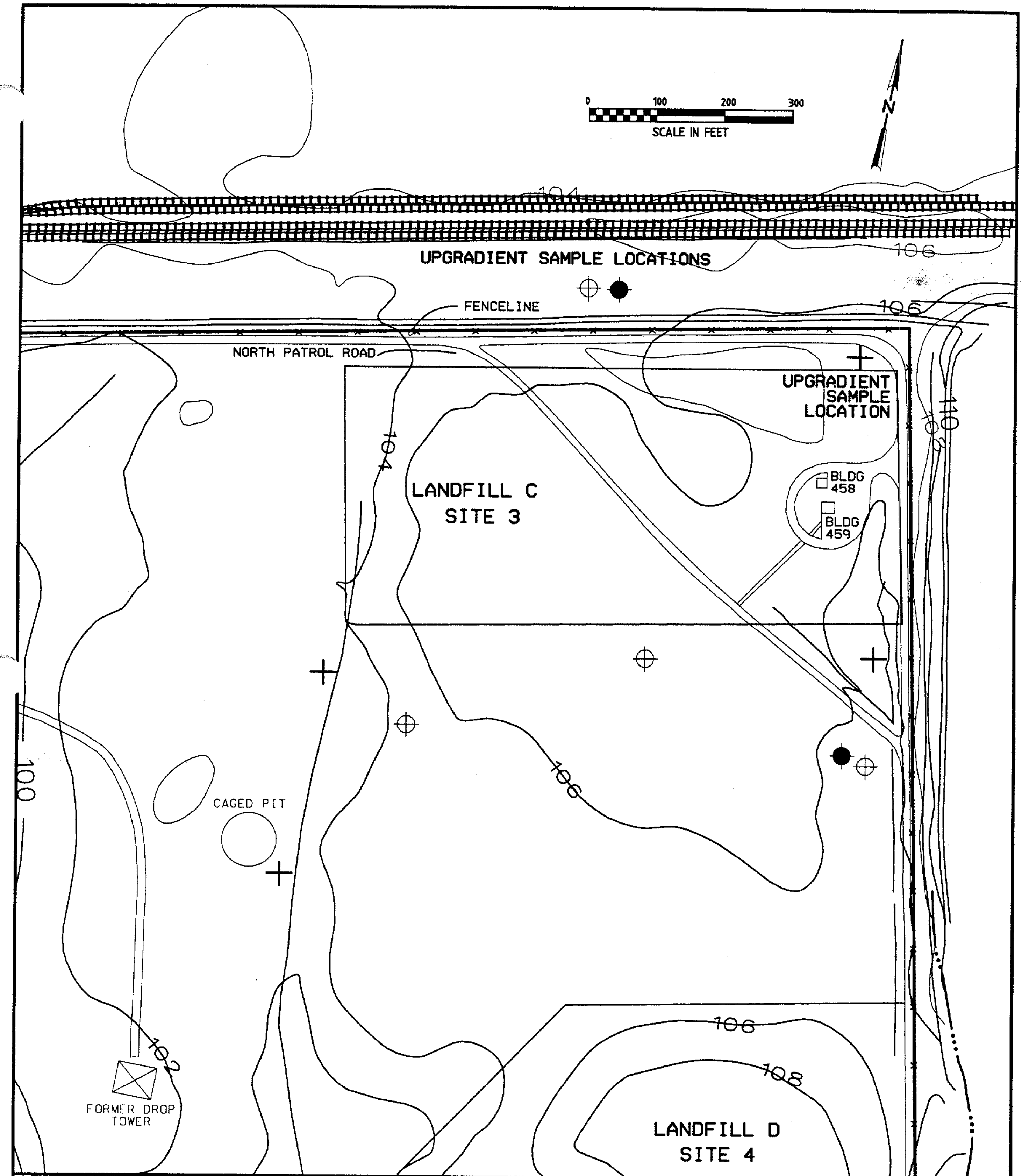
Surface Water Sampling

Figure 1-4 and Figure 1-5 depict the Site 3 and Site 4 proposed surface water sampling locations. These locations are in low-lying drainage areas observed during the site visit. Three surface water samples will be collected at each site for a total of six surface water samples for both sites. One surface water sample will be collected from each site at a location considered to represent upgradient conditions. The remaining four surface water samples (two from each site) will be collected from water bodies (drainage ditches, ponded water) adjacent to the sites. Each of the six surface water samples will be co- located with and sampled during sediment sample collection. Exact sampling locations will be selected in the field based on observed areas of surface water ponding in drainage ditches and adjacent water bodies in the event that the proposed locations are found to be dry during the RI/FS activities. If possible, surface water sampling will be conducted during a rainy period when the sample locations have received overland flow.

All surface water samples will be analyzed for TCL organics, TAL inorganics, total phosphorous, alkalinity, hardness, BOD, COD, total suspended solids, and total dissolved solids. Field measurements for pH and temperature will also be collected.

Surveying

The 12 newly installed monitoring wells will be surveyed for horizontal and vertical control by a subcontracted surveyor licensed in the Commonwealth of Virginia. In addition, all soil, sediment, and surface water sampling locations will be surveyed for horizontal control.



LEGEND

+ Surface water sample location

⊕ Shallow monitoring well location

● Deep monitoring well location

Figure 1-4
PROPOSED MONITORING WELL AND
SURFACE WATER SAMPLING LOCATIONS
SITE 3 - LANDFILL C
St. Juliens Creek Annex

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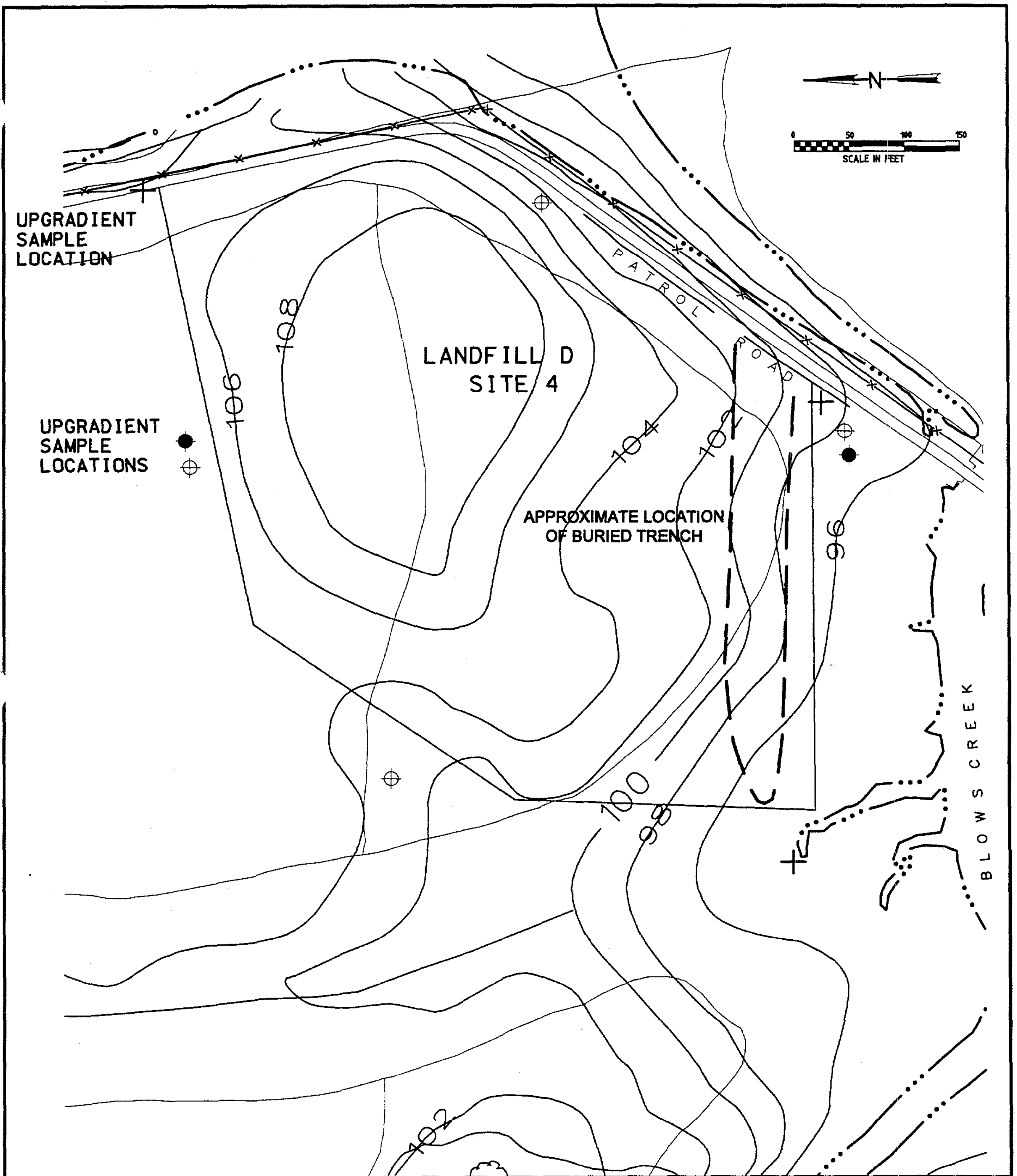

LEGEND

- Surface water sample location
- Shallow monitoring well location
- Deep monitoring well location

Figure 1-5
PROPOSED MONITORING WELL AND SURFACE WATER SAMPLING LOCATIONS
SITE-4 LANDFILL D
St. Juliens Creek Annex

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Section 2

Sampling Operations

All aspects of the sampling operations will conform to U.S. Navy specifications and guidelines. This includes the frequency of collecting and providing QC samples: duplicates; trip, field, and equipment blanks; and matrix spike and matrix spike duplicates.

Soil and Sediment Sampling Techniques

The RI/FS activities at Site 3 and Site 4 will involve the collection of soil and sediment samples. Several different sampling techniques will be employed during the soil and sediment sampling phase of the investigation including: Geoprobe® rig and drill rig split spoon sampling, stainless-steel trowel sampling, and grab sampling with a Ponar Dredge. A brief explanation of each sampling technique is provided below. The Standard Operating Procedures (SOPs) for the collection of soil and sediment samples are included in Attachment A.

Split Spoon and Geoprobe® Sampling

Direct push sampling techniques will be used at locations where samples are being collected from several different depths or where compaction of the soil has made sample collection using manual sampling techniques impossible. A Geoprobe® rig will be used to advance a drive point to the top of the desired sampling interval. The drive point will then be removed and a stainless-steel split spoon sampler will be used to collect the sample. If necessary, several samples within a 1-foot diameter area will be collected at each location to acquire the volume of sample needed to fill all sample containers. The split spoon sampler will then be retrieved and the sample will be extruded.

The volatile organic compound (VOC) sample containers will be filled first. The sample will be placed directly into the VOC sample container to minimize the volatilization of organic compounds. Where samples are being composited from several different intervals at the same boring location, one third of the VOC sample container will be filled at each interval. The VOC sample container will be tightly closed when soil is not being added. The remaining sample volumes will be placed into a stainless-steel bowl and mixed thoroughly. After mixing, all other sample containers will be filled. For composite samples, the VOC sample containers will be filled prior to homogenization.

Lithologic split-spoon sampling will be conducted at all monitoring well locations. Lithologic samples will be collected on five foot centers (0-2, 5-7, 10-12, etc.) during drilling of the shallow monitoring wells. Deep monitoring wells will have continuous lithologic samples collected. Deep monitoring wells will not be logged until after the last sample depth of the corresponding shallow monitoring well.

Stainless-Steel Trowel

A stainless-steel trowel will be used during the collection of sediment samples and shallow soil samples in areas where manual soil sampling techniques can be applied. The trowel will be used to transfer the soil or sediment from the sampling location into the sample containers. The VOC sample containers will be filled first. The sample will be placed directly into the VOC sample container to minimize the volatilization of organic compounds. The remaining sample volume will be placed into a stainless-steel bowl and mixed thoroughly. After mixing, all other sample containers will be filled.

Ponar Dredge Sampling

A Ponar Dredge will be used to collect sediment samples from beneath any surface water greater than 1-foot in depth. The ponar dredge is a "clamshell" type sampling device consisting of the bucket/jaws and the sampler arms. During sampling activities, a length of rope is attached to a ring on the top of the sampler arms. The sampler arms are then pushed towards the bucket to open the sampler jaws. The jaws are locked in the open position by inserting a spring-loaded steel pin through a small hole in the arms. The sampler is lifted by the rope, with the sampler's weight creating the tension which holds the locking pin in place. The sampler is lowered until the sediments are encountered, pulled up approximately 6-inches, and allowed to free fall. With the tension relieved, the spring on the locking pin forces the pin out of the hole in the arms. As the sampler is retrieved, the jaws close trapping the sediment sample inside. Any surface water entrapped in the sampler is slowly decanted through a screened port on the top of the ponar.

The VOC sample containers will be filled first. The sample will be placed directly into the VOC sample container to minimize the volatilization of organic compounds. The remaining sample volume will be placed into a stainless-steel bowl and mixed thoroughly. After mixing, all other sample containers will be filled.

All samples will be placed in clean glass containers provided by the laboratory. Any sample that is split for duplicate analysis will be mixed thoroughly before being split (except for VOCs). Table 2-1 presents the required containers, preservatives, and holding times for soil and sediment samples. Table 2-2 presents a summary of soil and sediment samples to be submitted for analyses.

Groundwater and Surface Water Sampling Techniques

Groundwater samples will be collected from the ten newly installed monitoring wells using a Grundfos® Redi-Flo 2 sampling pump. In the event that the sampling pump is not able to be used, the sample will be collected using a Teflon® bailer. Surface water samples will be collected from the drainage ditch which accepts surface water runoff from the facility. A brief explanation of the groundwater and surface water sampling techniques to be employed during the RI/FS at Site 3 and Site 4 are provided below. Detailed descriptions of monitoring well and surface water sampling techniques are included in Attachment A.

Table 2-1
REQUIRED CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR SOIL AND SEDIMENT SAMPLES

Analysis	Sample Container	Preservative	Holding Time	Volume of Sample Collected
TCL Volatiles	4-oz glass bottle with Teflon-lined cap	Cool to 4°C	14 days	Fill completely
TCL Semivolatiles	Two 4-oz glass bottles with Teflon-lined cap	Cool to 4°C	14 days	Fill completely
TCL Pest/PCB	Two 4-oz glass bottles with Teflon-lined cap	Cool to 4°C	14 days	Fill completely
TAL Inorganics	4-oz glass bottle with Teflon-lined cap	Cool to 4°C	6 months	Fill to shoulder
Total Phosphorus	Two 4-oz glass bottles with Teflon-lined cap	Cool to 4°C	7 days	Fill to shoulder
Total Organic Carbon	16-oz. glass jar w/ Teflon lid	Cool to 4°C	28 days	Fill to shoulder

Note: Refer to Table 2-3 for the required containers, preservatives, and holding times for the associated aqueous field quality control samples.

Table 2-2
SITE 3 AND SITE 4 SUMMARY OF SOIL AND SEDIMENT SAMPLES TO BE SUBMITTED FOR ANALYSIS

Matrix	Laboratory Parameter	Samples		Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
		Site 3	Site 4						
Soil	TCL Volatiles	14	20	4	1	3	2	3	40
	TCL Semivolatiles	14	20	4	1	0	2	3	40
	TCL Pesticides/PCBs	14	20	4	1	0	2	3	40
	TAL Metals and Cyanide	14	20	4	1	0	2	3	40
	Total Phosphorous	14	20	4	1	0	2	1	40
Sediment	TCL Volatiles	4	4	1	1	1	1	1	10
	TCL Semivolatiles	4	4	1	1	0	1	1	10
	TCL Pesticides/PCBs	4	4	1	1	0	1	1	10
	TAL Metals and Cyanide	4	4	1	1	0	1	1	10
	Total Phosphorous	4	4	1	1	0	1	1	10
	TOC	4	4	1	1	0	1	1	10

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10 per matrix.
[2]Field blanks are collected at a frequency of 1 per source water per event.
[3]Trip blanks are shipped with samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatile organic samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20 per matrix. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. The amount of extra volumes will be determined once the laboratories have been procured.
[5]Equipment blanks are collected at a frequency of 1 per day per matrix.
Aqueous field QC samples associated with the solid samples are provided for informational purposes only and are not included in matrix total. In addition, these samples will be analyzed by the TCL organics method (not low concentration).
This table is based on Navy Level D QA/QC requirements.

Monitoring Well Sampling

Before sampling, groundwater will be purged from each well. The volume of groundwater in the monitoring well will be calculated using values for the depth of the well, the depth to water, and the well diameter. Purging will be performed until a minimum of three well volumes of water have been removed and the temperature, specific conductance, and pH have stabilized within 10 percent for three consecutive readings. Sampling will commence when the parameter measurements have stabilized. Wells that are pumped dry during purging will be allowed to recover before sampling; the sample will be obtained as soon as a sufficient volume of groundwater to fill all sample containers has entered the well. The Investigation Derived Waste Management Plan (IDWMP) discusses treatment and disposal of purge water.

Samples will be placed in containers and preserved according to the Navy's Level D protocol and analyzed within the proper holding time. For VOC samples the bottles will be filled so as to minimize aeration of the samples. Sample vials will be filled completely and capped to prevent the entrapment of any air bubbles in the vial. Groundwater samples on which metals analysis will be conducted will be split into two portions. One portion will be filtered through a 0.45-micron membrane filter, transferred to a bottle and analyzed for dissolved metals. The remaining portion will be transferred to a bottle and analyzed for total metals.

Table 2-3 presents the required containers, preservatives, and holding times for groundwater and surface water samples. Table 2-4 presents a summary of groundwater and surface water to be submitted for analysis.

The bottle cap should be removed carefully from the laboratory cleaned sample bottle. The cap should not be laid down nor the inside touched. At no time should the inside of the bottle come into contact with anything other than the sample.

All appropriate preservatives will be added to the sample containers by the contracted laboratory before shipment to the CDM Federal field team. TCL VOC samples will be preserved with hydrochloric acid (HCl), TAL metals samples will be preserved with nitric acid (HNO_3), and cyanide samples will be preserved with sodium hydroxide (NaOH). All samples will be kept cool at 4°C, using bagged ice.

Groundwater samples will also be measured for temperature, pH, conductivity, and dissolved oxygen in the field.

Surface Water Sampling

Surface water samples will be collected by submersing the sampling container directly into the surface water body. Care will be taken to ensure that the body of the sampling container is facing downstream so that any sediment disturbed during the immersion of the container does not enter the sampling vessel. If the volume of surface water encountered is insufficient to allow the direct submersion of the sampling containers, a glass interim vessel will be used to transfer the surface water sample to the sample containers. The glass interim vessel will be laboratory cleaned to the same specifications as the sample containers.

Samples will be placed in containers and preserved according to Navy Level D protocol and analyzed within the proper holding time. For VOC samples, the bottles will be filled so as to minimize aeration of the samples. During the collection of surface water samples, care will be taken to ensure that any pre-added preservative is not rinsed from the sampling container during sample collection. Sample vials will be filled completely and capped to prevent the entrapment of any air bubbles in the vial.

The bottle cap should be removed carefully from the laboratory cleaned sample bottle. The cap should not be laid down nor the inside touched. At no time should the inside of the bottle come into contact with anything other than the sample.

All appropriate preservatives will be added to the sample containers by the contracted laboratory before shipment to the CDM Federal field team. Low concentration volatile samples will be preserved with hydrochloric acid (HCl), TAL metals samples will be preserved with nitric acid (HNO_3), and cyanide samples will be preserved with sodium hydroxide (NaOH). All samples will be kept cool at 4°C, using bagged ice.

Surface water samples will also be measured in the field for temperature, pH, conductivity, and dissolved oxygen.

Table 2-3 presents the required containers, preservatives, and holding times for groundwater and surface water samples. Table 2-4 summarizes the groundwater and surface water samples to be submitted for analyses.

Equipment Decontamination

All non-dedicated sampling equipment will be decontaminated prior to the beginning of sampling activities and after each use. Specific field decontamination procedures are presented in Attachment A.

Field Quality Control Procedures

Quality control duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and to provide an estimate of the components of variance and the bias in the analytical process.

Blanks

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. ASTM Type II water will be used for blanks. Three types of blanks will be generated during sampling activities: trip blanks, field blanks, and equipment blanks.

One trip blank will be included for each cooler containing samples for VOC analysis. The trip blanks will be prepared prior to each sampling event, shipped or transported to the field with the sampling bottles, and sent to the laboratory unopened for analysis. Trip blanks will not be prepared or handled in the field. Trip blanks will indicate if any contamination occurred during shipment to the field, field storage, or during shipment from the field to the analytical laboratory.

One field blank will be collected each source water per sampling event. An event is defined as one week of sampling. The field blanks will indicate if any contaminants were

Table 2-3
REQUIRED CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR WATER SAMPLES

Analysis	Sample Container	Preservative	Holding Time	Volume of Sample Collected
TCL Volatiles and Low Concentration Volatiles	Three 40-ml glass vial w/Teflon lined cap	HCl to pH <2; Cool to 4°C	14 days	Fill completely; no air bubbles
TCL Semivolatiles	2 1-liter amber bottle w/Teflon lined cap	Cool to 4°C	7 days to extraction, 40 days to analysis	Fill to shoulder
TCL Pest/PCB	2 1-liter amber bottle w/Teflon lined cap	Cool to 4°C	7 days to extraction, 40 days to analysis	Fill to shoulder
TAL Metals [1]	1-liter polyethylene bottle for each analysis	HNO_3 to pH <2; Cool to 4°C	6 months	Fill to shoulder
TAL Cyanide	1-liter bottle	NaOH to pH > 12; Cool to 4°C	14 days	Fill to shoulder
Total Phosphorus	250 ml polyethylene bottle	H2SO4 to pH <2; Cool to 4°C	28 days	Fill to shoulder
Alkalinity	250-mL polyethylene bottle	Cool to 4°C	14 days	Fill to shoulder
Biochemical Oxygen Demend	2 1-liter polyethylene bottle	Cool to 4°C	48 hours	Fill to shoulder
Chemical Oxygen Demend	125-mL polyethylene bottle	H2SO4 to pH <2; Cool to 4°C	28 days	Fill to shoulder
TDS	250-mL polyethylene bottle	Cool to 4°C	28 days	Fill to shoulder
TSS	250-mL polyethylene bottle	Cool to 4°C	28 days	Fill to shoulder
Hardness	250-mL polyethylene bottle	HNO_3 to pH <2; Cool to 4°C	28 days	Fill to shoulder

Notes:

[1] Groundwater samples will be analyzed for both total and dissolved metals. Filtration should occur prior to preservation.

* VOC aqueous field QC samples associated with the soil and sediment samples will be analyzed for TCL volatiles. VOC field QC samples associated with the groundwater samples will be analyzed for Low Concentration volatiles.

Table 2-4
SITE 3 AND SITE 4 SUMMARY OF AQUEOUS SAMPLES TO BE SUBMITTED FOR ANALYSIS

Matrix	Laboratory Parameter	Samples		Field	Field	Trip	Matrix	Equipment	Matrix
		Site 3	Site 4	Duplicates[1]	Blanks[2]	Blanks[3]	Spikes[4]	Blanks[5]	Total
Groundwater *	Low Concentration Volatiles	12	12	3	2	6	2	6	43
	TCL Semivolatiles	12	12	3	2	0	2	6	37
	TCL Pesticides/PCBs	12	12	3	2	0	2	6	37
	TAL Metals (filtered)	12	12	3	2	0	2	6	37
	TAL Metals (unfiltered)	12	12	3	2	0	2	6	37
	TAL Cyanide	12	12	3	2	0	2	6	37
	Total Phosphorous	12	12	3	2	0	2	6	37
Surface Water	TCL Volatiles	3	3	1	1	1	1	1	11
	TCL Semivolatiles	3	3	1	1	0	1	1	10
	TCL Pesticides/PCBs	3	3	1	1	0	1	1	10
	TAL Metals	3	3	1	1	0	1	1	10
	TAL Cyanide	3	3	1	1	0	1	1	10
	Total Phosphorous	3	3	1	1	0	1	1	10
	Alkalinity	3	3	1	0	0	0	0	7
	BOD/COD	3	3	1	0	0	0	0	7
	TDS/TSS	3	3	1	0	0	0	0	7
	Hardness	3	3	1	0	0	0	0	7

Notes:
* Groundwater samples will be collected in two rounds: 6 samples per landfill per sampling round. This table summarizes the total number of groundwater samples to be collected.
[1]Field duplicates are collected at a frequency of 1 per 10 per matrix.
[2]Field blanks are collected at a frequency of 1 per source water per event.
[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples. Trip blanks shipped with groundwater samples will be analyzed for volatile organics using the same method used for groundwater samples (low concentration volatile organics).
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20 per matrix. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. The amount of extra volumes will be determined once the laboratories have been procured.
[5]Equipment blanks are collected at a frequency of 1 per day per matrix.
This table is based on Navy Level D QA/QC requirements.

introduced during the handling of the sample containers in the field or during sample analysis at the laboratory. The sample container will be filled with ASTM Type II water in the field at the time of sampling. The blanks will be capped, packed, and shipped with the samples. One equipment blank per matrix will be collected and analyzed everyday during sampling activities. The equipment blanks will indicate the efficiency of equipment decontamination procedures.

Duplicates

Field duplicate samples will be collected at a frequency of 1 per 10 field samples per matrix. The location from which the duplicates are taken will be randomly selected. The duplicate sample will be submitted for analysis as two independent samples. These samples will be numbered non-sequentially.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one per 20 field samples. Analytical results of these samples indicate the impact the matrix (water, soil, sediment) has on extracting the analyte for analysis. Data validators will use these results to evaluate the accuracy of the analytical data.

Section 3

Documentation

Sample Designation

Numbering Format for Field Samples

Each field sample will be designated by an alphanumeric code that will identify St. Juliens Creek Annex, the site number, the sample type, and the sample number. The following table is a general guide for sample identification:

First Segment of Sample Designation		Second Segment of Sample Designation	
Base Code	Site Number	Sample Type	Sample Number
AA	AAA	AAAA	AAAA

Symbol Definition: A = Alphanumeric

Base Code - Consists of two alphanumeric characters

SJ = St. Juliens Creek Annex

Site Number - Consists of three alphanumeric characters. The first character will distinguish a site from a SWMU. The last two characters will contain a number between 0 and 99, representing the site or SWMU number.

S = Site

The site numbers for this CTO are:

S3 = Site 3 - Landfill C

S4 = Site 4 - Landfill D

Sample Type - Consists of four alphanumeric characters consisting of the type of sample and the samples location. The possible combinations include the following:

SS = Surface soil sample

SB = Soil boring (subsurface) sample

SD	=	Sediment sample
SW	=	Surface water sample
GP	=	Geoprobe® groundwater sample
GW	=	Groundwater sample
DR	=	Drum sample
PZ	=	Piezometer sample
SG	=	Soil gas sample
TR	=	Trench sample
IS	=	Investigation-derived waste (IDW) soil sample
IW	=	Investigation-derived waste (IDW) water sample

Sample Number - Consists of up to four alphanumeric characters. The characters will include a sequential sample number (or depth of sample collection) obtained from the Field Sampling Plan and modifiers to designate the following:

P	=	Duplicate
F	=	Filtered
S	=	Shallow well
D	=	Deep well

Examples of this numbering system for samples are:

SJS3-SB01-005P	=	Site 3, soil boring location 1, subsurface soil sample collected from a depth of 5 ft. bgs, and also had a duplicate collected from this location.
SJS4-GW03-002F	=	Site 4, groundwater sample collected from monitoring well #3, this is the second sample (round) collected from this well, and the metals portion of the sample was filtered.

Numbering Format for QA/QC Samples

Each QA/QC sample will be designated by an alphanumeric code that will identify the sample type and the date that the sample was collected. The following table is a general guide for sample identification:

First Segment of Sample Designation	Second Segment of Sample Designation
Sample Type	Sample Date
AA	AAAAAA

Symbol Definition: A = Alphanumeric

Sample type - Consists of two alphanumeric characters. The possible combinations include the following:

FB = Field blank

TB = Trip blank

EB = Equipment blank

Sample date - Consists of six alphanumeric characters that represent the date the sample was collected. The date will always be given in a DDMMYY format.

Examples of this numbering system for QA/QC samples are:

FB-011096 = Field blank collected on October 1, 1996

TB-290797 = Trip blank collected on July 29, 1997

EQ-010898 = Equipment blank collected on August 1, 1998

Sample Shipping Procedures

Strict adherence to both personnel and equipment decontamination procedures will help ensure the safety of onsite workers as well as the acquisition of quality data.

All field sampling activities will be documented through the use of field logs and chain-of-custody procedures. Sample containers will be clean, first-quality containers provided by the contracted laboratory. A complete listing of the types of bottles and preservatives to be used is given in Tables 2-1 and 2-3 in Section 2 of this FSP. An identification label will be attached to each sample container indicating the sample number, station number, analysis to be performed, preservative used, date and time of sample collection, and the name of the responsible sampling team member.

After collection, samples will be packed in coolers with vermiculite (and ice) for shipment to the contracted laboratory via an overnight courier. Chain-of-custody forms will be taped to the inside of the lid of each cooler. Chain-of-custody forms contain general information about the location of the activity and the members of the sampling team, as well as specific information about the type of sample, sample location, number of sample containers from each station, and analyses to be performed. Each time the sample is relinquished or received, the party involved signs the form and indicates the time and date.

The coolers used to deliver the samples will be sealed with strapping tape. Evidence tape will be placed across the front and back of each lid to control tampering. Samples will be stored in refrigerators or coolers packed with ice in order to maintain sample temperatures

<= 4° C. The longest expected onsite storage time is three days. All other sample analysis will be shipped to the laboratory at the end of each day of sampling.

Field Sampling Plan

Attachment A

Standard Operating Procedures

Field Measurement of pH

Field Measurement of Specific Conductance and Temperature

Field Measurement of Dissolved Oxygen

Volatiles Monitoring with an OVM

Shallow Soil Sampling

Sediment Sampling

Homogenization of Soil and Sediment Samples

Groundwater Sampling from Monitoring Wells

VOC Sampling - Water

Water Level Measurements

Logging of Soil Borings

Surface Water Sampling

General Guidance for Monitoring Well Installation

Installation of Shallow Monitoring Wells

Field Rinse Blank Preparation

Field Filtering

Packaging and Shipping Procedures

Decontamination of Personnel and Equipment

Field Measurement of Dissolved Oxygen

Field Measurement of pH

I. Purpose

To provide a general guideline for field measurement of pH of groundwater samples.

II. Scope

The following general discussion applies to most commonly used pH meters but may differ between specific brands. The operator's manual should be consulted for specific calibration and operating procedures.

III. Equipment and Materials

- pH buffer solution for pH 4, 7, and 10
- Deionized water in squirt bottle
- pH meter
- Combination electrodes
- Beakers
- Glassware that has been washed with soap and water, rinsed twice with hot water, and rinsed twice with deionized water

IV. Procedures and Guidelines

A. Calibration

Calibrate unit prior to initial daily use and at least once every 4 hours or every five samples, whichever is less. Calibrate with at least two solutions. Clean probe according to manufacturer's recommendations. Duplicate samples should be run once every 10 samples or every 4 hours which ever is more frequent.

1. Place electrode in pH 7 buffer solution.
2. Allow meter to stabilize and then turn calibration dial until a reading of 7.0 is obtained.
3. Rinse electrode with deionized water and place it in a pH 4 or pH 10

buffer solution.

4. Allow meter to stabilize again and then turn slope adjustment dial until a reading of 4.0 is obtained for the pH 4 buffer solution or 10.0 for the pH 10 buffer solution.

5. Rinse electrode with deionized water and place in pH 7 buffer. If meter reading is not 7.0, repeat sequence.

B. Procedure

1. Before going out into the field:

   a) Check batteries.
   b) Do a quick calibration at pH 7 and 4 to check electrode.
   c) Obtain fresh solutions.

2. Calibrate meter using calibration procedure in the operators manual.

3. Pour the sample into a clean beaker.

4. Rinse electrode with deionized water between samples.

5. Immerse electrode in solution. Make sure the white KCl junction on the side of the electrode is in the solution. The level of electrode solution should be one inch above sample to be measured.

6. Recheck calibration with pH 7 buffer solution after every five samples.

C. General

1. When calibrating the meter, use pH buffers 4 and 7 for samples with pH < 8, and buffers 7 and 10 for samples with pH > 8. If meter will not read pH 4 or 10, something may be wrong with the electrode.

2. Measurement of pH is temperature dependent. Therefore, buffers temperatures should be within about 2 degrees C of sample temperatures. For refrigerated or cool samples, use refrigerated buffers to calibrate the pH meter.

3. Weak organic and inorganic salts and oil and grease interfere with pH measurements. If oil and grease are visible, note it on the data sheet. Clean electrode with soap and water and rinse with distilled water. Then recalibrate meter.

4. Following field measurements:

   a) Report any problems.
   b) Compare with previous data.
   c) Clean all dirt off meter and inside case.
   d) Store electrode in pH 4 buffer.

5. Accuracy and precision are dependent on the instrument used; refer

to manufacturer's manual. Expected accuracy and precision are +/- 0.1 pH unit.

V. Key Checks and Items

- Check batteries
- Calibrate

VI. Preventive Maintenance

- Refer to operation manual for recommended maintenance.
- Check batteries, have a replacement set on hand.

STANDARD OPERATING PROCEDURE

Field Measurement of Specific Conductance and Temperature

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for field measurement of specific conductivity and temperature of groundwater samples. The following general discussion applies to most commonly used meters but may differ between specific brands. The operator's manual should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Conductivity meter and electrode
- Distilled water in squirt bottle
- Standard potassium chloride (KCl) solution (0.01 N)

III. Procedures and Guidelines

A. Technical:

Detection limit = 1 µmho/cm @ 25°C; range = 0.1 to 100,000 µmho/cm

B. Calibration:

Calibrate prior to initial daily use with standard solution. The standards should have different orders of conductance. Clean probe according to manufacturer's recommendations. Duplicates should be run once every 10 samples. Calibration procedure:

1. With mode switch in OFF position, check meter zero. If not zeroed, set with zero adjust.
2. Plug probe into meter.
3. Turn mode switch to red line and turn red line knob until needle aligns with red line on dial. If they cannot be aligned, change the batteries.

4. Immerse probe in 0.01 N standard KCl solution. Do not allow the probe to touch the sample container.

5. Set the mode control to TEMPERATURE. Record the temperature on the bottom scale of the meter in degrees C.

6. Turn the mode switch to appropriate conductivity scale (i.e., x100, x10, or x1). Use a scale that will give a midrange output on the meter.

7. Wait for the needle to stabilize. Multiply reading by scale setting and record the conductivity.

8. If the conductivity meter does not perform an automatic temperature adjustment, the conductivity may be adjusted to 25°C using the formula:

$$G_{25} = G_T / [1 + 0.02 (T - 25)]$$

Where:

G_{25} = conductivity at 25°C, µmho/cm

T = temperature of sample, degrees C

G_T = conductivity of sample at temperature T, µmho/cm

The table below lists the values of conductivity that the calibration solution would have if the distilled water were totally nonconductive; however, even water of high purity will possess a small amount of conductivity.

Temperature °C	**Conductivity (µmho/cm)**
15	1,141.5
16	1,167.5
17	1,193.6
18	1,219.9
19	1,246.4
20	1,273.0
21	1,299.7
22	1,326.6
23	1,353.6
24	1,380.8
25	1,408.1
26	1,436.5
27	1,463.2
28	1,490.9
29	1,518.7
30	1,546.7

9. Rinse the probe with deionized water.

C. Sample Measurement:

Pour the sample into a small beaker and place the probe in the sample. Note and record the reading. Rinse the probe with deionized water when done.

IV. Attachments

- Conductivity meter calibration sheet

V. Key Checks and Preventive Maintenance

- Check battery.
- Calibrate meter.
- Clean probe with deionized water when done.
- When reading results, note sensitivity settings.
- Refer to operations manual for recommended maintenance.
- Check batteries, and have a replacement set on hand.

CONDUCTIVITY METER CALIBRATION SHEET

Date	Time	Analyst Initials	Instrument Readings: Uncalibrated @ EC=225	Instrument Readings: Calibrated @ EC=225	Comments

STANDARD OPERATING PROCEDURE

Field Measurement of Dissolved Oxygen

I. Purpose

To provide general guidelines for the calibration and use of the Dissolved Oxygen (DO) meter.

II. Scope

The following general discussion applies to more commonly used meters but may differ between specific brands. The operator's manual should be consulted for specific calibration and operation procedures.

III. Equipment and Materials

- Operations manual
- A DO probe and readout/control unit with batteries
- Electrolyte solution (KCl dissolved in deionized water) and probe membrane

IV. Procedures and Guidelines

A. Calibration

Calibrate prior to initial daily use before any readings are taken. Clean probe according to manufacturer's recommendations.

1. Prepare DO probe according to manufacturer's recommended procedures using electrolyte solution.
2. In the off position, set the pointer to zero using the screw in the center of the meter panel.
3. Turn function switch to red line and adjust using red line knob until the meter needle aligns with red mark at the 31 degrees C position.
4. Turn function switch to zero and adjust to zero using the zero control knob.
5. Attach prepared probe and adjust retaining ring finger tight.
6. Allow 15 minutes for optimum probe stabilization (when meter is off or during disconnection of the probe).
7. For YSI meters, place probe in hollow stopper that is supplied for use with the YSI Calibration Chamber.

8. Place approximately 1/2 inch of deionized water into a 4-ounce, wide mouth screw cap bottle. Keep this bottle capped and with the DO meter.

9. Just before use, shake the bottle to saturate the water with air.

10. Remove cap, place probe in bottle keeping an air-tight seal around the rubber stopper. Swirl water around in the bottle while waiting for conditions to reach equilibrium.

11. Shield chamber from sun and wind to avoid temperature fluctuations during calibration.

12. Turn function switch to temperature and record temperature reading. Determine calibration factor for that temperature and altitude correction factor from tables supplied by manufacturer.

13. Multiply the calibration factor by the correction factor to get a corrected calibration value.

14. Turn function switch to appropriate ppm range and adjust the calibrate knob until the meter reads the corrected calibration value. Wait two minutes to verify calibration value. Re-adjust as necessary.

B. Procedure

1. Before going out into the field:

   a) Check batteries
   b) Obtain fresh electrolyte solution
   c) Prepare DO probe

2. Calibrate meter using calibration procedure.

3. Place probe in water to be measured. The probe should be moved through the water at 1 ft/sec or use a probe with a built-in stirrer.

4. Allow sufficient time for probe to stabilize to water temperature and DO. Record DO meter reading.

V. Attachments

DO Meter Calibration Sheet.

VI. Key Checks and Items

- Battery check
- Calibration

VII. Preventive Maintenance

- Refer to operation manual for recommended maintenance.
- Check batteries, have replacement set on hand.

DO METER
CALIBRATION SHEET

Date	Time	Analyst's Signature	Temp (C)	Alt. (ft)	Predict (ppm 0_2)	Actual (ppm 0_2)	Comment

STANDARD OPERATING PROCEDURE

Field Measurement of Organic Vapors Using an HNU

I. Purpose

To provide general guidelines for the calibration and use of the HNU photoionization detector.

II. Scope

This is a broad guideline for the field use of an HNU. For specific instructions, refer to the operations manual.

III. Equipment and Materials

- Operations manual
- An HNU readout/control unit and photoionization probe (either 10.2 or 11.7 eV depending on requirements) with fully charged battery pack
- Charging unit
- A cylinder of calibration gas, typically 100 ppm isobutylene in air
- A regulator for the calibration gas cylinder
- A short length of 1/8th-inch tube to transfer calibration gas from the cylinder to the HNU probe (as short as possible)

IV. Procedures and Guidelines

ONLY PROPERLY TRAINED PERSONNEL SHOULD USE THIS INSTRUMENT. FOR SPECIFIC INSTRUCTIONS, SEE OPERATIONS MANUAL.

A. CALIBRATE THE HNU

1. Identify the probe by lamp model.
2. Connect the sensor/probe to the readout/control unit.
3. Perform a battery check by turning the function switch to "Batt."
4. Turn function switch to "Standby" and set the readout to zero by turning the zero knob.
5. Hold the sensor/probe to your ear to verify that it is powered. A faint humming sound will be heard.

6. Set the range to the appropriate setting.

7. Connect the tube from the calibration gas cylinder to the end of the probe and open the valve on the calibration gas cylinder.

8. Sample the calibration gas and adjust to the proper reading with the span control knob.

9. If calibration cannot be achieved, disassemble the sensor/probe assembly and clean lamp. If the span knob setting is at the end of the span range, unit must be serviced by qualified personnel.

B. SAMPLING WITH THE HNU

1. Once calibration is complete, unit is ready for sampling. When not in use, set function knob to ``Standby."

2. When done for the day, turn unit off and disconnect the sensor/probe.

3. Charge the battery overnight (complete recharge takes 14 hours).

4. For preventive maintenance, refer to instruction manual.

V. Attachments

HNU calibration sheet

VI. Key Checks and Items

- Check battery.
- Zero and calibrate.
- Verify sensor probe is working.
- Recharge unit after use
- Select the probe suitable for the monitoring required.

VII. Preventive Maintenance

A complete preventive maintenance program is beyond the scope of this document. For specific instructions, refer to the operations manual. Some key items are discussed below:

- A complete spare HNU should be available on site whenever field operations require this instrument.
- A spare lamp should be on hand so a defective unit can be changed without returning the unit.
- Occasional cleaning of the lamp should be performed as needed.
- Charge batteries daily.

- Occasionally allow the batteries to totally discharge before recharging to prevent battery memory from occurring.

HNU Calibration Sheet

Date	Time	Analyst Initials	Uncalibrated @ 10 ppm	Calibrated @ 10 ppm	Comments

STANDARD OPERATING PROCEDURE

Volatiles Monitoring by OVM

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for the calibration and use of an OVM Organic Vapor Monitor. This is a broad guideline for field use of an OVM; for specific instruction, refer to the operators manual.

II. Equipment and Materials

- Operations manual
- An OVM hand readout unit and side pack assembly
- 100 ppm isobutylene as calibration gas
- T-type feeder tube with 1.5 liter/min. regulator

III. Procedures and Guidelines

ONLY PROPERLY TRAINED PERSONNEL SHOULD USE THIS INSTRUMENT. FOR SPECIFIC INSTRUCTIONS, SEE OPERATIONS MANUAL.

OVM, Organic Vapor Monitor

1. Introduction

   The OVM Organic Vapor Monitor is designed to detect organic materials in air. It uses a photo-ionization detector (PID) as its detection principle. This detector allows the monitor to respond to a wide variety of organic compounds.

2. Operational Checks

   - See basic operating instructions in operations manual.

3. Calibration

   - See basic operating instructions in operations manual.

IV. Key Checks and Preventive Maintenance

- Check battery.
- Zero and calibrate.
- Verify sensor probe is working.
- Recharge unit after use.

A complete preventive maintenance program is beyond the scope of this document. For specific instructions, refer to the operations manual. Some key issues are discussed below:

- A complete spare instrument should be available whenever field operations require volatiles monitoring.
- Spare parts should be on hand so minor repairs may be made in the field.
- Batteries should be charged daily.
- Occasionally allow the batteries to totally discharge before recharging to prevent battery memory from occurring.

Standard Operating Procedure

Explosimeter

I. Purpose and Scope

This SOP provides a guideline for field measurements of the levels of combustible gas and oxygen in air. The following general discussion applies to most explosimeter but may differ between specific brands. The operator's manual should be consulted fo specific calibration and operating procedures.

II. Equipment and Materials

- Industrial Scientific (MX251) Combustible Gas and Oxygen Indicator, or equivalent meter, which can be field calibrated
- Flow-control regulator and hose
- Calibration gas (50 percent LEL pentane—0.75 percent pentane and 15 percent oxygen in nitrogen)
- Equipment calibration data sheet

III. Procedures and Guidelines

A. **Calibration:** The explosimeter must be calibrated before initial daily use. Record calibration information on equipment calibration data sheet. Calibration will be performed according to the following procedure:

1. Turn instrument on
    - Unscrew knurled nut on bottom
    - Rotate metal cover 180°
    - Tighten knurled nut
2. Check battery
    - Check for no ``LoBatt" display—do not use if LoBatt displayed
3. Calibrate instrument

- Observe that instrument reads 0 percent LEL and 21 percent Oxygen (OX) (record readings)

- Connect sampling pump onto top of instrument

- Connect .75 percent Pentane/15 percent oxygen gas (with 1.5 LPM Regulator and direct tubing)

- Turn pump ON

- Turn gas ON

- Record LEL and O_2 after stabilized; LEL must read 50 percent +/-5 percent; O_2 must read 15 percent +/- 5 percent

- Disconnect sample pump and return to charger

B. **Sample Measurement:** The instrument is then ready for air sampling. Note and record the readings for percent LEL and percent O_2.

IV. Attachments

- Equipment calibration data sheet

V. Key Checks and Preventive Maintenance

Check that the batteries be adequately charged. Certain materials such as silicone, silicates, and organic lead compounds tend to poison the catalyst in the instrument, thereby giving erroneously low readings; calibration checks should be made frequently if such materials are suspected to be present.

If the CGI does not cal-check within ±5 percent of 50 percent LEL, an internal calibration must be performed, or the instrument replaced.

EXPLOSIMETER CALIBRATION SHEET

Date	Time	Analyst Initials	Instrument Readings: Uncalibrated @LEL=0% O_2=21%	Instrument Readings: Calibrated @LEL=50%±5 O_2=15%±5	Comments

STANDARD OPERATING PROCEDURE

Shallow Soil Sampling

I. Purpose

To provide general guidelines for the collection and handling of surface soil samples during field operations.

II. Scope

The method described for surface soil sampling is applicable for loosely packed earth and is used to collect disturbed-soil samples.

III. Equipment and Materials

- Sample jars.
- A hand auger or other device that can be used to remove the soil from the ground. Only stainless steel, teflon, or glass materials should be used. The only exception is split spoons, which are most commonly available in carbon steel; these are acceptable for use only if they are not rusty.
- A stainless steel spatula should be used to remove material from the sampling device.
- Unpainted wooden stakes or pin flags
- Vermiculite
- Fiberglass measuring tape (at least 200 feet in length)

IV. Procedures and Guidelines

A. Wear protective gear, as specified in the Health and Safety Plan.

B. To locate samples, identify the correct location using the pin flags or stakes. Proceed to collect a sample from the undisturbed soil adjacent to the marker following steps C and D. If markers are not present, the following procedures will be used.

1. For samples on a grid:

    a. Use measuring tape to locate each sampling point on the first grid line as prescribed in the sampling plan. As each point is located, drive a numbered stake in the ground and record its location on the site map and in the logbook.

b. Proceed to sample the points on the grid line.

c. Measure to location where next grid line is to start and stake first sample. For subsequent samples on the line take two orthogonal measurements: one to the previous grid line, and one to the previous sample on the same grid line.

d. Proceed to sample the points on the grid line as described in Section C below.

e. Repeat 1c and 1d above until all samples are collected from the area.

2. For non-grid samples:

a. Use steel measuring tape to position sampling point at location described in the sampling plan by taking two measurements from fixed landmarks (e.g., corner of house and fence post).

b. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.

c. Proceed to sample as described in Section C below.

d. Repeat 2a through 2c above until all samples are collected from the area.

C. To the extent possible, differentiate between fill and natural soil. If both are encountered at a boring location, sample both as prescribed in the field sampling plan. Do not locate samples in debris, tree roots, or standing water. In residential areas, do not sample in areas where residents' activities may impact the sample (e.g., barbecue areas, beneath eaves of rooves, driveways, garbage areas). If an obstacle prevents sampling at a measured grid point, move as close as possible, but up to a distance of one half the grid spacing in any direction to locate an appropriate sample. If an appropriate location cannot be found, consult with the Field Team Supervisor (FTS). If the FTS concurs, the sampling point will be deleted from the program. The FTS will contact the CH2M HILL project manager (PM) immediately. The PM and Navy Technical Representative (NTR) will discuss whether the point should be deleted from the program. If it is deleted, the PM will follow-up with the NTR in writing.

D. To collect samples:

1. Use a decontaminated stainless steel scoop/trowel to scrape away surficial organic material (grass, leaves, etc.) adjacent to the stake. New disposable scoops or trowels may also be used to reduce the need for equipment blanks.

2. If sampling:

a. Surface soil: Obtain soil sample by scooping soil using the augering scoop/trowel, starting from the surface and digging down to a depth of about 6 inches, or the depth specified in the workplan.

b. Subsurface soil. Obtain the subsurface soil sample using an auger down to the depths prescribed in the field sampling plan.

3. Take an OVM reading of the sampled soil and record the response in the field notebook. Also record lithologic description and any pertinent observations (such as discoloration) in the logbook.

4. Empty the contents of the scoop/trowel into a decontaminated stainless steel pan.

5. Repeat this procedure until sufficient soil is collected to meet volume requirements.

6. For TCL VOC and field GC aliquots, fill sample jars directly with the trowel/scoop and cap immediately upon filling. DO NOT HOMOGENIZE.

7. For TCL pesticides/PCBs and SVOCs, TAL metals, and field XRF aliquots, homogenize cuttings in the pan using a decontaminated stainless steel utensil in accordance with SOP Decon.

8. Transfer sample for analysis into appropriate containers with a decontaminated utensil.

9. Backfill the hole with vermiculite. To the extent possible, replace topsoil and grass and attempt to return appearance of sampling area to its pre-sampled condition. For samples in non-residential, unmowed areas, mark the sample number on the stake and leave stake in place. In mowed areas, remove stake.

V. Attachments

None.

VI. Key Checks and Items

- Phthalate-free latex or surgical gloves and other personal protective equipment.
- Transfer volatiles first, avoid mixing.
- Decontaminate utensils before reuse, or use dedicated, disposable utensils.

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCl, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification

III. Procedures and Guidelines

This section covers several aspects of the soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586, field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

B. **Heading Information**

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If stationing, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first initial and full last name.

C. **Technical Data**

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons.

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below. `

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488-93, Visual-Manual Procedure for Description and Identification of Soils.

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests (ASTM D 2487). It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488-93, attached). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488-93 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488-93.

E. Soil Name

The basic name of a soil should be the ASTM D 2488-93 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488-93. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488-93.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488-93.

F. Group Symbol

The appropriate group symbol from ASTM D 2488-93 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488-93, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group. Grain size is estimated in accordance with ASTM D 2488-93 (Table 2).

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 3.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586-84). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 4 and 5.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. **Equipment and Calibration**

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586-84. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log, CH2M HILL Form D1586, and a completed example

ASTM D 2488-90: Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

V. Key Checks and Preventive Maintenance

Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later. Check that sample numbers and intervals are properly specified. Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP Decontamination of Drilling Rigs and Equipment.

Table 1
EXAMPLE SOIL DESCRIPTIONS

POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size

FAT CLAY (CH), dark gray, moist, stiff

SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max

POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense

ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica

SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick

SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation

LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff

WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

Table 5
FIELD EQUIPMENT CHECKLIST FOR SOIL BORING LOGGING

Siting

___Lath, flagging, and orange spray paint
___Lumber crayon
___100-foot tape
___Brunton or Silva compass

Logging Equipment

___Soil Boring Guideline
___Clipboard
___Form D1586 on all-weather paper
___Pens/pencils
___Engineer's pocket tape measure with tape lock
___Field notebook on all-weather paper
___Squirt bottle with water
___Spatula
___HCL, 10 percent solution

Sampling and Packaging

___Jars with lids and labels (Form #131)
___Shelby tubes and plastic end caps
___Airtight tape (e.g., electrical)
___Newspaper
___Wax, stove, melting pot, and matches
___Indelible fine felt-tipped markers (e.g., "Sharpie" brand)

Test Equipment

___Pocket penetrometer
___Torvane
___Well sounder

Other

___Camera, film
___Hand lens
___Rags
___Ear protectors
___Screwdrivers
___Hard hat
___Sunscreen
___Insect repellent

Attachments

CH2M HILL

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT ______ LOCATION ______

ELEVATION ______ DRILLING CONTRACTOR ______

DRILLING METHOD AND EQUIPMENT ______

WATER LEVELS ______ START ______ FINISH ______ LOGGER ______

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG, FORM D1586

REV 11/89 FORM

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
DEN 22371.G5	BL-3	SHEET 1 OF 3

SOIL BORING LOG

PROJECT Howard Ave Landslide LOCATION Howard & 24th Ave, Centennia,

ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colora

DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig

WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL	SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5					
	4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
	5.0					
5	6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H_2S odor, many fine roots up to about 1/4 inch	Driller notes very soft drilling 4ft. dark grey, wet silty cuttings.
	8.0					
	10.0	3-ST	1.3	—	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730 Driller notes rough drilling action and chatter @ 13 ft
	15.0					
15	15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
	20.0					Driller notes smoother, firm drilling @ 19 ft
20	21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ b tip of 6-S, poss boulders or
	23.0					Driller notes very hard, sl grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETE LOG FORM

REV 11/89 FORM

Designation: D 2488 – 90

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.5 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1.2 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.1.3 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.1.4 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.5 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.6 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.1.7 *sand*—particles of rock that will pass a No. 4

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[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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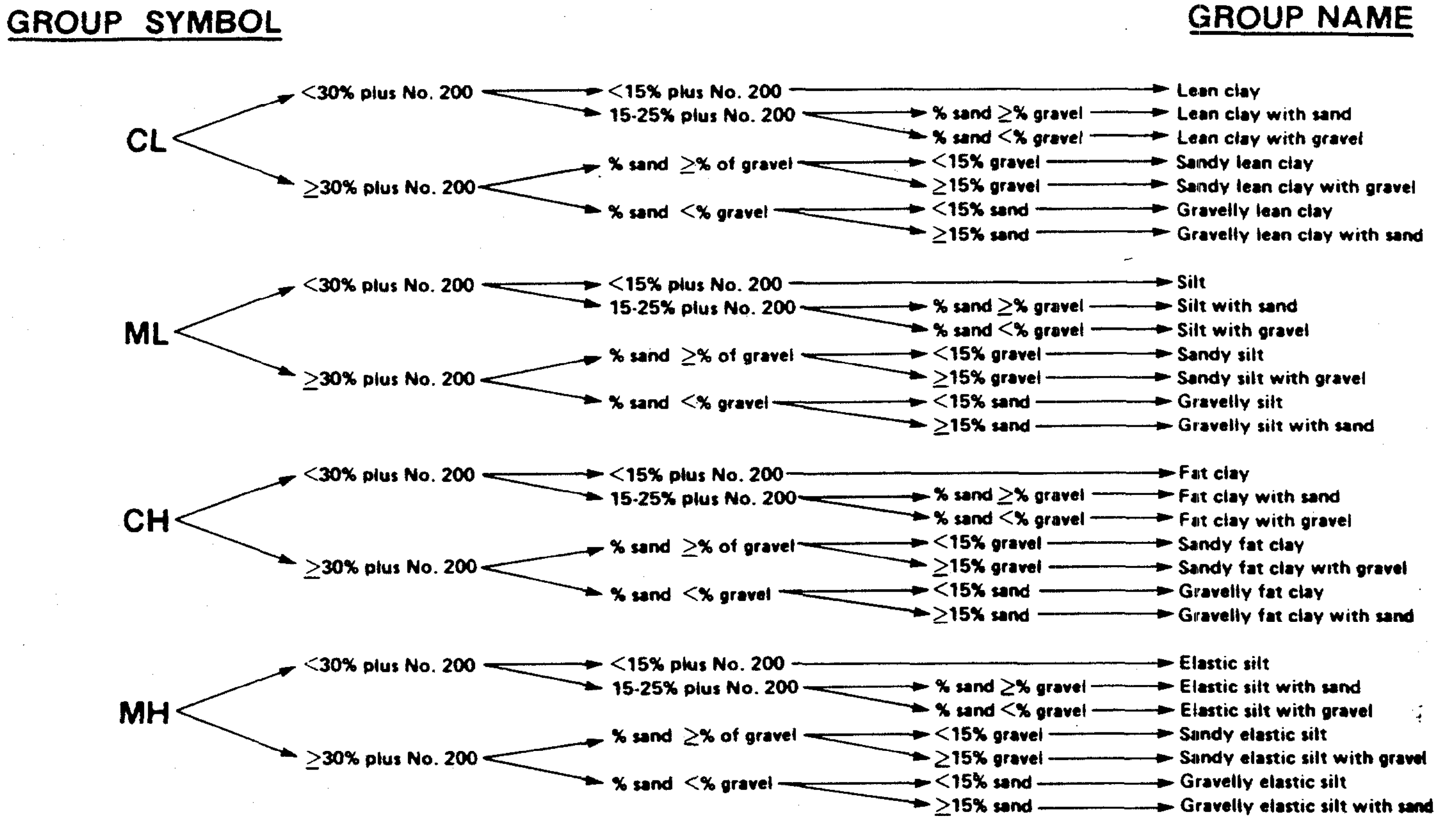
[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

(4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.1.8 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

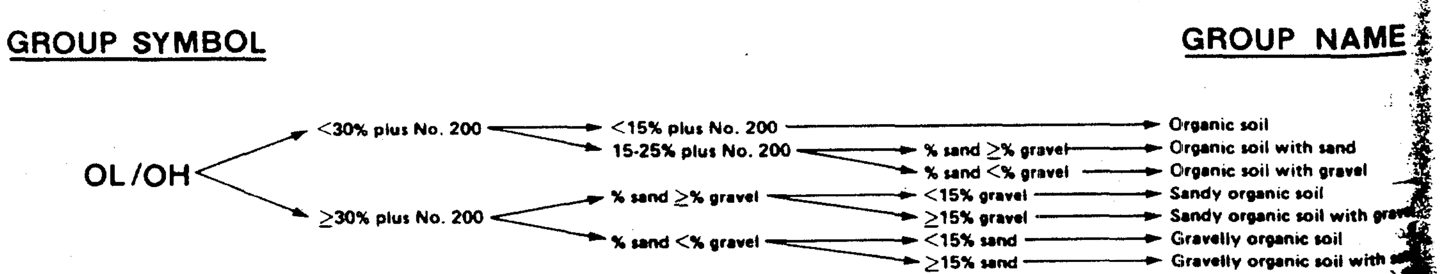
4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

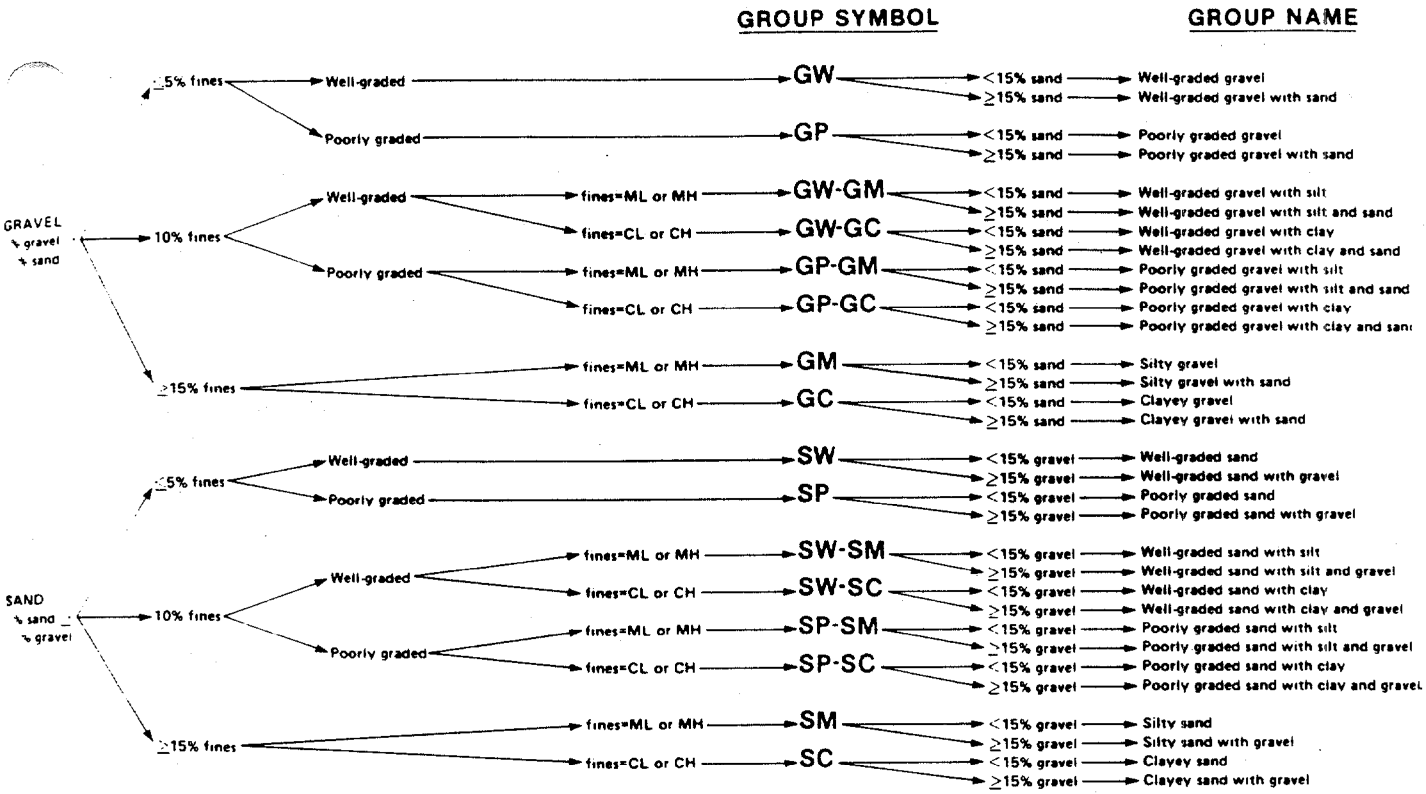
NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

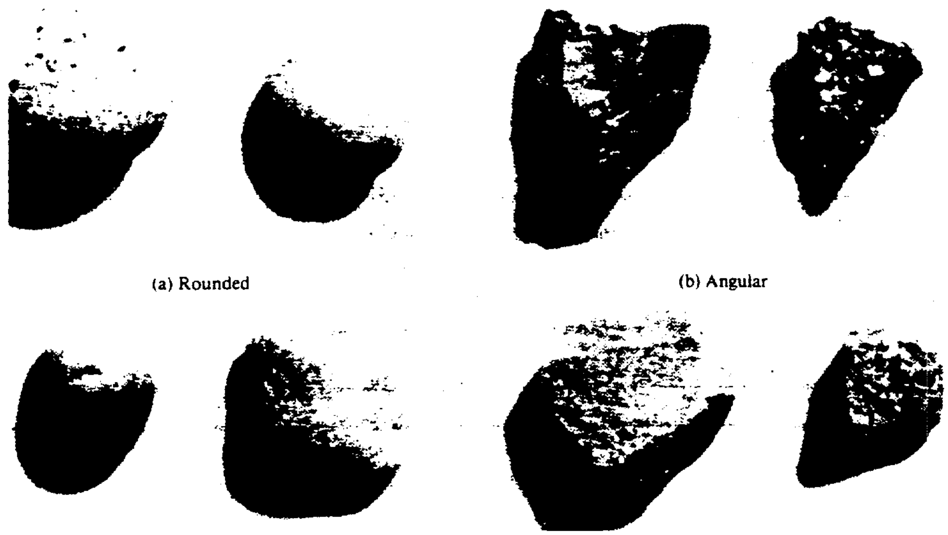
6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.



(a) Rounded (b) Angular

(c) Subrounded (d) Subangular

FIG. 3 Typical Angularity of Bulky Grains

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0..5 lb)
9.5 mm (3/8 in.)	200 g (0.5 lb)
19.0 mm (3/4 in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that significantly larger than the particles in the soil matrix, the soil ma can be accurately described and identified in accordance with preceeding schedule.

9.4 If the field sample or specimen being examined smaller than the minimum recommended amount, report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the s (coarse sizes only), gravel, cobbles, and boulders, as ang subangular, subrounded, or rounded in accordance with criteria in Table 1 and Fig. 3. A range of angularity ma stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cob and boulders as flat, elongated, or flat and elongated if meet the criteria in Table 2 and Fig. 4. Otherwise, do mention the shape. Indicate the fraction of the particles have the shape, such as: one-third of the gravel particles flat.

10.3 *Color*—Describe the color. Color is an impor property in identifying organic soils, and within a g

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

TABLE 2 Criteria for Describing Particle Shape (see Fig.

The particle shape shall be described as follows where length, widt thickness refer to the greatest, intermediate, and least dimensions of a p respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elong

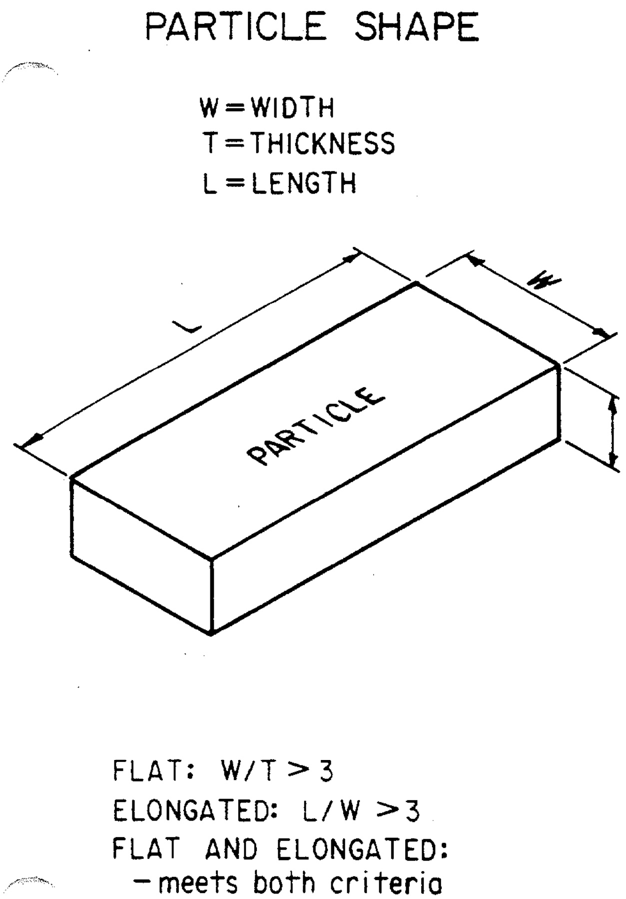


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpre-

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

tation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification are given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %
Few—5 to 10 %
Little—15 to 25 %
Some—30 to 45 %
Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)": about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be ...ult to clearly identify the soil as belonging to one ...ory. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at th boundary between a soil of low compressibility and a soil c high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should refle similarity to surrounding or adjacent soils. For example: soi in a borrow area have been identified as CH. One sample considered to have a borderline symbol of CL and CH. T show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symb should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be use indiscriminately. Every effort shall be made to first place th soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus siev size No. 4 material can then be estimated from the wash te (X4.3).

X4.3 *Wash Test (for relative percentages of sand an fines)*—Select and moisten enough minus No. 4 sieve si material to form a 1-in (25-mm) cube of soil. Cut the cube i half, set one-half to the side, and place the other half in small dish. Wash and decant the fines out of the material i the dish until the wash water is clear and then compare th two samples and estimate the percentage of sand and fine Remember that the percentage is based on weight, n volume. However, the volume comparison will provide reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break dow lumps of fines with the finger to get the correct percentage

X5. RATIONALE

X5.1 This practice was significantly revised in the D 2488 – 84 version from the previous version D 2488 – 69 (1975). The revisions are documented in the literature.[3]

X5.2 Changes in this version from the previous versic include rewording of 1.2.3 to say (disturbed and undi turbed), the addition of 5.7 to refer to the practice f describing frozen soils, and the addition of Appendix X5 c Rationale.

[3] Howard, A. K. "The Revised ASTM Standard on the Description and Identification of Soils (Visual-Manual Procedure)," *Geotechical Testing Journal*, GTJODJ Vol. 10, No. 4, December 1987.

Surface Water Sampling

I. Purpose and Scope

This procedure presents the techniques used in collecting surface water samples. Materials, equipment, and procedures may vary; refer to the Field Sampling Plan and operators manuals for specific details.

II. Materials and Equipment

Materials and equipment vary depending on type of sampling; the Field Sampling Plan should be consulted for project-specific details.

- Open tube sampler
- Dip sampler
- Weighted bottle sampler
- Hand pump
- Kemmerer or Van Dorn sampler
- Depth-integrating sampler
- Sample containers
- Meters for specific conductance, temperature, pH, and dissolved oxygen

III. Procedures and Guidelines

Before surface water samples are taken, all sampler assemblies and sample containers are cleaned and decontaminated as described in SOP Decontamination of Personnel and Equipment. Methods for surface water sample collection are described below.

A. Manual Sampling

Surface water samples are collected manually by submerging a clean glass, stainless steel, or Teflon container into the water body. Samples may be collected at depth with a covered bottle that can be removed with a tripline. The most common sampler types are beakers, sealable bottles and jars, pond samplers, and weighted bottle samplers. Pond samplers have a fixed or telescoping pole attached to the sample container. Weighted bottle samplers are lowered below water surface, where the attached bottle is opened, allowed to fill, and pulled out of the water. When retrieved, the bottle is tightly capped and removed from the sampler assembly. Specific types of weighted bottle samplers include dissolved oxygen, Kemmerer, or Van Dorn, and are acceptable in most instances.

A sample is taken with the following specific steps:

1. The location and desired depth for water sampling are selected.
2. The sample site is approached from downstream in a manner that avoids disturbance of bottom sediments as much as possible. The sample bottle is gently submerged with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle.
3. For weighted bottle samplers, the assembly is slowly lowered to the desired depth. The bottle stopper is unseated with a sharp tug and the bottle is allowed to fill until bubbles stop rising to the surface.
4. When the bottle is full, it is gently removed from the water. If sample transfer is required, it should be performed at this time.
5. Measure dissolved oxygen, specific conductance, temperature, and pH at the sampling location.

STANDARD OPERATING PROCEDURE

Sediment Sampling

I. Purpose

These general outlines describe the collection and handling of sediment samples during field operations.

II. Scope

The sediment sampling procedures generally describe the equipment and techniques needed to collect representative sediment samples. Operators manual , if available, should be consulted for specific details

III. Equipment and Materials

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device)
- Stainless steel spoon or spatula for media transfer
- Measuring tape
- Log book
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.)
- Materials for classifying soils, particularly the percentage of fines
- Sample jars, including jars for Total Organic Carbon and pH, as appropriate

IV. Procedures and Guidelines

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas.
2. Make a sketch of the sample area showing important nearby river features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features. Also include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (along shore, mid-channel, etc).
3. Transfer sample into appropriate sample jars with a stainless steel spoon or utensil. The sampler's fingers should never touch the sediment since gloves may introduce organic interferences into the sample. Classify the soil type of

the sample using the Unified Soil Classification System, noting particularly the percentage of silt and clay.

4. Samples for volatile organics should immediately be placed in jars. Rocks and other debris should be removed before placement in jars.

5. For channel sampling, be on the alert for submerged hazards (rocks, tree roots, drop-offs, loss silt and muck) which can make wading difficult.

6. Sample sediment for TOC and pH also, to give context to organic and inorganic data during the risk assessment.

7. Follow the site safety plan designed for the specific nature of the site's sampling activities and locations.

8. Decontaminate all sampling implements and protective clothing according to prescribed procedures.

V. Attachments

None.

VI. Key Checks and Items

- Start downstream, work upstream.
- Log exact locations using permanent features.
- Beware of hidden hazards.

STANDARD OPERATING PROCEDURE

Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure presents general guidelines for the collection of groundwater samples from monitoring wells. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Probe box with inlet/outlet ports for purged groundwater and watertight ports for each probe
- pH meter: Orion Model SA250 or equivalent
- Temperature/conductivity meter: YSI Model 33 or equivalent
- Dissolved oxygen meter: YSI Model 57 or equivalent
- In-line disposable 0.45μ filters: QED FF8100 or equivalent
- Bailer, teflon or stainless steel
- Peristaltic pump, bladder pump, or submersible sampling pump with tubing, support cables, and power supply (may not be required if well yield is low)

III. Procedures and Guidelines

A. Setup and Purging

1. For the well to be sampled, information is obtained on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.
2. A pump will be used for well purging if the well yield is adequate; otherwise, a bailer may be used.
3. Instruments are calibrated according to manufacturer's instructions.
4. The well number, site, date, and condition are recorded in the field logbook.
5. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed.

6. Water level measurements are collected in accordance with SOP Water Level Measurements, and the total depth of the well is measured.

7. The volume in gallons of water in the well casing or sections of telescoping well casing is calculated as follows:

   $0.052 (\pi r^2 h) = 0.163 (r^2 h) =$ gallons

   where: $\pi = 3.14$

   r = Radius of the well pipe in inches
   h = height of water in well in feet

   The volume of water in typical well casings may be calculated as follows:

   2-inch diameter well:
   0.163 gal/ft x ___ (linear feet of water) = gallons

   4-inch diameter well:
   0.653 gal/ft x ___ (linear feet of water) = gallons

   6-inch diameter well:
   1.469 gal/ft x ___ (linear feet of water) = gallons

   The initial field parameters of pH, specific conductance, and temperature of water are measured and recorded in the field logbook. The measurement probes are inserted into the probe box. The purged groundwater is directed throughout the box, allowing measurements to be collected before the water contacts the atmosphere.

8. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP Decontamination of Personnel and Equipment.

9. If a bailer is being used, it is removed from either its protective covering or the well casing and attached to a cord compatible with constituents and long enough to reach the bottom of the well. If a sampling pump is being used, the air line, discharge line, and support cable or rope are attached to the pump. The support line should bear the weight of the pump. If the well is purged using dedicated tubing, it is lowered into the well to the top of the screened zone.

10. The sampling device is lowered to the well interval from which the sample is to be collected. The pump intake will be placed above the top of the screen, where possible. If a bailer is being used, it is allowed to fill with a minimum of surface disturbance to prevent sample water aeration. When the bailer is raised, the bailer cord must not touch the ground.

    During purging, the field parameters are measured at least once for each well volume. In productive wells, the well purging end point is determined using the field measurements. In nonproductive wells, the well is repeatedly bailed dry to obtain a minimum of three well volumes, then allowed to recover before sampling.

12. Three to five well volumes are purged (more may be purged if parameters do not stabilize). Purging is stopped when field parameters have stabilized over two consecutive well volumes. Field parameters are considered stabilized when pH measurements agree within 0.5 units, temperature measurements agree within 1°C, and specific conductance and dissolved oxygen measurements agree within 10 percent.

B. Sample Collection

Once purging has been completed, the well is ready to be sampled. The elapsed time between completion of purging and collection of the groundwater sample from the well should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)
5. Additional remarks

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs. Samples may be field filtered before transfer to the sample bottle. Filtration must occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as

the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) using the pressure provided by the pumping device for its operation. When a bailer is used, filtration may be driven by a peristaltic pump.

3. VOC samples from wells purged using dedicated tubing and a sampling pump will be collected using a bailer

4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

5. The bottle is capped, then labeled clearly and carefully.

6. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

7. If the sampler is dedicated, it is returned to the well and the well is capped and locked. Nondedicated samplers are cleaned and decontaminated in accordance with SOP Decontamination of Personnel and Equipment.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:

- Inspect sampling pump regularly and replace as warranted
- Bring supplies for replacing the bladder if using a positive-displacement bladder pump
- Inspect tubing regularly and replace as warranted
- Inspect air/sample line quick-connects regularly and replace as warranted
- Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

STANDARD OPERATING PROCEDURE

Installation of Shallow Monitoring Wells

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of shallow monitoring wells and piezometers in unconsolidated or poorly consolidated materials. Methods for drilling and installing bedrock monitoring wells are presented in SOP Installation of Bedrock Monitoring Wells.

II. Equipment and Materials

Drilling

- Drilling rig
- Hollow-stem augers

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainlesss steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless steel screen.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless steel
- Centering Guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse) filter pack, and secondary (fine) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets
- Pure, additive-free powdered bentonite

- Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Double surge block with solid bottom, top open, separated by 2 feet of slotted pipe
- Well-development pump, and associated equipment
- Containers (e.g., 55 gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Continuous-flight hollow-stem augers with a minimum 6-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOP Shallow Soil Sampling.

The use of water to assist in hollow-stem auger drilling for monitoring well installation will be avoided, unless required for such conditions as running sands.

Hollow-stem augers, rods, split-spoon samplers, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Split-spoon samplers and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP Decon details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Field Sampling Plan.

B. Monitoring Well Installation

Shallow monitoring wells will be constructed inside the hollow-stem augers, once the borehole has been advanced to the desired depth. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the augers to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field. Based on lithologic samples previously obtained at the site, and comparison with samples to be obtained in the well borings, standard well screen slot of 0.010-inch and silica sand gradations conforming to Morie No. 1 are anticipated.

A primary sand pack (Morie No. 1) consisting of clean silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The augers will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the augers be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained, sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for the shallow water table and small saturated thickness of the surficial aquifer.

A bentonite pellet seal at least 2 feet thick will be placed above the sand pack. The pellets will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square or round, with a minimum radius of approximately 3.5 feet. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12-inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

C. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include two surge blocks separated by approximately 2 feet of coarsely slotted pipe. The lower surge block will be solid; the upper surge block will be open and attached to riser pipe leading to the ground surface. Water will be pumped continuously from the surge block screened interval throughout the surging process. The pumping will be accomplished by airlift induction methods or using a centrifugal pump or equivalent.

Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone.

Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP Decontamination of Personnel and Equipment. Water generated during well development will be contained and managed as detailed in the Field Sampling Plan Investigation Denied Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring well construction

CH2M HILL

PROJECT NUMBER	BORING NUMBER
	SHEET 1 OF 1

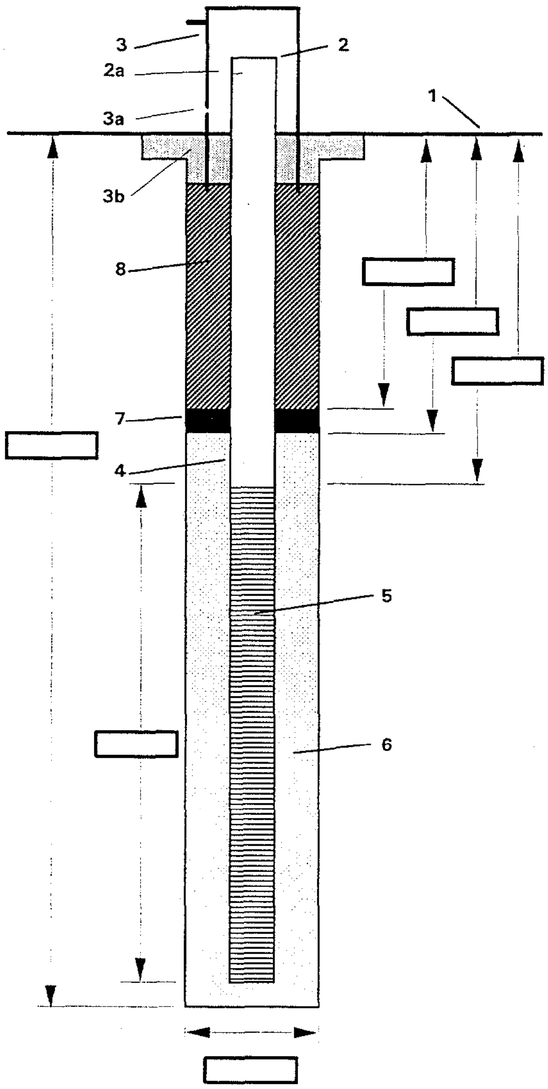
WELL COMPLETION DIAGRAM

PROJECT :   LOCATION :

ELEVATION :   DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS :   START :   END :   LOGGER :



1- Ground elevation at well __________

2- Top of casing elevation __________
   a) vent hole? __________

3- Wellhead protection cover type __________
   a) weep hole? __________
   b) concrete pad dimensions __________

4- Diameter/type of well casing __________

5- Type/slot size of screen __________

6- Type screen filter
   a) Quantity used __________

7- Type of seal
   a) Quantity used __________

8- Grout
   a) Grout mix used __________
   b) Method of placement __________
   c) Quantity of well casing grout __________

Development method __________

Development time __________

Estimated purge volume __________

Comments __________

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in monitoring wells, where a second phase of floating liquid (e.g., gasoline) is not encountered. This SOP includes guidelines for discrete measurements of static water levels.

II. Equipment and Materials

A. Discrete Measurements of Static Water Level

- Electronic water level meter, Solinst or equivalent, with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less

III. Procedures and Guidelines

A. Measurement of Static Water Level

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Sight across the top of the locking well casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface. The measuring point will be a standardized surveyed location on the top of each well casing, adjacent to the lock hasp, indicated by a notch, paint mark, or similar method. Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the log book.

Measure and record the three following additional readings: (1) the depth of the well; (2) the depth from the top of the casing to the top of the well riser; and (3) the distance to the surface of the concrete pad or to ground. Measurements are to be taken with respect to the measuring point on the top of the well casing. The depth of the well may be measured using the water-level probe with the instrument turned off.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

A. Discrete Measurements of Static Water Level

Prior to each use, verify that the battery is charged by pressing the test button on the water-level meter. Verify that the unit is operating correctly by testing the probe in distilled or deionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE

VOC Sampling—Water

I. Purpose

To provide general guidelines for sampling aqueous volatile organic compounds.

II. Scope

Standard techniques for collecting representative samples are summarized. Site specific details are discussed in the Field Sampling Plan.

III. Equipment and Materials

- Sample vials, clean latex or surgical gloves, pH meter
- Hydrochloric acid (HCl) for preservation
- pH meter or pH indicating paper
- Surgical or latex gloves

IV. Procedures and Guidelines

1. Sample VOCs before sampling other analyte groups.
2. When sampling for VOCs, especially residential wells, evaluate the area around the sampling point for possible sources of air contamination by VOCs. Products that may give off VOCs and possibly contaminate a sample include perfumes and cosmetics, skin applied pharmaceuticals, automotive products (gasoline, starting fluid, windshield deicers, carburetor cleaners, etc.) and household paint products (paint strippers, thinners, turpentine, etc.).
3. VOC sample vials will be pre-preserved with 0.5 ml HCl. To confirm that sufficient HCl has been added, the pH of a test sample will be checked. Sample pH must be less than 2. A small quantity of HCl will be available on site for the case where additional acid is required to preserve the sample.
4. Keep the caps off the sample vials for as short a time as possible.
5. Wear clean latex or surgical gloves.
6. Fill the sample vial immediately, allowing the water stream to strike the inner wall of the vial to minimize formation of air bubbles. DO NOT RINSE THE SAMPLE VIALS BEFORE FILLING.

7. Fill the sample vial with a minimum of turbulence, until the water forms a positive meniscus at the brim.

8. Replace the cap by gently setting it on the water meniscus. Tighten firmly, but DO NOT OVERTIGHTEN.

9. Invert the vial and tap it lightly. If you see air bubbles in the sample, do not add more sample. Use another vial to collect another sample. Repeat if necessary until you obtain a proper sample.

V. Attachments

None.

VI. Key Checks and Items

- Check for possible sources of contamination.
- Check pH.
- Fill slowly, with as little turbulence as possible.
- Check for air bubbles.

Field Rinse Blank Preparation

I. Purpose

To prepare a blank to determine adequacy of decon procedures and whether any cross-contamination is occurring during sampling.

II. Scope

The general protocols for preparing the rinse blank are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II grade water)
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP Decontamination of Personnel and Equipment.

B. To collect the sample for volatiles analysis, pour blank water over one piece of equipment and into 40-ml vials until there is a positive meniscus and seal vials. Note the sample number and associated piece of equipment in the field notebook.

For non-volatiles, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

C. Document and ship samples in accordance with the procedures for other samples.

D. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II grade water.

STANDARD OPERATING PROCEDURE

Field Filtering

I. Purpose

To provide a general guideline for the field filtering of water samples for dissolved metals analysis.

II. Scope

This is a general discussion of the standard method of field filtering techniques. Operating manuals should be consulted regarding specific procedures.

III. Equipment and Materials

- Geotech Filtering apparatus or equivalent
- Pump
- nitric acid (HNO_3) solution - high grade - reagent grade not acceptable
- Glass fiber prefilters
- Vacuum source
- 45 μm cellulose acetate filters
- inline filters

IV. Procedures and Guidelines

A. REAGENT PREPARATION

1. 10% HNO_3 solution: Add about 900 ml of ASTM Type II water to a 1 liter Erlenmeyer flask. Using a graduated cylinder, ASTM Type II, add 100 ml concentrated HNO_3 to the DI water while stirring.

B. PROCEDURE

1. Attach a vacuum source (pump, syringe, etc.) or a Q.E.D. online filter or equivalent to the receiver assembly.
2. Flush the entire filter system with 10% HNO_3 solution. Open assembly, discard rinsate, and reassemble unit.
3. Flush the entire filter system with 60 ml ASTM Type II water. Open assembly, discard rinsate and reassemble unit (not required when using Q.E.D. online filter).
4. Filter sample and transfer to polyethylene bottle (with preservative) for shipment.

STANDARD OPERATING PROCEDURE

Homogenization of Soil and Sediment Samples

I. Purpose

The homogenization of soil and sediment samples is performed to minimize any bias of sample representativeness introduced by the natural stratification of constituents within the sample.

II. Scope

Standard techniques for soil and sediment homogenization and equipment are provided in this SOP. These procedures do not apply to aliquots collected for TCL VOCs or field GC screening; samples for these analyses should NOT be homogenized.

III. Equipment and Materials

Sample containers, stainless steel spoons or spatulas, and stainless steel pans.

IV. Procedures and Guidelines

Soil and sediment samples to be analyzed for semivolatiles, pesticides, PCBs, metals, cyanide, or field XRF screening should be homogenized in the field. After a sample is taken, a stainless steel spatula should be used to remove the sample from the split spoon or other sampling device. The sampler should not use fingers to do this, as gloves may introduce organic interferences into the sample.

Samples for VOCs should be taken immediately upon opening the spoon and should not be homogenized.

Prior to homogenizing the soil or sediment sample, any rocks, twigs, leaves, or other debris should be removed from the sample. The sample should be placed in a decontaminated stainless steel pan and thoroughly mixed using a stainless steel spoon. The soil or sediment material in the pan should be scraped from the sides, corners, and bottom, rolled into the middle of the pan, and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually, and then rolled to the center of the pan and mixed with the entire sample again.

All stainless steel spoons, spatulas, and pans must be decontaminated following procedures specified in SOP Decontamination of Personnel and Equipment prior to homogenizing the sample. A composite equipment rinse blank of homogenization equipment should be taken each day it is used.

5. Discard filter assembly and prefilter.

V. Attachments

None.

VI. Key Checks and Items

- 10% HNO_3 solution for cleaning
- All water must be ASTM Type II
- Prefilter with glass fiber filters if sample is turbid
- Record lot number of nitric acid and water
- Note monitoring wells with high concentrations of suspended solids in field notebooks
- The equipment blank collected with the sample is called a filtration blank and is collected through the filter.

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

I. Purpose

The purpose of this procedure is to outline equipment and methods that will be used for well installation and development and provide site personnel with a review of the well installation procedures that will be performed.

II. Scope

Surface casing well installations and shallow unconsolidated well installations are planned.

III. Equipment and Materials

- Drilling Rig
- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded well casing
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, 0.010-inch factory slotted well screen
- PVC, bottom cap, threaded to match the well screen.
- Stainless steel centralizers if needed.
- Above-grade well completion: PVC well cap, threaded or push-on type, vented.
- Clean silica sand, provided in factory-sealed bags, well-rounded, and containing no organic material.
- Bentonite seal: Pure, additive-free bentonite pellets.
- Bentonite for grout: Pure, additive-free powdered bentonite.
- Cement-Bentonite Grout. Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage.
- Above-grade protective casing: Permanent isolation casing with heavy duty locking cover, painted with epoxy paint for rust protection, industrial lock.

- Double surge block with bottom solid, top open, separated by 2 feet of slotted pipe for well development
- Pump and associated development equipment
- Calibrated meters to ensure pH, temperature, and specific conductance
- Containerization for water produced from well

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double cased.
2. The threaded connections will be water-tight.
3. Well screens will be constructed of 0.010 slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact length will be determined by the field team supervisor.
4. Wells will be surrounded by three concrete-filled, 4-inch diameter steel guard posts.
5. A record of the finished well construction will be compiled.
6. All soils and liquids generated during well installations will be drummed for proper disposal.

Shallow Unconsolidated Well Installation

- Monitoring wells in unconsolidated materials will be installed using 6-¼ inch ID augers to accommodate well completion materials.
- Unconsolidated monitoring wells will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, schedule 40 PVC screen with threaded bottom plug and riser.
- Screens will be filter packed with a proper sized and graded, thoroughly washed, sound, durable, well-rounded siliceous sand.
- The filter pack will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken.
- Annular well seals will consist of 2 feet of pelletized bentonite clay and placed above the filter pack.
- The top of the annular seal will be measured after the pellets have been allowed to settle and before the grout is applied.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.

- The grout mixture consists of 94 lbs of cement (1 bag) per 6 gallons of water and 2 to 3 lbs of powdered bentonite per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the bottom of the space to be grouted to the surface (tremie grouting).
- After allowing the grout to settle overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be concreted in place for each new well; the casing will extend at least 2 feet above grade and painted a bright color.

Deep Well Installation

- Hollow stem auger drilling techniques will be used to drill boreholes for installation of surface isolation casing. 8¼-inch minimum ID HSA will be used to drill the borehole into the confining layer. Lithologic samples also will be collected.
- When the borehole is advanced from ground surface to the confining layer for placement of a 6-inch ID surface casing, the borehole will have a minimum diameter of 10 inches. The borehole will extend a minimum of 2 feet into competent bedrock for seating of the surface casing.
- The surface casing will be pressure grouted in place using a cement-bentonite mixture and allowed to cure for a minimum of 12 hours before drilling is allowed to continue.
- The borehole will be advanced beyond the 6-inch surface casing by the mud rotary drilling method. The addition of bentonite drilling mud will be avoided is possible. However, this may become necessary if the borehole collapse during the drilling process. Other methods such as wire-line techniques may be used is the addition of liquids into the borehole are prohibited.
- Monitoring wells will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, schedule 40 PVC screen with threaded bottom plug and riser.
- Screens will be filter packed with a proper sized and graded, thoroughly washed, sound, durable, well-rounded siliceous sand.
- The filter pack will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken.
- Annular well seals will consist of 2 feet of pelletized bentonite clay and placed above the filter pack.

- The top of the annular seal will be measured after the pellets have been allowed to settle and before the grout is applied.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 94 lbs of cement (1 bag) per 6 gallons of water and 2 to 3 lbs of powdered bentonite per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the bottom of the space to be grouted to the surface (tremie grouting).
- After allowing the grout to settle overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be concreted in place for each new well; the casing will extend at least 2 feet above grade and painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has cured (at least 48 hours).
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- Development will include surging the well by abruptly stopping flow and allowing water in the well column to fall back into the well.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air lift method will be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums supplied by CH2M HILL. CH2M HILL will label and date the drums, and transport the drums to an EPA designated site for storage.

V. Attachments

None.

VI. Key Check and Items

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures

I. Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with about 3 inches of vermiculite.

B. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.

C. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.

D. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Sample label should be visible through the bag.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.

G. Fill remaining spaces with vermiculite.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

I. Separate copies of forms. Seal proper copies (traffic reports, packing lists) along with a return address label within a large zip-lock bag and tape to inside lid of cooler.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. **Do not** cover custody seals.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

II. Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with several additional restrictions. First, a special airbill including a Shipper's Certification for Restricted Articles is required. Second, "Flammable Liquid N.O.S." or "Flammable Solid N.O.S." (as appropriate) labels must be placed on at least two sides of the cooler. Third, sample containers are packaged in metal cans with lids before being placed in the cooler, as indicated below:

- Place approximately ½ inch of vermiculite in the bottom of the can.
- Position the sample jar in the zip-loc bag so that the sample tags can be read through the plastic bag.
- Place the jar in the can and fill the remaining volume with vermiculite.
- Close the can and secure the lid with metal clips.
- Write the traffic report number on the lid.
- Place "This Side Up" and "Flammable Liquid N.O.S." or "Flammable Solid N.O.S." (as appropriate) labels on the can.
- Place the cans in the cooler.
- For medium concentration samples, ship samples with ice or "blue ice" inside the coolers. (Double bag ice in zip-lock plastic bags.)

III. Special Instructions for Shipping Medium and High Concentration Samples by Federal Express

A. Label cooler as hazardous shipment:

- Write shipper's address on outside of cooler. If address is stenciled on, just write "shipper" above it.
- Write or affix sticker saying "This Side Up" on two adjacent sides.
- Write or affix sticker saying "ORM-E" with box around it on two adjacent sides. Below ORM-E, write NA#9188.
- Label cooler with "Hazardous Substance, N.O.S." and "liquid" or "solid," as applicable.

B. Complete the special shipping bill for restricted articles.

- Under Proper Shipping Name, write "Hazardous Substance, N.O.S." and "liquid" or "solid," as applicable.
- Under Class, write "ORM-E.
- "Under Identification No., write NA No. 9188.

C. For high concentration samples, ship samples with "blue ice" only inside coolers.

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water)
- Distilled water
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- Laboratory-grade detergent (low phosphate) and water solution
- Concentrated (V/V) pesticide grade methanol (DO NOT USE ACETONE)
- 10% (V/V) nitric acid (HNO_3) and water solution (only ultrapure grade HNO_3 is to be used)
- Large plastic pails or tubs for laboratory-grade detergent and water, scrub brushes, squirt bottles, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Phthalate-free gloves
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in laboratory-grade detergent solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with laboratory-grade detergent solution, remove, and discard into DOT approved 55-gallon drum.
2. Wash outer gloves in laboratory-grade detergent solution, rinse, remove, and discard into DOT approved 55-gallon drum.
3. Remove disposable coveralls ("Tyveks") and discard into approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep hoses from touching the ground
3. Turn off pump after sampling. Remove pump from well and place pump in decontamination tube, making sure that tubing does not touch the ground
4. Turn pump back on and pump 1 gallon of laboratory-grade detergent solution through the sampling pump.
5. Rinse with 1 gallon of 10% methanol solution pumped through the pump. (DO NOT USE ACETONE).
6. Rinse with 10% HNO_3 solution pumped through the pump, when sampling for inorganics (carbon steel split spoons will be rinsed with a 1% solution).
7. Rinse with 1 gallon of tap water.
8. Rinse with 1 gallon of deionized water.
9. Keep decontaminated pump in decontamination tube or remove and

wrap in aluminum foil or clean plastic sheeting.

10. Collect all rinsate and dispose of in a DOT approved 55-gallon drum.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Prior to entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with laboratory-grade detergent solution.
5. Rinse with potable water.
6. Rinse with 10% HNO_3 solution when sampling for inorganics (carbon steel split spoons will be rinsed with a 1% solution).
7. Rinse with distilled or potable water and methanol solution (DO NOT USE ACETONE).
8. Air dry.
9. Rinse with deionized water.
10. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
11. Collect all rinsate and dispose of in a DOT approved 55-gallon drum.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with laboratory-grade detergent solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT approved 55-gallon drum.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with laboratory-grade detergent solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT approved 55-gallon drum.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Navy

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of laboratory-grade detergent, methanol, nitric acid, and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

Final

Health and Safety Plan
Landfill C (Site 3) and Landfill D (Site 4)

St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order 027

May 1997

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

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Prepared by

CDM Federal Programs Corporation

Fairfax, Virginia

Submitted by

CH2M HILL

Federal Group, Ltd.
Herndon, Virginia

HEALTH AND SAFETY PLAN FORM | CDM FEDERAL PROGRAMS CORPORATION

CDM Federal Health and Safety Program

PROJECT NAME: St Julien's Creek Annex, Landfill C & D	CONTRACT TASK ORDER NO.: 027 REGION III
JOBSITE ADDRESS: St. Julien's Creek Annex	CLIENT: U.S. Navy
Chesapeake, VA	CONTRACT NO.: N62470-95-6007
SITE CONTACT: Randy Jackson, NTR	CLIENT CONTACT: Randy Jackson, NTR
PHONE NO.: 1-757-322-4587	PHONE NO.: 1-757-522-4587

( ) AMENDMENT NO. ____ TO EXISTING APPROVED HSP - DATE EXISTING APPROVED HSP ____________

OBJECTIVES OF FIELD WORK:

To perform a remedial investigation on two landfills at the St. Julien's Creek Annex, Landfill C (Site 3) and Landfill D (Site 4). Fieldwork will consist of a geophysical survey, drilling and installation of monitoring wells, groundwater sampling, surface soil sampling, sediment and surface water sampling, and DPT subsurface soil sampling (e.g. Geoprobe).

TYPE: Check as many as applicable

( ) Active	(√) Landfill	( ) Unknown
(√) Inactive	( ) Uncontrolled	(√) Military
(√) Secure	( ) Industrial	( ) Other specify:
( ) Unsecure	( ) Recovery	
( ) Enclosed space	( ) Well Field	

DESCRIPTION AND FEATURES: Summarize below. Include principal operations and unusual features (containers, buildings, dikes, power lines, hills, slopes, river)

The St. Julien's Creek Annex facility is a low-lying wedge of land between the Southern Branch of the Elizabeth River and St. Julien's Creek. Elevations range from sea level along the banks of the two bordering waterways, and along Blows Creek located in the northern part of the facility, to 15 feet above mean sea level (msl) northeast of Blows Creek. A northwest-southeast trending ridge generally bisects the area, dividing the St. Julien's Creek drainage basin to the southwest and the Blows Creek drainage basin to the northeast.

St. Julien's Creek receives the majority of surface water runoff from the Annex, which empties into the Southern Branch of the Elizabeth River. The remaining runoff from the Annex flows directly into the Southern Branch of the Elizabeth River, or is diverted into storm drains that empty either into the Elizabeth River or St. Julien's Creek. The Southern Branch of the Elizabeth River flows north to discharge into the James River, which flows into the Chesapeake Bay. The St. Julien's Creek Annex facility was initially recognized to be situated within the boundaries of the 100-year flood plain. However, a 1984 Environmental Assessment Addendum indicated that according to the 1983 National Flood Insurance Program flood maps, the 100-year flood level for the originally proposed St. Julien's Creek Annex facility is 8.5 feet above msl.

SURROUNDING POPULATION: (√) Residential (√) Industrial ( ) Rural (√) Urban ( ) OTHER:

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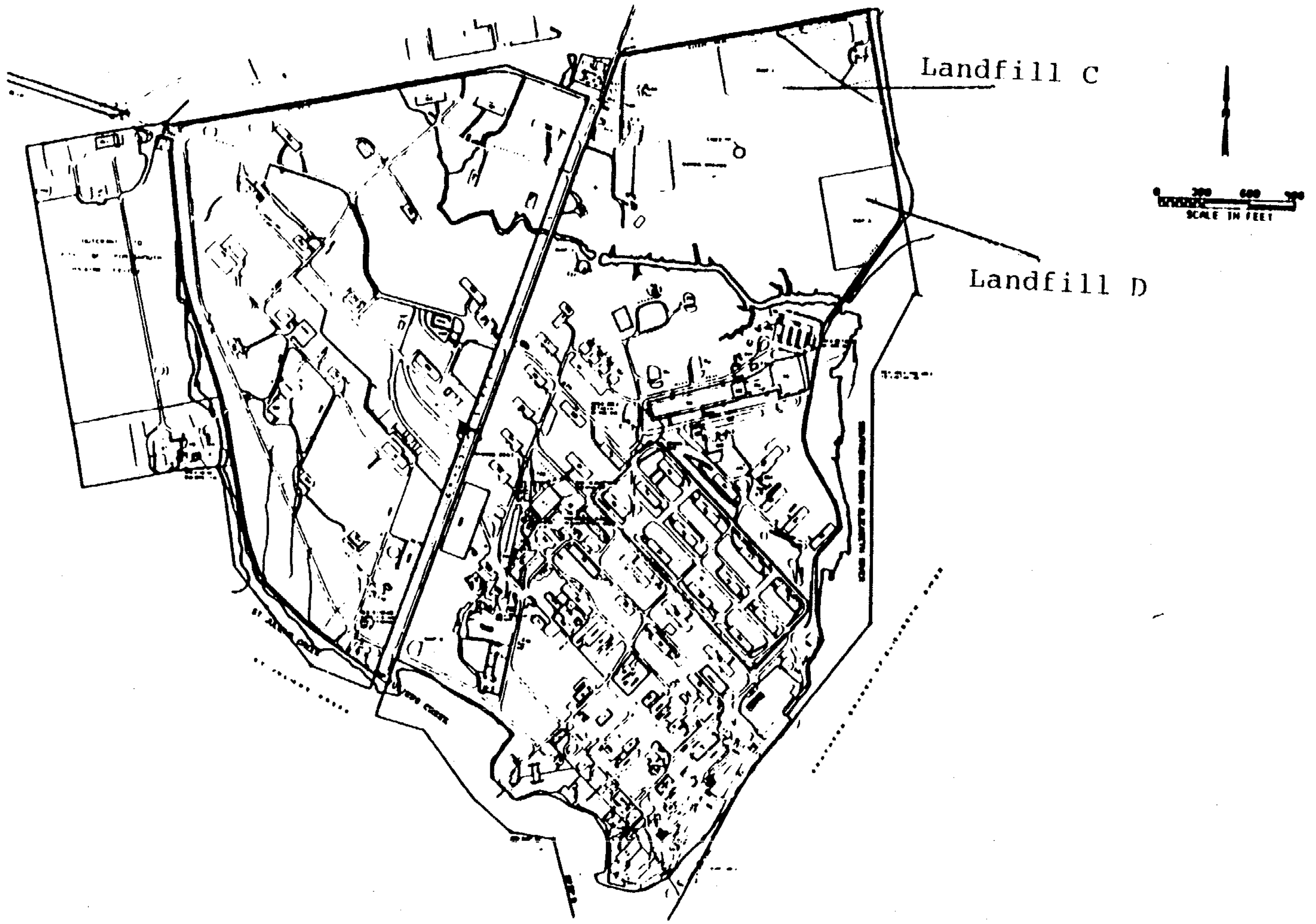
THIS PAGE RESERVED FOR MAP (Show Exclusion, Contamination Reduction, and Support Zones. Indicate evacuation and reassembly points.)



HEALTH AND SAFETY PLAN FORM — CDM FEDERAL PROGRAMS CORPORATION

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HISTORY: Summarize below. In addition to history, include complaints from public, previous agency actions, known exposures or injuries, etc.

The St. Julien's Creek Annex was originally an ammunition facility. Activity at the Annex has decreased in conjunction with present national peacetime conditions. The current primary mission of the St. Julien's Creek Annex facility is to provide a radar testing range and various administrative and warehousing facilities for the nearby Norfolk Naval Shipyard and other local Navy activities. Processes and operations at the St. Julien's Creek Annex facility have included general ordnance operations involving wartime transfer of ammunition to various other U.S. Naval facilities throughout the United States and abroad. The St. Julien's Creek Annex facility has also been involved in non-ordnance operations, including degreasing operations, paint shops, machine shops, vehicle and locomotive maintenance shops, pest control shops, battery shops, print shops, electrical shops, boiler plant operations, wash rack operations, potable and salt water fire protection systems, and fire training operations. Many of these operations have been discontinued, such as locomotive maintenance, printing, and pest control. Materials stored at the St. Julien's Creek Annex have included oil, ordnance materials, non-ordnance chemicals, and disaster preparedness chemicals. Various parts of the facility are used to store small amounts of waste before transfer to accumulation points. Landfills C & D are not considered by the Navy to pose a UXO hazard.

WASTE TYPES: (√) Liquid (√) Solid ( ) Sludge ( ) Gas ( ) Unknown ( ) Other **specify**:

WASTE CHARACTERISTICS: Check as many as applicable.

( ) Corrosive (√) Flammable ( ) Radioactive

(√) Toxic ( ) Volatile (√) Reactive

( ) Inert Gas ( ) Unknown ( ) Other **specify**:

HAZARDS OF CONCERN:

( ) Heat Stress attach guidelines (√) Noise

(√) Cold Stress attach guidelines (√) Inorganic Chemicals

(√) Explosive/Flammable (√) Organic Chemicals

( ) Oxygen Deficient ( ) Motorized Traffic

( ) Radiological ( ) Heavy Machinery

( ) Biological ( ) Slips, Trips & Falls

WORK ZONES: Describe the Exclusion, Contamination Reduction, and Support Zones in terms onsite personnel will recognize.

Due to the nature of the investigation, formal workzones are impractical. The site health and safety officer will determine workzones as necessary during the course of operations. A 30-foot zone around drill rigs and a 20-foot zone around the Geoprobe rig is recommended for the protection of non-workers.

PRINCIPLE DISPOSAL METHODS AND PRACTICES: **Summarize below:**

Investigation derived waste (IDW) handling and disposal procedures are in the Workplan for this field investigation.

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HAZARDOUS MATERIAL SUMMARY: Circle waste type and estimate amounts by category

CHEMICALS Amounts/Units:	SOLIDS Amounts/Units:	SLUDGES Amounts/Units:	SOLVENTS Amounts/Units:	OILS Amounts/Units:	OTHER Amounts/Units:
Acids	Flyash	Paint	**Halogenated (chloro, bromo) Solvents**	Oily Wastes	Laboratory
Pickling Liquors	Asbestos	Pigments	Hydrocarbons	Gasoline	Pharmaceutical
Caustics	Milling/Mine Tailings	Metal Sludges	Alcohols	Diesel Oil	Hospital
Pesticides	Ferrous Smelter	POTW Sludge	Ketones	Lubricants	Radiological
Dyes/Inks	Non-ferrous Smelter	Aluminum	Esters	**PCBs**	**Municipal**
Cyanides	**Metals**	Distillation Bottoms	Ethers	**Polynuclear Aromatics**	Construction
Phenols	Other	Other	Other	Other	**Munitions**
Halogens	**Specify:**	**Specify:**	**Specify:**	**Specify:**	Other
Dioxins					**Specify:**
Other					
Specify:					

OVERALL HAZARD EVALUATION: ( ) High ( ) Medium (√) Low ( ) Unknown (Where tasks have different hazards, evaluate each. Attach additional sheets if necessary)

JUSTIFICATION: Prior investigations.

FIRE/EXPLOSION POTENTIAL: ( ) High ( ) Medium (√) Low ( ) Unknown

BACKGROUND REVIEW: (√) COMPLETE ( ) INCOMPLETE

KNOWN CONTAMINANTS	HIGHEST OBSERVED CONCENTRATION (ppm, in soil)	PEL/TLV	IDLH	WARNING CONCENTRATION (ppm)	SYMPTOMS/EFFECTS OF ACUTE EXPOSURE	PHOTO-IONIZATION POTENTIAL
Arsenic*	13.5	0.5 mg/m^3	NE	NE	Vomiting, cyanotic expression	NA
Barium	107	0.5 mg/m^3	50 mg/m^3	NE	Irrit eyes, skin burns	NA
Chromium*	256	0.5 mg/m^3	25 mg/m^3	NE	Irrit eyes, sens dermis	NA
Cobalt	14.7	0.05 mg/m^3	20 mg/m^3	NE	Wheezing, coughing	NA
Copper	263	1.0 mg/m^3	100 mg/m^3	NE	Irrit eyes, nose, metallic taste	NA
Lead	366	0.05 mg/m^3	100 mg/m^3	NE	Weakness, facial pallor	NA
Manganese	153	1.0 mg/m^3	500 mg/m^3	NE	Parkinson's, asthenia	NA
Mercury	1.6	0.05 mg/m^3	10 mg/m^3	NE	Irrit eyes, skin, chest pain	NA
Nickel	1400	0.02 mg/m^3	10 mg/m^3	NE	Sens dermis, allergic asthma	NA
Arochlor 1254	0.04	0.5 mg/m^3	5 mg/m^3	NE	Irrit eyes, chloracne, liver damage	NA
Benzo(a)pyrene*	0.38	NE	NE	NE	NA	NA
Chrysene*	0.48	NE	NE	NE	NA	NA
Fluoranthene	0.66	NE	NE	NE	NA	NA
Phenantherene	0.42	NE	NE	NE	NA	NA
Pyrene	0.52	NE	NE	NE	NA	NA
NA=Not Available S=Soil A=Air	NE=None Established SW=Surface Water	D=Drums T=Tailings SL=Sludge	W=Waste D=Drums	U=Unknown TK=Tanks L=Lagoon	GW=Groundwater SD=Sediment OFF=Offsite	*Potential or known carcinogen

HEALTH AND SAFETY PLAN FORM						CDM FEDERAL PROGRAMS CORPORATION
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FIELD ACTIVITIES COVERED UNDER THIS PLAN				HAZARD		
TASK DESCRIPTION/SPECIFIC TECHNIQUE-STANDARD OPERATING PROCEDURES/SITE LOCATION(Attach additional sheets as necessary)	Type	Primary	Contingency	SCHEDULE		
1 Drilling and Installation of Groundwater Wells	**Intrusive**	A B C **D**	A B **C** D	Hi	Med	**Low**
	Non-intrusive	**Modified**	Exit Area			
2 DPT (Geoprobe) Subsurface Soil & Groundwater Sampling	**Intrusive**	A B C **D**	A B **C** D	Hi	Med	**Low**
	Non-intrusive	**Modified**	Exit Area			
3 Groundwater, Soil, Surface Water, and Sediment Sampling	**Intrusive**	A B C **D**	A B **C** D	Hi	Med	**Low**
	Non-intrusive	**Modified**	Exit Area			
4 Surface Geophysics	Intrusive	A B C **D**	A B C D	Hi	Med	**Low**
	Non-intrusive	**Modified**	**Exit Area**			
5 Decontamination of Equipment	Intrusive	A B C **D**	A B C D	Hi	Med	**Low**
	Non-intrusive	**Modified**	**Exit Area**			
6	Intrusive	A B C D	A B C D	Hi	Med	Low
	Non-intrusive	Modified	Exit Area			

PERSONNEL* AND RESPONSIBILITIES (Include subcontractors)

NAME	FIRM/REGION	CDM Federal HEALTH CLEARANCE	RESPONSIBILITIES	ONSITE?
Brian Jenks	Federal/FFX	Yes	Field Team Leader	1 - 2 - 3 - 4 - 5
Lisa Campbell	Federal/FFX	Yes	Site Health & Safety Officer	1 - 2 - 3 - 4 - 5
Todd Stribley	Federal/FFX	Yes	Staff	2 - 3 - 5
Sharon Budney	Federal/FFX	Yes	Staff	2 - 3 - 5

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PROTECTIVE EQUIPMENT: Specify by task. Indicate type and/or material as necessary. Use copies of this sheet if needed.

BLOCK A — TASKS: **1 - 2 - 3** - 4 - 5 - 6 — (√) Primary
LEVEL: A - B - C - **D - Modified** — ( ) Contingency

Respiratory: (√) Not Needed
( ) SCBA, Airline:
( ) APR:
( ) Cartridge:
( ) Escape Mask:
( ) Other:

Head and Eye: ( ) Not Needed
(√) Safety Glasses:
( ) Face Shield:
( ) Goggles:
(√) Hard Hat:
( ) Other:

Boots: ( ) Not Needed
(√) Boots: Leather steel-toed work boots
( ) Overboots:
( ) Rubber:

Prot. Clothing: ( ) Not Needed
( ) Encapsulated Suit:
( ) Splash Suit:
( ) Apron
(√) Tyvek Coverall:
( ) Saranex Coverall:
( ) Cloth Coverall:
( ) Other:

Gloves: ( ) Not Needed
( ) Undergloves:
(√) Gloves: Latex or leather
( ) Overgloves:

( ) Other - specify below:

BLOCK B — TASKS: **1 - 2 - 3** - 4 - 5 - 6 — ( ) Primary
LEVEL: A - B - **C** - D - Modified — (√) Contingency

Respiratory: ( ) Not Needed
( ) SCBA, Airline:
(√) APR:
(√) Cartridge: GMC-H
( ) Escape Mask:
( ) Other:

Head and Eye: ( ) Not Needed
(√) Safety Glasses:
( ) Face Shield:
( ) Goggles:
(√) Hard Hat:
( ) Other:

Boots: ( ) Not Needed
(√) Boots: Leather steel-toed work boots
(√) Overboots:
( ) Rubber:

Prot. Clothing: ( ) Not Needed
( ) Encapsulated Suit:
( ) Splash Suit:
( ) Apron
(√) Tyvek Coverall:
( ) Saranex Coverall:
( ) Cloth Coverall:
( ) Other:

Gloves: ( ) Not Needed
(√) Undergloves: Latex
(√) Gloves:
( ) Overgloves:

( ) Other - specify below:

BLOCK C — TASKS: 1 - 2 - 3 - **4 - 5** - 6 — (√) Primary
LEVEL: A - B - C - **D - Modified** — ( ) Contingency

Respiratory: (√) Not Needed
( ) SCBA, Airline:
( ) APR:
( ) Cartridge:
( ) Escape Mask:
( ) Other:

Head and Eye: ( ) Not Needed
(√) Safety Glasses: If needed
( ) Face Shield:
( ) Goggles:
(√) Hard Hat: If needed
( ) Other:

Boots: ( ) Not Needed
(√) Boots: Leather steel-toed work boots
( ) Overboots:
( ) Rubber:

Prot. Clothing: (√) Not Needed
( ) Encapsulated Suit:
( ) Splash Suit:
( ) Apron
( ) Tyvek Coverall:
( ) Saranex Coverall:
( ) Cloth Coverall:
( ) Other:

Gloves: (√) Not Needed
( ) Undergloves:
( ) Gloves:
( ) Overgloves:

( ) Other - specify below:

BLOCK D — TASKS: 1 - 2 - 3 - **4 - 5** - 6 — ( ) Primary
LEVEL: A - B - C - **D - Modified** — (√) Contingency

Respiratory: (√) Not Needed
( ) SCBA, Airline:
( ) APR:
( ) Cartridge:
( ) Escape Mask:
( ) Other:

Head and Eye: (√) Not Needed
( ) Safety Glasses:
( ) Face Shield:
( ) Goggles:
( ) Hard Hat:
( ) Other:

Boots: (√) Not Needed
( ) Boots: Leather steel-toed work boots
( ) Overboots:
( ) Rubber:

Prot. Clothing: (√) Not Needed
( ) Encapsulated Suit:
( ) Splash Suit:
( ) Apron
( ) Tyvek Coverall:
( ) Saranex Coverall:
( ) Cloth Coverall:
( ) Other:

Gloves: (√) Not Needed
( ) Undergloves:
( ) Gloves:
( ) Overgloves:

(√) Other - specify below:
Leave area until cleared by SHSO

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MONITORING EQUIPMENT: Specify by task. Indicate type as necessary. Attach additional sheets as necessary.

INSTRUMENT	TASK	ACTION GUIDELINES		COMMENTS (Includes schedules of use)
Combustible Gas Indicator	1	0-10% LEL 10-25 LEL **>25% LEL** 21.0% 02 <21.0% 02 **<19.5% 02**	No explosion hazard Potential explosion hazard; notify SHSO. **Explosion hazard; interrupt task/evacuate** Oxygen normal Oxygen deficient; notify SHSO **Interrupt task/evacuate**	( ) Not Needed
Radiation Survey Meter	4	3X Background **>2mR/hr**	Notify SHSO **Interrupt task/evacuate**	( ) Not Needed To be used during site walkover.
Photoionization Detector Type OVM ( ) 11.7 ev (√) 10.2 ev ( ) 9.8 ev	1 - 2 - 5	**0 - 2 ppm: Level D** **2-25 ppm: Level C** **>25 ppm: Interrupt task or evacuate**		( ) Not Needed No chemicals detected during prior sampling are detectable with a PID. However, it will be still be used.
Flame Ionization Detector Type ________				(√) Not Needed
Detector Tubes/Monitox Type ________ Type ________				(√) Not Needed
Respirable Dust Monitor Type Miniram Type ________	1 - 2 - 3 - 4 - 5	**0 - 0.5 (or visible dust): Level D** **0.01 - 5: Level C or interrupt task** **>5 : Interrupt task or evacuate, notify SHSO**		( ) Not Needed Major health concerns are associated with airborne dusts.
Other **Specify**		**Specify:**		

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DECONTAMINATION PROCEDURES

ATTACH SITE MAP INDICATING EXCLUSION, DECONTAMINATION, AND SUPPORT ZONES AS PAGE TWO

Personalized Decontamination Summarize below and/or attach diagram; discuss use of work zones. 1. Wash boots in soap solution and rinse with water. If disposable boots are used, discard into waste drum. 2. Wash outer gloves in soap oslution, rinse, remove, and discard into waste drum. 3. Remove disposal coveralls (if used) and discard into waste drum. 4. Remove respirator (if used). Discard cartidges in waste drum. 5. Remove inner gloves and discard into waste drum. 6. At end of work day, shower entire body, including hair, either at work site or at residence. 7. Sanitize respirator (if worn). ( ) Not Needed	Sampling Equipment Decontamination Summarize below and/or attach diagram; discuss use of work zones. 1. Don gloves, wrap soil contact points in aluminum foil (shiny side out), and rinse and scrup with potable water. 2. Wash all equipment surfaces that contacted the pontentially contaminated soil/water with soap solution, and rinse with potable water. 3. Rinse with 10% nitric acid solution (when sampling for inorganics). Carbon steel split spoons will be rinsed with a 1% solution. 4. Rinse with distilled or potable water and methanol solution. Do not use acetone. 5. Air dry, rinse with deionized water and allow to completely air dry. 6. Wrap exposed areas with aluminum foil (shiny side out). Collect and dispose of wastewater in liquid waste drum. ( ) Not Needed	Heavy Equipment Decontamination Summarize below and/or attach diagram; discuss use of work zones. 1. Heavy equipment includes drill rigs, drilling rods and tools, backhoes, and other large pieces of machinery. 2. Set up on decontamination pad in area designated by the Navy. 3. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas. ( ) Not Needed
Containment and Disposal Method Investigation derived waste (IDW) handling and disposal procedures are in the Workplan for this field investigation.	Containment and Disposal Method Investigation derived waste (IDW) handling and disposal procedures are in the Workplan for this field investigation.	Containment and Disposal Method Investigation derived waste (IDW) handling and disposal procedures are in the Workplan for this field investigation.

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EMERGENCY CONTACTS		
Water Supply		
Site Telephone	Cellular Phone	To be determined
EPA Release No.		1-800-424-8802
Facility Management	Shipyard Duty Desk	1-757-396-3221
Site Spills	COMNAVBASE Duty Desk	1-757-322-2866
Emergencies	Shipyard Emergency #	1-757-396-3333

EMERGENCY CONTACTS	NAME	PHONE
Health and Safety Manager	Chuck Myers	1-703-968-0900
Project Manager	David Schroeder	1-703-968-0900
H & S Coordinator	Dean Costello	1-703-968-0900
Client Contact	Randy Jackson	1-757-322-4587
Other (specify)		
Environmental Agency		
State Spill Number	VA Release Office	1-800-468-8892
Fire Department	Shipyard Fire Dept.	1-757-396-3335
Police Department	Shipyard Security Office	1-757-396-5111
State Police	VA State Police	1-757-494-2434
Health Department	Chesapeake Health Dept.	1-757-382-8600
Poison Control Center	VA Poison Center	1-800-552-6337
Occupational Physician	Dr. Tom Winters	1-800-350-4511

CONTINGENCY PLANS Summarize below:

Many contaminants on site do not have a TLV number associated with them (e.g. PAHs). As a result, people must take care not to have skin contact with soil on the site. Due to the toxicity of many metals that have been detected, attention to air monitoring is critical. Dust suppression procedures may be necessary. If a visible dust cloud is seen, move away from the site immediately until the cloud clears away. If Level C is needed, special care should be used to tape the seems of the Tyvek coveralls. During sampling activities, make sure that the "buddy" system is used.

MEDICAL EMERGENCY	
Hospital Name: Maryview Hospital	1-757-398-2200
Hospital Address: Oakley Street	
Name of Contact at Hospital:	
Name of 24-Hour Ambulance: Shipyard Emergency	1-757-396-3333

Route to Hospital (Attach map with route to hospital)

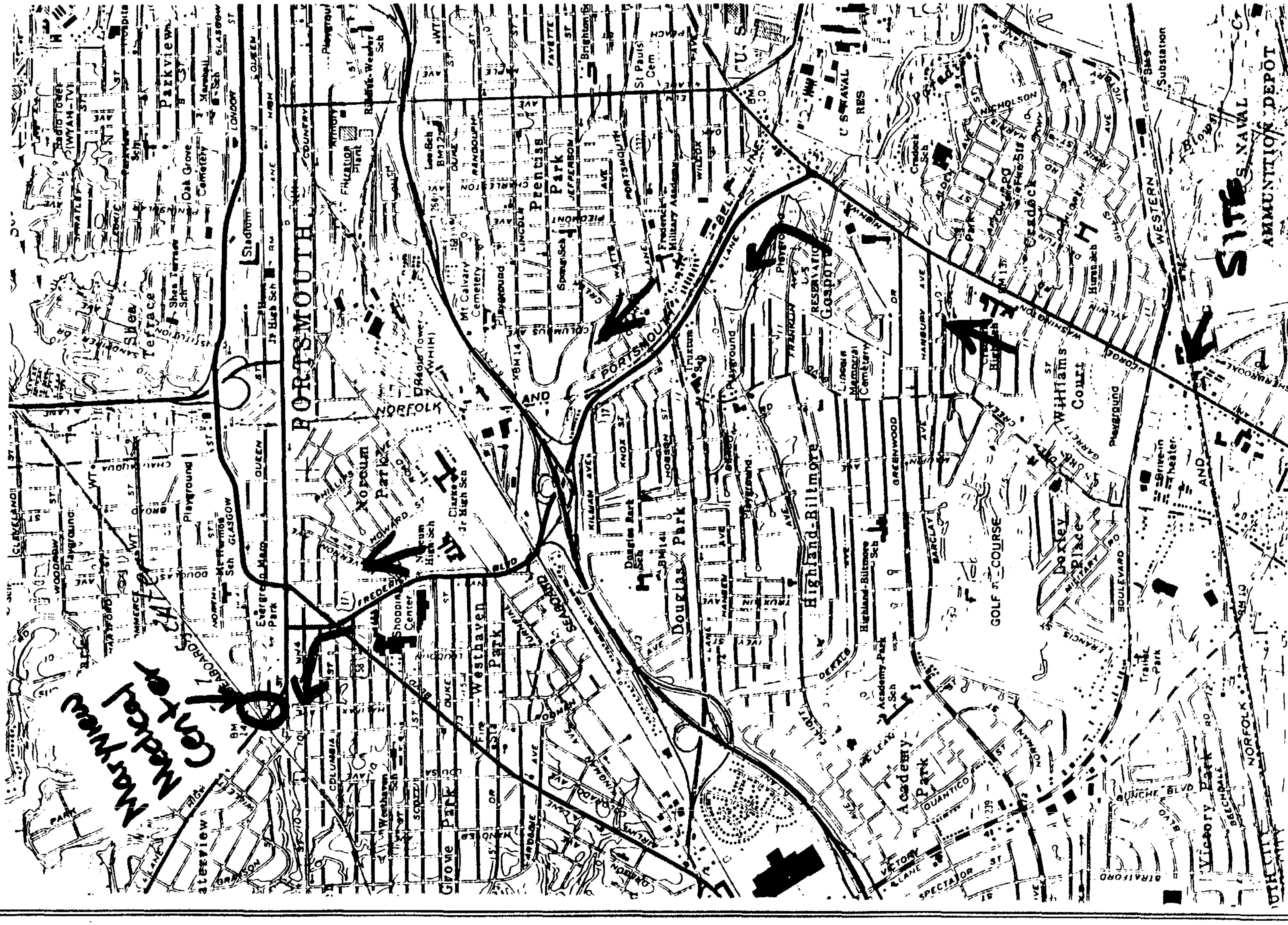
Leave main gate of Annex and take left onto Victory Blvd. At Route 17 (George Wash. Hwy) take a right and go north. Make left onto Frederick Blvd, and continue on Frederick until it dead-ends. Make left onto High Street, hospital is on the right at first light.

Distance to Hospital: Approximately 5 miles

HEALTH AND SAFETY PLAN APPROVALS

Prepared by: Dean Costello [signature]	Date: 1/23/97
SHSO Signature: Lisa Campbell	Date: 1/27/97
HSM Signature: [signature]	Date: 1/23/97

THIS PAGE RESERVED FOR HOSPITAL ROUTE MAP



The following personnel have read and fully understand the contents of this Health and Safety Plan and further agree to all requirements contained herein.

Name	Affiliation	Date	Signature

Final

Investigation Derived Waste Management Plan Landfill C and Landfill D Remedial Investigation/Feasibility Study

St. Juliens Creek Annex
Chesapeake, Virginia

Contract Task Order 0027

May 7, 1997

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CDM Federal Programs Corporation

Fairfax, Virginia

Submitted by

CH2M HILL

Herndon, Virginia

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Introduction

The Remedial Investigation/Feasibility Study (RI/FS) of Landfill C (Site 3) and the Landfill D (Site 4) at St. Juliens Creek Annex will produce investigation-derived soil and water wastes. Generation of these wastes will subsequently require waste management and disposal in a manner that eliminates potential hazards to the public. This management plan documents methodologies and procedures that CDM Federal field personnel will implement to handle, manage and dispose of all investigation-derived wastes.

The investigation-derived wastes (IDW) to be generated during the RI/FS field investigations include:

- Soil cuttings generated during monitoring-well installation and accumulated wash-cuttings at the decontamination pad.
- Groundwater pumped during monitoring-well development, and purged well volumes extracted during groundwater sampling.
- Personal Protective Equipment (PPE), such as nitrile gloves and tyvek, used during all phases of the investigation, and expendables used during sampling, such as tubing and sample containers.

This IDWMP describes proposed waste handling procedures for soil and groundwater. Disposal practices for personal protective equipment (PPE) and other general IDW considerations are also documented.

Proposed Waste Handling

This section documents the proposed waste handling procedures for soil and groundwater to be followed during the Site 3 and Site 4 RI/FS.

Soils

Cuttings generated during monitoring-well installation or soil boring advancement with a drill rig will be contained in 55-gallon drums, which will be sealed and labeled. In addition, soil cuttings that accumulate in the decontamination pad from the washing of drilling equipment will be placed in drums, sealed and labeled.

At the conclusion of the drilling event, the drums filled with soil cuttings will be stockpiled within the boundary of each site at a location designated by Navy personnel pending the analytical results of the TCLP sampling of the drum contents. At the end of the RI/FS activities, composited soil samples will be collected from drums filled with soil cuttings and submitted for full TCLP analyses.

After receipt of the TCLP sampling results, CDM Federal will formulate a preliminary assessment of any potential hazards posed by the IDW, and submit waste management recommendations to the Navy, and if requested by the Navy, to the EPA. If the analytical soil results are low, and if TCLP results are below the TCLP limits listed in 40 CFR 261.24, as amended, CDM Federal will recommend that the stockpiled soils be dispersed near the boring from which they were removed.

If the composite soil samples from the drums contain contaminant concentrations above TCLP limits, the drummed soils cuttings will be considered hazardous. These wastes will be manifested, handled as hazardous waste, and shipped to a regulated hazardous waste landfill, treated, or stockpiled as appropriate and as directed by the Navy.

The proposed steps for accumulating and handling IDW soil are as follows:

1. Shovel cuttings from all borings directly into 55-gallon drums.
2. Stockpile all drums in areas designated by the Navy.
3. Collect composite TCLP samples from the drums.
4. Send TCLP samples to approved off-site laboratory.
5. Secure notification from the Navy that the wastes are not listed by 40 CFR 261.
6. Stockpile the drums at Site 3 and Site 4 during the 30-day TCLP analysis period.
7. Receive TCLP and general analytical results from the laboratory and write a memorandum recommending to the Navy whether to handle the wastes as hazardous or discard in place. Both TCLP results and the applicable certification from the Navy will be considered in the recommendations.
8. Continue to stockpile drums until instructions from the Navy are received.
9. Remobilize to St. Juliens Creek Annex to spread cuttings from all locations that are nonhazardous.
10. Transport empty drums to an area designated by the Navy for disposal.
11. If some wastes test hazardous or should otherwise be considered hazardous wastes, segregate these drums and stockpile at a location specified by Navy personnel, pending decision on handling.
12. CH2M HILL and Navy negotiate contract modification for handling hazardous IDW soils. The wastes must be handled and disposed of in 90 days.
13. CDM Federal arranges and carries out handling and disposal of hazardous wastes according to the Navy's instructions. The Navy will be responsible for signing all manifests.

Groundwater

Groundwater as an investigation-derived waste will be produced during two field activities, (1) monitoring-well development and (2) groundwater purging and sampling.

The groundwater that is to be contained will be pumped and stored in 55-gallon steel drums, which will be sealed and labeled.

At the conclusion of the RI/FS, the drums containing groundwater will be stockpiled within the boundary of each site at a location designated by Navy personnel pending the analytical results of soil and groundwater sampling, and TCLP sampling of the drums. At the end of the RI/FS field activities, composited water samples will be collected from drums filled with groundwater and submitted for full TCLP analyses.

After receipt of the TCLP sampling results, CDM Federal will formulate a preliminary assessment of any potential hazards posed by the IDW, and submit waste management recommendations to the Navy, and if requested by the Navy, to the EPA. If the analytical groundwater results are low, and if TCLP results are below the TCLP limits listed in 40 CFR 261.24, as amended, CDM Federal will recommend that the groundwater be discharged to the industrial wastewater treatment facility. If the composite groundwater samples from the drums contain contaminant concentrations above TCLP limits, the drummed groundwater will be considered hazardous. These wastes will be manifested, handled as hazardous waste, and shipped to a regulated hazardous waste landfill, treated, or stockpiled as appropriate and as directed by the Navy.

The proposed steps for accumulating and handling IDW groundwater are as follows:

1. Development water from each of the newly installed monitoring wells will be pumped into 55-gallon drums.

2. Groundwater purged from the newly installed monitoring wells during the groundwater sampling activities will also be pumped into 55-gallon drums.

3. Secure notification from the Navy that the wastes are not listed, as specified in 40 CFR 261.

4. Receive TCLP results from the laboratory and write a memorandum to the Navy recommending whether to handle the groundwater as hazardous or to instruct a subcontractor to dispose of the water.

5. If groundwater is hazardous according to TCLP results or other criteria CH2M HILL and Navy will need to negotiate a contract modification for handling hazardous IDW groundwater. The waste, by law, must be handled and disposed of in 90 days.

6. CDM Federal coordinates with subcontractor for the handling and disposal of hazardous groundwater according to regulations. The Navy will be responsible for signing all manifests.

Personal Protective Equipment and Expendables

The personal protective equipment worn by CDM Federal field personnel and subcontractors will be placed in 55-gallon steel drums and labeled appropriately. Examples of PPE to be contained include: nitrile gloves, tyvek, and rubber boots. In addition, any expendable items that were contaminated during sampling will be contained in drums, such as in-line water filters, C-flex tubing, and paper towels.

Personal protective equipment and sampling expendables will be placed in marked bags and discarded in dumpsters if the TCLP results indicate no toxicity hazard. If TCLP results indicate that soils or groundwater are hazardous, the PPE will be handled with the soil.

General Considerations

General considerations pertinent to the generation and handling of IDW are documented below. These include the minimization of waste volume, drum labeling and storage, and disposal and manifesting protocol

Minimizing the Volume of IDW

To minimize the volume of groundwater to be handled, the minimum volume of water will be purged from the monitoring wells to stabilize the pH, conductivity, dissolved oxygen, and temperature of the discharged water.

Labeling

Every 55-gallon drum containing investigation-derived wastes will be labeled with the following information: the type of IDW (groundwater, soil, or PPE), the date the drum was filled and sealed, and a brief warning not to handle the drum or its contents without permission from the Naval Facilities Engineering Services Command. An example of the information included on each drum is:

Investigation Derived Wastes
Purge Water from Site 3 - MW1
3-1-97
Do Not Handle - Analysis Pending
Mr. Randy Jackson

Storing IDW

The drums that contain IDW will be stockpiled within the boundary of the site on which they were generated at a location designated by Navy personnel, pending the receipt of RCRA characterization results. For planning purposes, it is necessary that IDW only be stored on base for 60 days in order to comply with the 90-day accumulation time.

Disposal and Manifesting

After the receipt of test results, CDM Federal will formulate a preliminary assessment of any potential hazards posed by the IDW, and submit waste management recommendations to the Navy. If the test results indicate that the IDW is not hazardous, CDM Federal will recommend that the water be disposed of to the industrial wastewater treatment plant, the soil returned to drilling locations, and PPE be disposed of in a trash dumpster for disposal with other nonhazardous trash generated at the base. Otherwise, the water, soils, and PPE will be manifested, handled, treated, and disposed of as a hazardous waste by a subcontractor yet to be identified. The Navy will be responsible for signing all manifests.