N00158.AR.000046
NAS WILLOW GROVE
5090.3a

PLAN OF ACTION FOR EXTENDED SITE INSPECTIONS AND REMEDIAL INVESTIGATIONS AT NAS WILLOW GROVE HORSHAM TOWNSHIP, PENNSYLVANIA

CONTRACT NO. N62472-86-C-1037

Prepared for:

United States Navy
Northern Division
Naval Facilities Engineering Command
Philadelphia, Pennsylvania 19142-5094

Prepared by:

Mid-Atlantic Regional Operations
EA Engineering, Science, and Technology, Inc.
15 Loveton Circle
Sparks, Maryland 21152

August 1991

EA Project 10388.07

EA Engineering, Science, and Technology

EA Mid-Atlantic Regional Operations
Hunt Valley/Loveton Center
15 Loveton Circle
Sparks, MD 21152
Telephone: 301-771-4950
Fax: 301-771-4204

30 August 1991

Commanding Officer, Northern Division
Naval Facilities Engineering Command
Building 77L, Code 1421/FK
U.S. Naval Base
Philadelphia, PA 19112-5094

Attn. Frank Klanchar

Dear Frank:

I have responded to the comments you provided me by making the appropriate changes in the text. Below are summarized the changes made. In addition, I have made changes in the text where I have found inaccuracies or further clarification was needed per our conversations. If you have any questions concerning these changes please contact me at 301-771-4950.

Response to Navy Comments:

1) Pg. 2-5, Sec. 2.3.1--the degree symbols have been added to the text.

2) Pg. 2-9, para.1--the word "stratigraphically" has been added to the text to indicate that the triassic sediments do overlie the Stockton Formation although they are not present at the site due to uplift and erosion.

3) Pg. 2-15, last line--the proposed revision has occurred but the NPDWS finally settled on is 15 µg/L not 5 µg/L as originally proposed. The text has been changed accordingly.

4) Fig. 3.1-2--the figure has been corrected to differentiate between planned and previous monitoring wells.

5) Pg. 3-44, para. 2--the well depths range from 20-29 ft. This has been added to the text.

6) Pg. 3-46, 3.6.3.1--the proper designation is Air Force Well No. 1 (AFW-1) the text has been amended.

7) A, B, Pg. 3-46,--number of soil samples at the Wash Rack has been left unchanged as per our conversations. the sample depth has been changed in the test to 3 ft. The deep well adjacent to WRW-1 has been retained and no additional wells have been added.

C--As stated already in the text, pump testing of AFW-1 is planned in order to assess the impact of production well pumping on ground-water gradient at the Wash Rack as well as at Privet Road.

8) Pg. 3-46, Section 3.6.3.1--figure has been corrected.

9) Pg. 5-3--as was decided in the last TRC meeting, double casing has been deemed unnecessary and has been deleted from the text where it was previously mentioned (9th Street).

10) Pg. 5-3, Line 2--the discharge of purge water to the ground, after carbon filtration if volatile contamination is indicated, has not been opposed by the State or EPA at this time.

11) This issue is addressed in comment 7C.

Other revisions:

A) Pg. 3-8 and 9--all references to deep wells have been charged to intermediate wells to reflect the planned depth of 100 ft for these wells. Deep wells, such as those at 9th Street Landfill have total depths of 175 ft.

NOTE: Please advise RI contractor of the need to address the artesian wells during the winter months.

B) Pg. 3-9, para. 7--additional information has been included about the pump tests.

- pump tests will be separated in time by 1 week minimum
- Wells within 200 ft will be electronically monitored with an In Situ Data Logger.
- Other wells within 1,000 ft will be monitored by hand.
- During the period of monitoring of all site wells 1 month prior to the pump tests, wells will be gauged by hand, twice per day at 12-hour intervals.

C) Pg. 3-17, para. 4--the sample station numbers from the stations taken beyond the installation boundaries have been included. These sampling locations do not appear on any map in the report.

D) Pg. 3-35, para. 2--in the Sampling Plan for the Fire Training Area the word intermediate has been substituted for deep as per comment A.

E) Pg. 5-5, para. 1--a sentence was deleted from this paragraph because it was redundant.

Please call if there are any questions.

Sincerely,

Gregg T. Campbell

Gregg Campbell
Geologist III

PLAN OF ACTION
FOR EXTENDED SITE INSPECTIONS
AND REMEDIAL INVESTIGATIONS
AT NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

CONTRACT NO. N62472-86-C-1037

Prepared for:

United States Navy
Northern Division
Naval Facilities Engineering Command
Philadelphia, Pennsylvania 19142-5094

Prepared by:

Mid-Atlantic Regional Operations
EA Engineering, Science, and Technology, Inc.
15 Loveton Circle
Sparks, Maryland 21152

August 1991

EA Project 10388.07

CONTENTS

	Page
LIST OF FIGURES	
LIST OF TABLES	
1. PROJECT DESCRIPTION	1-1
1.1 Objective	1-1
1.2 Background	1-3
1.3 Scope	1-8
1.4 Data Usage	1-8
1.5 Organization of the Plan of Action	1-9
2. SITE DESCRIPTION	2-1
2.1 Introduction	2-1
2.2 Biological Features	2-1
2.2.1 Ecosystems	2-1
2.2.2 Endangered and Threatened Species	2-4
2.3 Physical Features	2-5
2.3.1 Climatology	2-5
2.3.2 Topography	2-5
2.3.3 Soil	2-6
2.3.4 Surface Water	2-7
2.3.5 Geology	2-9
2.3.6 Hydrogeology	2-11
2.3.7 Ground-Water Quality	2-14
3. MONITORING NETWORK DESIGN AND RATIONALE	3-1
3.1 NAS Site 1--Privet Road Compound (RI)	3-1
3.1.1 Significant Findings of the PA	3-1
3.1.2 SI Investigation	3-2
3.1.3 RI Field Sampling Plan	3-8
3.2 NAS Site 2--Antenna Field Landfill (RI)	3-10
3.2.1 Significant Findings of the PA	3-10
3.2.2 SI Investigation	3-11
3.2.3 RI Field Sampling Plan	3-17
3.3 NAS Site 3--9th Street Landfill (RI)	3-19
3.3.1 Significant Findings of the PA	3-19
3.3.2 SI Investigation	3-20
3.3.3 RI Field Sampling Plan	3-27

CONTENTS (Cont.)

		Page
3.4	NAS Site 5--Fire Training Area (RI)	3-31
3.4.1	Significant Findings of the PA	3-31
3.4.2	SI Investigation	3-31
3.4.3	RI Field Sampling Plan	3-34
3.5	NAS Site 7--Abandoned Rifle Range No. 2 (ESI)	3-36
3.5.1	Significant Findings of the PA	3-36
3.5.2	SI Investigation	3-37
3.5.3	ESI Field Sampling Plan	3-41
3.6	ARF Site 4--Washrack Area (ESI)	3-42
3.6.1	Significant Findings of the PA	3-42
3.6.2	SI Investigation	3-44
3.6.3	ESI Field Sampling Plan	3-46
3.7	Installation-Wide Tasks	3-48
3.7.1	Background Soil Samples	3-48
3.7.2	Upgradient Background Surface Water Sample	3-48
4.	MONITORING PARAMETERS AND FREQUENCY OF COLLECTION	4-1
4.1	Analytical Parameters	4-1
4.2	Frequency of Collection	4-1
4.3	Control Limits	4-2
4.3.1	Analytical Laboratory	4-2
4.3.2	Topographic Survey	4-2
4.4	Data Quality Objectives	
5.	FIELD METHODS AND SAMPLING PROCEDURES	5-1
5.1	Monitoring Well Installation and Development	5-1
5.2	Sampling of Monitor Wells	5-5
5.3	Surficial Soil Sampling	5-7
5.4	Subsurface Soil Sampling	5-7
5.5	Test Pits	5-7
5.6	Surface Water and Sediment Sampling	5-8
5.7	Site Survey	5-9
5.7.1	Horizontal Control	5-9
5.7.2	Vertical Control	5-9
5.7.3	Field Data	5-9

CONTENTS (Cont.)

5.8 Aquifer Testing 5-10

6. RI FIELD TASKS SCHEDULE 6-1

REFERENCES
GLOSSARY

LIST OF FIGURES

Number	Title
1-1	Location of IAS Report sites, Naval Air Station.
1-2	Location of Phase I: Record Search sites, Air Reserve Facility.
2-1	Site topography.
2-2	Site geologic map.
3.1-1	NAS Site 1, Privet Road Compound site plan.
3.2-1	NAS Site 2, Antenna Field Landfill site plan.
3.3-1	NAS Site 3, 9th Street Landfill site plan.
3.4-1	NAS Site 5, Fire Training Area site plan.
3.5-1	NAS Site 7, Abandoned Rifle Range No. 2 site plan.
3.6-1	ARF Site 4, Washrack Area, water table contour map (17 May 1989).
3.6-2	ARF SITE 4, Washrack Area, water table contour map (11 December 1989).
5.1-1	Schematic construction of monitoring well.
6-1	NAS - Willow Grove Schedule of Tasks - RI Field Work - Phase I

LIST OF TABLES

Number	Title
1-1	Summary of SI conclusions and recommendations.
3.1-1	Wastes disposed at the Privet Road Compound, 1967-1975.
3.2-1	Wastes disposed at the Antenna Field Landfill, 1948-1960.
3.3-1	Wastes disposed at the 9th Street Landfill, 1960-1967.
3.4-1	Wastes disposed at the Fire Training Area, 1967-1969.
4-1	Field sampling plan: remedial investigation.
4-2	Parameter list.
4-3	Quality assurance criteria.
4-4	Analytical program: remedial investigation.
4-5	Analytical control limits.
4-6	Data quality objectives.

1. PROJECT DESCRIPTION

1.1 OBJECTIVE

EA Engineering, Science, and Technology has been contracted by the Northern Division, Naval Facilities Engineering Command to perform Extended Site Inspection (ESI) studies and Remedial Investigations (RI) at Naval Air Station (NAS) Willow Grove, Horsham Township, Pennsylvania. These studies are part of the Navy's Installation Restoration (IR) Program (formerly known as the Navy Assessment and Control of Installation Pollutants [NACIP] Program) designed to identify contamination of Navy and Marine Corps lands/facilities resulting from past operations and to institute corrective measures as needed. This IR Program consists of four distinct phases.

1. Preliminary Assessment (PA)... formerly known as an Initial Assessment Study (IAS) under the NACIP program, determines the seriousness of the hazardous substance release or threat of release. The purpose of the PA is to evaluate the release or potential release of hazardous substances and to recommend additional response action at the site. As a result, no action may be taken if available data indicate that there is no threat or potential threat to public health or the environment. Alternatively, the best response action may be an immediate removal of the threat or potential threat. The PA, therefore, establishes a priority for scheduling a site inspection by characterizing a site.

2. Site Inspection (SI)... augments the information collected in the PA and:

   - Eliminates from further consideration those releases that pose no threat or potential threat to public health or the environment.

- Determines the potential need for removal action.

- Collects or develops additional data, as appropriate, to evaluate the release pursuant to the Hazard Ranking System (HRS).

- Collects data, as appropriate, beyond that required to score and list the release for more effective and rapid initiation of the Remedial Investigation/ Feasibility Study.

3. Remedial Investigation/Feasibility Study (RI/FS)... performs extensive onsite investigations including physical and analytical monitoring to quantify the extent of the problem and to develop alternatives for possible corrective measures.

4. Remedial Action (RA) Plans... evaluating, designing, and implementing corrective projects to control and mitigate confirmed contamination.

These phases are implemented sequentially with each phase determining whether the subsequent phase is necessary.

The objective of these studies is an evaluation of the extent to which specific toxic or hazardous materials have contaminated the environment at Naval Air Station Willow Grove. The work will include identification and quantification of pollutant concentrations, extent of, or potential for migration from suspected sites, and possible effects on human health and the environment. The study will consist of field investigations and will include: monitoring well installation, collection of water, soil, sediment, and biological samples, analysis of contamination, and

preparation of contamination concentration profiles. Site remediation actions may subsequently be conducted depending on recommendations and findings contained in the PA, SI, and RI/FS Reports.

1.2 BACKGROUND

PAs were performed which identified 16 sites at NAS Willow Grove--seven sites at the Air Reserve Facility (ARF) in 1984 (Weston 1984) and nine sites at the NAS in 1986 (Rogers, Golden & Halpern 1986). Since then, an additional site, the Navy Fuel Farm, has been added to the program. The PA studies included record searches, interviews, air photo interpretations, and site reconnaissance to identify potential sites. No field investigations were performed in the PA phase. The SI phase included field investigations designed to verify the presence of contamination at the suspected site or provide the basis for eliminating the site from the IR Program. The SI is not intended to evaluate the magnitude or extent of contamination; this evaluation is part of the RI/FS phase. Table 1-1 lists the sites and their status with respect to the IR Program. The site locations are shown on Figures 1-1 and 1-2.

The Site Inspection studies were performed in accordance with the Quality Assurance/Quality Control Project Plan for Installation Restoration Program Studies, NAS Willow Grove, Pennsylvania (EA 1988a). EA reviewed the PA studies, performed site reconnaissance, and prepared the Plan of Action (POA) for SI studies at NAS Willow Grove (EA 1988b). The POA included electromagnetic terrain conductivity (EM) surveys and soil vapor contaminant assessment (SVCA) at selected sites to provide remotely sensed data concerning potential contaminants. These data were necessary to finalize plans for direct sampling methods (i.e., test borings and monitoring wells).

EM surveys were conducted during the period 17 October - 8 November 1988. SVCA was conducted during the period 17 October - 2 December 1988. A complete description of these investigations is provided in the interim report (EA 1989a). The results are summarized below.

EM surveys were conducted around the perimeter of four sites to assess the potential presence of ground water with elevated electrical conductivity. At the Antenna Field Landfill and Abandoned Rifle Range No. 2, the conductivity anomalies observed were attributable to cultural interferences (e.g., metal fences, overhead power lines, underground utilities). Electrical conductivity appears to increase with depth (up to the ±45 ft effective depth of survey) on the downgradient side of the North End Landfill. The electrical conductivity of shallow ground water downgradient of the 9th Street Landfill does not appear to be significantly elevated.

At the 9th Street Landfill, EM surveying was also conducted on a grid pattern to assess the distribution of fill material. Several EM anomalies are correlative with SVCA anomalies at this site. The SVCA anomalies are attributable to tetrachloroethylene (PCE).

SVCA was conducted at several other sites where primarily volatile organic compounds were of concern. Volatile organic hydrocarbons were not detectable at Building No. 118 Abandoned Fuel Tank, Steam Plant Building No. 6 Tank, and the ARF Heating Plant. Volatile organic compounds were detectable at the Fire Training Area, Abandoned Rifle Range No. 2, the Washrack Area, and Building No. 330 Waste Oil Storage Area. Significant levels of volatile organic hydrocarbons were detected at the Navy Fuel Farm. Based on these results, the original field sampling plan as proposed in the POA was modified (EA 1989a).

Field work to implement the primary phase of the SI began in mid-February 1989 and continued until mid-May. A complete description of these investigations is provided in the SI report (EA 1990). The results are summarized below.

Thirty-five ground-water monitoring wells were installed at eight different sites as part of the SI studies. The number and placement of wells at each site were designed to assess the quality of ground

water both upgradient and downgradient of the site. Subsurface data gathered during drilling were used to establish general stratigraphic relationships. Ground-water gradient and probable direction of flow were derived from depth to ground water measurements made in each well. Ground-water samples were obtained for laboratory analysis in June, September, and December, 1989.

Nineteen test borings were completed at four sites to characterize subsurface conditions in the vicinity of EM or SVCA anomalies or waste handling areas. Soil samples were obtained for laboratory analysis.

Eleven surface water and sediment sampling locations at the NAS and one surface water sampling site off-base were sampled during this study. Surficial soil samples were collected at two sites.

All sample analyses were performed by EPA Contract Laboratory Program methods in accordance with the Quality Assurance/Quality Control Project Plan for Installation Restoration Program Studies at NAS Willow Grove. The sites under investigation can be grouped into two basic types--landfills and spill sites. Historical activities at the landfill sites indicate that there is potential for contamination by compounds or elements of any of the major classes of hazardous substances. Samples obtained at these sites were analyzed for gross organic indicator parameters and the targeted compounds (Target Compound List--TCL) and analytes (Target Analyte List--TAL) of EPA's Hazardous Substance List (HSL). Petroleum, oils, and lubricants (POL), fuels, and solvents are the potential contaminants at the spill sites. Samples obtained at these sites were analyzed for gross organic indicator parameters and the TCL volatile organic compounds (VOC).

Several different criteria were selected to assess the significance of the analytical results at NAS Willow Grove. Ground-water results were compared to federal drinking water standards as set by the Safe Drinking Water Act. Both maximum contaminant level (MCL) and proposed MCL standards were used when available. Surface water results were

compared to EPA Ambient Water Quality Criteria and Pennsylvania Water Quality Standards. No standards for soil or sediment currently exist except for lead. EPA has promulgated an interim guidance cleanup level for lead. These criteria represent standards which potentially may be considered applicable or relevant and appropriate requirements (ARARs). With respect to metals other than lead, results were compared to published background values. This information was considered in light of upgradient-downgradient comparisons at each site.

Site Inspection studies have been completed at 12 sites at NAS Willow Grove: 8 of 9 NAS PA sites, the Navy Fuel Farm (an additional NAS site), and 3 of 7 ARF PA sites. The presence of contamination was confirmed at seven of the sites investigated. Five of these are recommended for an RI/FS. Further investigation of two of the sites is recommended as Extended Site Inspection (ESI) studies. Further investigation of one of the sites is anticipated to be within the scope of investigations of one of the recommended sites. The SI conclusions and recommendations are summarized in Table 1-1.

The presence of contamination was not confirmed at the North End Landfill, Building No. 118 Abandoned Fuel Tank, Steam Plant Building No. 6 Tank, and the ARF Heating Plant. No further investigations are warranted at these sites.

It was concluded that the Privet Road Compound is a source of chlorinated hydrocarbons in the water-table aquifer. Pesticides and polychlorinated biphenyls (PCB) were detected in sediment samples from the drainage swales adjacent to the site; however, the PCB may have an upstream source. The Privet Road Compound is upgradient of the Washrack Area. Chlorinated hydrocarbons in the water-table aquifer at the Washrack Area appear, at least in part, to have an upgradient source. An RI/FS was recommended at the Privet Road Compound.

The Antenna Field Landfill was found to be a source of dieldrin discharge to surface water. It was recommended for an RI/FS.

Ground water in the water-table and semiconfined aquifers upgradient of the 9th Street Landfill was found to contain chlorinated hydrocarbons. It was concluded that the 9th Street Landfill is also a source of chlorinated hydrocarbons in ground water. Additional concerns at this site include pesticides in surface water and sediment, and pesticides andcyanide in surficial soil. An RI/FS was recommended at the 9th Street Landfill.

The Fire Training Area was found to be a source of chlorinated and non-chlorinated hydrocarbons in the water-table aquifer. It was recommended for an RI/FS.

With one possible exception, the SI study had not confirmed the presence of contamination at Abandoned Rifle Range No. 2. Methylene chloride, a common laboratory contaminant which was not reported in round 1 samples, was detected in round 2 and 3 samples. Since methylene chloride was also detected during the SVCA, this site was recommended for an ESI.

Ground water in the water-table aquifer upgradient of the Washrack Area was found to contain chlorinated hydrocarbons. It was concluded that the site is also a potential source of chlorinated hydrocarbons in ground water. An ESI was recommended at the Washrack Area.

A contamination plume underlies the main fuel tanks at the Navy Fuel Farm. Both nonaqueous-phase liquid (NAPL) and aqueous-phase contamination is present. The drainage swale serving the fuel farm passes in close proximity to the location of the jet fuel spill site near Building 330 where hydrocarbons were detected in subsurface soil samples. An RI/FS was recommended at the Navy Fuel Farm. The Navy Fuel Farm investigation is proceeding on a schedule independent of the preceding IR Program sites which are addressed by this POA.

1.3 SCOPE

This document constitutes the Plan of Action (POA) for the Remedial Investigations (RI) and Extended Site Inspection (ESI) studies at Naval Air Station Willow Grove. It provides herein a site specific field sampling plan. All work will be performed in accordance with the Quality Assurance/Quality Control Project Plan and the generic Safety and Health Plan established for Installation Restoration Program Studies at Willow Grove Naval Air Station, and the site specific Safety, Health, and Emergency Response Plan.

The field tasks described in this POA represent Phase 1 of the overall RI Investigation. Results from the Phase 1 activities may identify data gaps which will then be addressed in a Phase 2 RI investigation. At the conclusion of Phase 2 activities, a database will be generated suitable for a risk assessment to be performed and feasibility studies to be undertaken at appropriate sites.

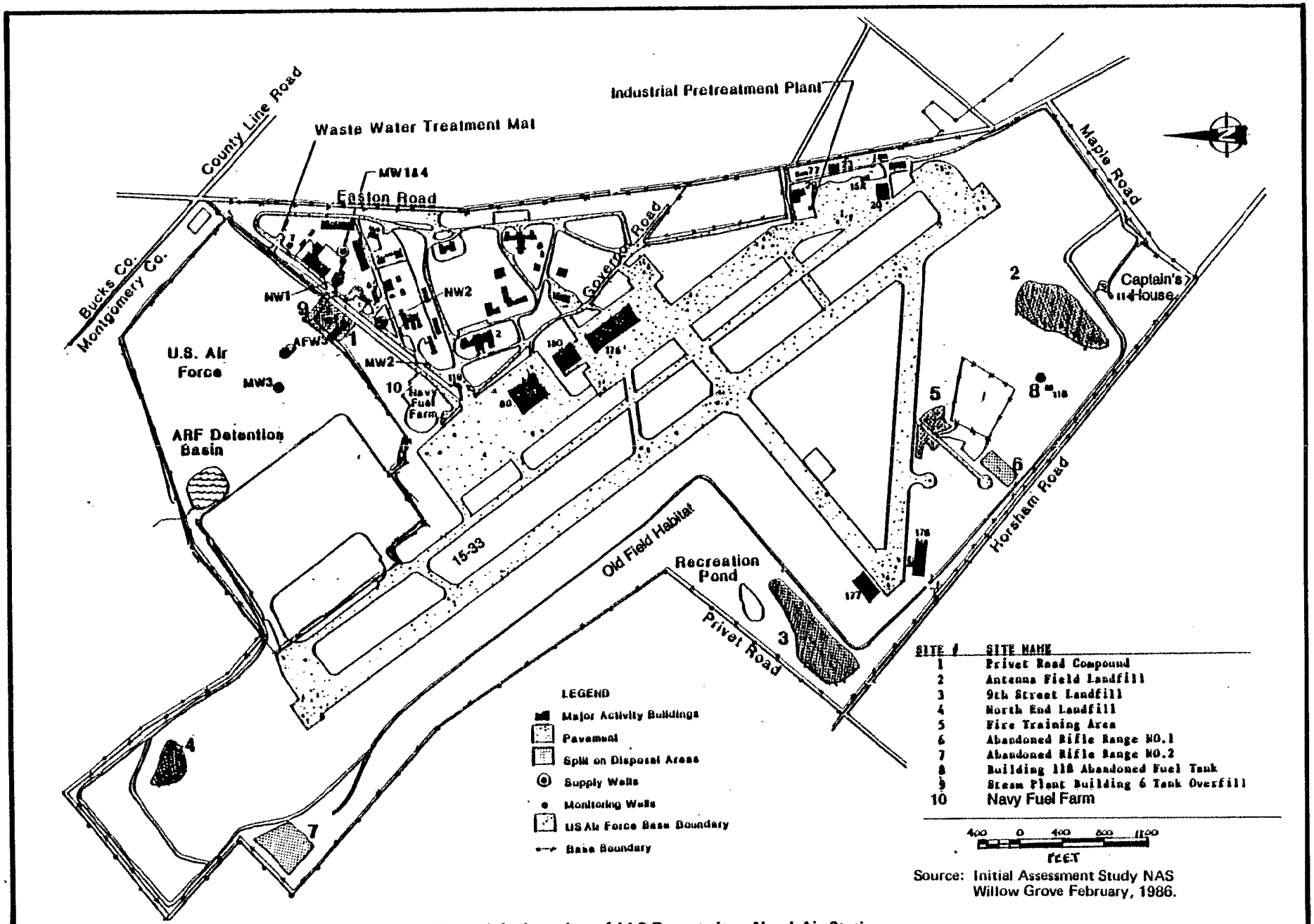
1.4 DATA USAGE

The purpose of the ESI field investigations is to assess the presence or absence, as well as the order of magnitude, of specific toxic or hazardous contaminants identified during the PA and SI studies, or other contaminants which may be present in concentrations considered to be hazardous. The result of this investigation should be a database adequate to support the Site Inspection step evaluation of any contamination found, as well as site-specific recommendations as to whether or not to proceed into the RI/FS study step.

The purpose of the RI field investigations is an evaluation of the nature and extent of contamination, and the threat or potential threat to human health or the environment. The result of this investigation should be a database adequate to support the selection and analysis of remedial alternatives in the Feasibility Study (FS).

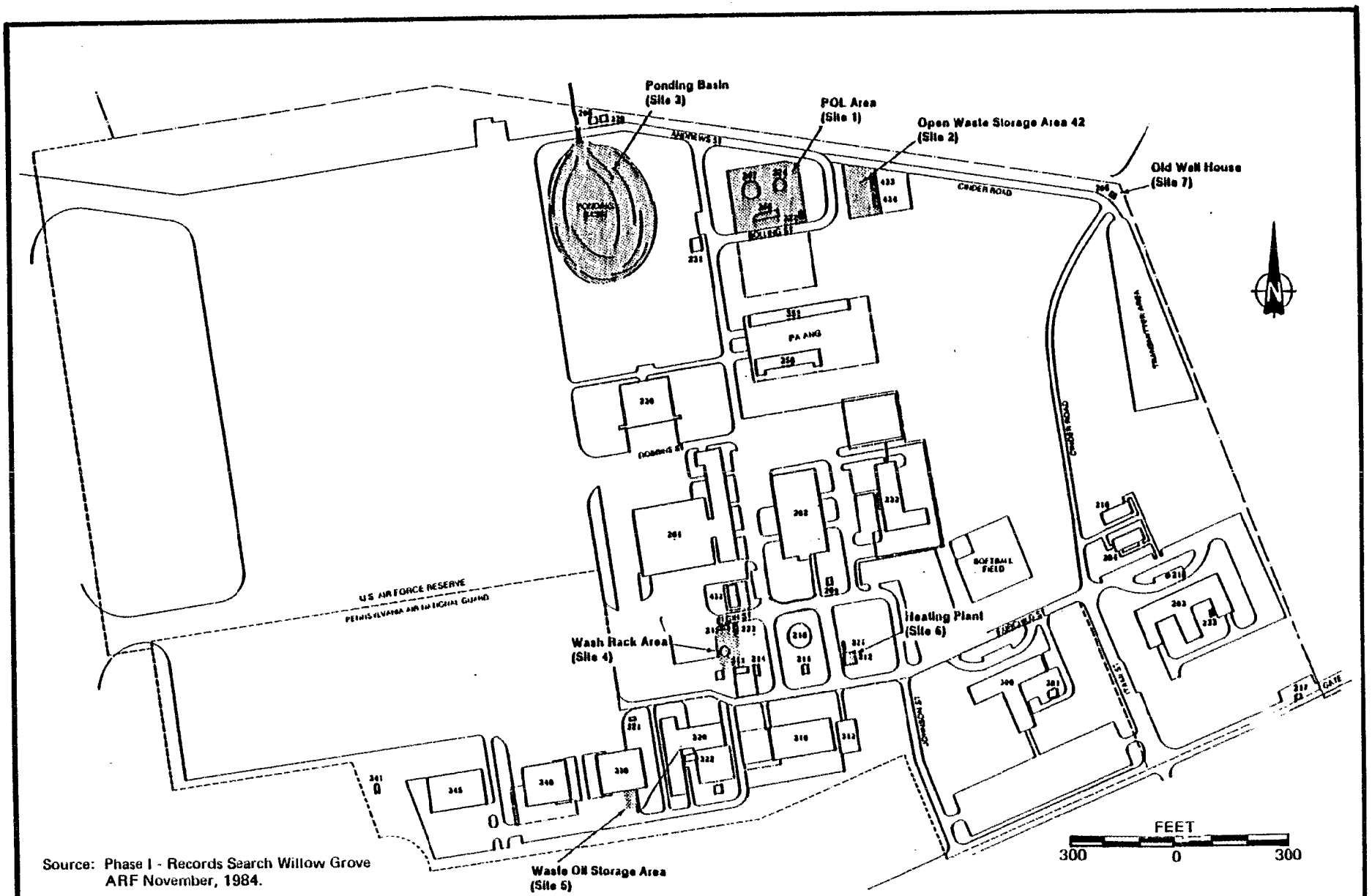
1.5 ORGANIZATION OF THE PLAN OF ACTION

A description of NAS Willow Grove is provided in Section 2. Descriptions of each site and the site specific field sampling plan for each site are provided in Section 3. Sampling frequency, analytical parameter lists and control limits are described in Section 4. Field methods and sampling procedures are discussed in Section 5. The planned project schedule is provided in Section 6.



Source: Initial Assessment Study NAS Willow Grove February, 1986.

Figure 1-1. Location of IAS Report sites, Naval Air Station.



Source: Phase I - Records Search Willow Grove ARF November, 1984.

Figure 1-2. Location of Phase I: Record Search Sites Air Reserve Facility.

TABLE 1-1 SUMMARY OF SI CONCLUSIONS AND RECOMMENDATIONS

Site	PA Recommendation for SI	SI Performed	SI Recommendation	Contaminants of Concern	Media
NAS Site 1, Privet Road Compound	Yes	Yes	RI/FS	VOC, pesticides, PCB	ground water, surface water, sediment
NAS Site 2, Antenna Field Landfill	Yes	Yes	RI/FS	dieldrin	surface water and sediment
NAS Site 3, 9th Street Landfill	Yes	Yes	RI/FS	VOC, pesticides	ground water, surface water, sediment, soil
NAS Site 4, North End Landfill	Yes	Yes	NFI	---	---
NAS Site 5, Fire Training Area	Yes	Yes	RI/FS	VOC	ground water
NAS Site 6, Abandoned Rifle Range No. 1	No	No	NFI	---	---
NAS Site 7, Abandoned Rifle Range No. 2	No	Yes	ESI	methylene chloride	ground water
NAS Site 8, Building No. 118 Abandoned Fuel Tank	No	Yes	NFI	---	---
NAS Site 9, Steam Plant Building No. 6 Tank	No	Yes	NFI	---	---
NAS Site 10, Navy Fuel Farm	NA	Yes	RI/FS	hydrocarbons	ground water
ARF Site 1, POL Area	Yes	An RI/FS managed by the Air Force has been completed.			
ARF Site 2, Open Storage Area No. 42	Yes	An RI/FS managed by the Air Force has been completed.			
ARF Site 3, Ponding Basin	Yes	An RI/FS managed by the Air Force has been completed.			
ARF Site 4, Washrack Area	Yes	Yes	ESI	VOC	ground water
ARF Site 5, Building No. 330 Waste Oil Storage Area	Yes	Yes	*	hydrocarbons	soil
ARF Site 6, Heating Plant	Yes	Yes	NFI	---	---
ARF Site 7, Old Well House	Yes	No	NFI	---	---

Notes:
PA = Preliminary Assessment (formally Initial Assessment Study or Records Search).
SI = Site Inspection.
ESI = Extended Site Inspection.
RI/FS = Remedial Investigation/Feasibility Study.
NFI = No Further Investigation.
* = Further investigation within the scope of NAS Site 10.

2. SITE DESCRIPTION

2.1 INTRODUCTION

Naval Air Station (NAS) Willow Grove is located in southeastern Pennsylvania, approximately 25 mi north of Philadelphia by road. NAS Willow Grove comprises about 1,000 acres of flat to slightly rolling terrain in Horsham Township. It lies in the east-central portion of Montgomery County, immediately adjacent to Bucks County (Figure 2-1).

The NAS serves the Mid-Atlantic States and a portion of New York State. It provides facilities, services, materials, and training in direct support of all assigned units. These units include two P-3 antisubmarine warfare (ASW) squadrons, one helicopter ASW squadron, one fleet logistic support squadron, one Marine Aircraft Group (including an attack squadron and a heavy helicopter squadron), and numerous other Navy and Marine units. The Willow Grove Air Reserve Facility (ARF) occupies approximately 162 acres of land in the northeast section of the NAS (Figure 1-1). The Pennsylvania Air National Guard occupies approximately 45 acres in the southern portion of the ARF (Figure 1-2).

The following sections summarize existing site conditions as described in the PA reports (Weston 1984; Rogers, Golden and Halpern 1986).

2.2 BIOLOGICAL FEATURES

2.2.1 Ecosystems

The natural environment at NAS Willow Grove has been altered by development ever since the area was first used as an airport. The most intensive development has occurred from several hundred feet west of Runway 15/33 eastward, toward Route 611. Buildings and paved roadways are most concentrated in this portion of the activity. Development in the area is not limited to NAS Willow Grove. The region itself has experienced

considerable development related to urban growth around Philadelphia. Due to development on the activity, the land has not been allowed to retain a natural cover of vegetation. The vegetative communities that remain are limited and generally include lawn areas maintained by activity personnel, old field, immature forest, and wetland.

Maintained grassy field, after old field scrub/shrub, is probably the most common vegetative cover at the activity. Most of this habitat is west of the activity's runways. The herbaceous species and woody shrubs there provide habitat for many wildlife species. Typical herbaceous plants include cinquefoils (genus Potentilla), ragweed (Ambrosia artemisiifolia), field daisy (Chrysanthemum leucanthemum), wild strawberry (Fragaria vesca), and numerous grasses. Shrubs observed include multiflora rose (Rosa multiflora), poison ivy (Rhus radicans), chokecherry (Prunus virginiana), and blackberry (genus Rubus).

Wooded areas occur mainly along the western boundary of the activity and serve as a buffer between the activity and residences along Route 643 and the neighboring golf course. Common forest species observed include red maple (Acer rubrum), sassafras (Sassafras albidum), sycamore (Platanus occidentalis), and oak (genus Quercus). The mixed hardwoods also provide nesting, protective, and feeding habitat for many wildlife species.

Wetlands habitat is present within the activity. A review of the draft wetlands inventory map for this area [U.S. Department of the Interior (USDOI) 1985] indicates that, with the exception of open water classifications, only one small palustrine scrub/shrub-emergent wetland occurs on the activity. This area is downstream from the pond at the picnic area and is about 0.3 acres in size. A larger area of marsh habitat consisting mainly of sedges and bulrush, occupies topographically low areas just north of the runway end zone and covers several acres. Many of these wetland grasses were planted by activity personnel to attract waterfowl and the area has not been mapped as wetlands by USDOI.

Wildlife species occurring at NAS Willow Grove are those that commonly occur near urbanized areas. Species observed or reported to occur include eastern cottontail (genus Sylvilagus), muskrat (Ondatra zibethica), raccoon (Procyon lotor), woodchuck (Marmota monax), eastern gray squirrel (Sciurus carolinensis), and white-tailed deer (Odocoileus virginianus). The deer herd is estimated at about 60 individuals and the Navy is presently clearing some of the forested area as a measure to minimize the appearance of deer on the runway. Pheasants (Phasianus colchicum) have been observed in the old field habitat. A small flock of Canada geese (Branta canadensis) was observed at the pond adjacent to the Captain's House. Several pairs apparently nested successfully within the activity this year, since many goslings were sighted. A pair of mallards (Anas platyrhynchos) was observed in the wetlands area downstream from the pond at the picnic area. Other bird species observed or reported to occur in similar habitat include robin (Turdus migratorius), starling (Sturnus vulgaris), mourning dove (Zenaidura macroura carolinensis), wood thrush (Hylocichla mustelina), cardinal (genus Richmondena), mockingbird (Mimus polyglottos), and sparrow (genus Passer).

The only aquatic communities on the activity occupy two man-made impoundments, and include catfish (suborder Siluroidea, order Ostariophysi), largemouth bass (Micropterus salmoides), and sunfish (family Centrarchidae). These impoundments are the Recreational Pond and the Building 114 Pond (Figure 1-1). Both ponds are available to military personnel for recreational fishing. The Recreational Pond, which is located near the picnic grounds, has received contaminated runoff from spills related to aircraft accidents and fire fighting. Fish kills have been reported at this pond (Kowalczyk 1984 in Rogers, Golden and Halpern 1986). The pond may also receive baseflow discharges from NAS Site 3, 9th Street Landfill. As a receiving area for these baseflow discharges, the Recreational Pond is a potential site for contaminants. The effects of such pollution can be acute, as evidenced by the reported fish kills. The effects may also be chronic. Contaminants will settle out in the pond and become incorporated into bottom sediment. Benthic organisms which burrow and ingest the sediment may

be affected, and can bioaccumulate the pollutants and pass them along to the next level predator (for example, larger invertebrates, fish, and birds). Similarly, pelagic organisms such as plankton can come into contact with pollutants in the water column and pass the contamination along to larger predators. Man would be at the top of this food chain process if any fish from the pond were consumed.

2.2.2 Endangered and Threatened Species

The Endangered Species Act of 1973, as amended, provides for the protection of endangered and threatened species. Government agencies such as the U.S. Navy are required to submit for review by the U.S. Fish and Wildlife Service (USFWS) any proposed actions which may "jeopardize the continued existence" of any species listed under the act as threatened or endangered. USFWS has developed a list of endangered and threatened wildlife and plants of species determined by the Department of the Interior to need protection under the Endangered Species Act of 1973. It has also been determined that endangered and threatened wildlife or plants as recognized by the Commonwealth of Pennsylvania under Chapter 147, title 58 have not been reported within the boundaries of NAS Willow Grove. A comprehensive summary of threatened and endangered wildlife and plants has been prepared by the Wild Resource Conservation Fund (1985 in Rogers, Golden and Halpern 1986).

The peregrine falcon (*Falco peregrinus*), which is on the Federal Endangered and Threatened Species Lists, has been observed in the area, but is a rare transient during the period from March to November (Weston 1984).

2.3 PHYSICAL FEATURES

2.3.1 Climatology

NAS Willow Grove is located about 70 mi west of the Atlantic Ocean, which has a moderating effect on extreme temperatures. Normal minimum and maximum daily temperatures in the area range from 24°F in February to 86°F in July. Extreme temperatures on record for the Philadelphia area are -11°F and 106°F [National Oceanic and Atmospheric Administration (NOAA) 1979].

Average annual rainfall and snowfall at NAS Willow Grove are 44.5 and 21.5 in., respectively. Precipitation is fairly evenly distributed throughout the year, with an increase in rainfall during the summer months. Single snowstorms of 10 in. or more occur roughly every 5 years. Average annual and extreme frost penetrations in the vicinity of the activity are 20 and 30 in., respectively (de Chiaro and Koppelman 1984).

Mean annual relative humidity in the area ranges from 54 percent (early afternoon) to 78 percent before dawn. Mean annual Class A Pan Evaporation for the area is about 42 in. per year (NOAA 1979).

The prevailing wind direction at the activity is southwesterly during the summer and northwesterly during the winter. The mean annual wind speed and direction for the Willow Grove area is approximately 9 mph west-northwest (NOAA 1979).

2.3.2 Topography

NAS Willow Grove lies in the Triassic Lowlands Section of the Piedmont Physiographic Province. This section is characterized by rolling topography. Broad northeast-southwest trending ridges in the area reflect resistant conglomeratic sandstone beds or diabase dikes. Numerous intermittent and perennial streams form a trellis pattern that is aligned

with the strike of the underlying geologic formations. Small ponds and lakes are abundant and wetland areas are present. Site topography is illustrated on Figure 2-1.

NAS Willow Grove occupies the high ground that forms a divide between the Pennypack and Little Neshaminy Creek watersheds. Most of the activity, however, lies within the Little Neshaminy Creek basin.

The elevation ranges between 240 and 360 ft across the activity. The lowest portion of the activity occurs at the northern clear zone of Runway 15/33. A marsh has developed in this area. Slopes are generally less than 3 percent; however, in areas where the land has been regraded, slopes may be steeper.

2.3.3 Soil

The U.S. Department of Agriculture (USDA), Soil Conservation Service (SCS) has mapped the distribution of various soil types in Montgomery County. In this locality, soil types belonging to four series predominate. These are the Lansdale loam, Lawrenceville silt loam, Readington silt loam, and Reaville silt loam. The Lansdale loam is well drained and belongs to the "B" hydrologic soil group as determined by the SCS. The silt loam soil types are moderately well drained and all belong to the "C" hydrologic soil group. The limiting permeability of all four soil series ranges between 0.04 and 0.2 in. per hour (0.08 to 0.4 ft per day) (SCS 1967). Permeabilities on the order of 0.1 ft per day were measured in the soil zone at a nearby facility that is also located on the outcrop of the middle member of the Stockton Formation (Satterthwaite Associates, Inc. 1984). The reaction pH associated with the soil series present on NAS Willow Grove ranges between 4.5 and 6.5 (SCS 1967).

Somewhat poorly drained silt loam soil types belonging to the Chalfont, Croton, and Doylestown soil series are developed in depressions and low-lying areas at NAS Willow Grove. However, these soil types are not abundant. The North End Landfill, and Abandoned Rifle Range No.2, are

located on soil types of the Chalfont Series. These soil types are somewhat poorly drained and belong to the "C" hydrologic soil group. All other sites occupy well or moderately drained soil types.

Previous surveys of this area [Northern Division Naval Facilities Engineering Command (NORDIVNAVFACENGCOM) 1983] indicate that much of the area occupied by NAS Willow Grove is characterized by a seasonal high or perched water table that rises to within 2.5 ft of the surface. This condition may have important implications for the potential for migration of contaminants from certain sites at NAS Willow Grove. In particular, the North End Landfill, and abandoned Rifle Range No. 2, coincide with areas mapped as containing perched water tables that reach to within 1 ft of the ground surface. Waste materials buried at these locations may experience saturated conditions periodically. Portions of the North End Landfill actually lie within a perennial marsh and are therefore permanently saturated.

Most of the soil within the boundaries of NAS Willow Grove has been disturbed. In addition, large areas have been filled with mixed earth materials having unknown drainage characteristics. Made-land immediately adjacent to the runways and taxiways and in the built-up areas is primarily Triassic shale and sandstone or silty materials underlain by shale and sandstone. These materials vary widely in depth and drainage potential. However, drainage typically ranges form very good to moderately good (NORDIVNAVFACENGCOM 1983). Caution must be exercised in interpreting soil data in this area.

2.3.4 Surface Water

Prior to development of NAS Willow Grove, runoff from the site was minimal due to the combined effects of well-drained soil conditions and generally low land slopes. However, development over the years has reduced the percentage of pervious land surface within the activity to less than 60 percent. As a result, the quantity of runoff from the activity has increased greatly.

A large ponding area has been artificially created within the northern clear zone of Runway 15/33. The Northern Ponding Area, as it is known, is the outfall for the storm sewer which serves the runway. During heavy rainfall the entire area bounded by the runway berm and the perimeter road is flooded by runoff. The Northern Ponding Area outlets to Park Creek, a tributary of the Little Neshaminy Creek.

During heavy rainfall very local flooding conditions are associated with various swales and man-made drainage ditches (NORDIVNAVFACENGCOM 1983). A survey of these flooding areas has not been conducted.

For the most part, runoff from surfaced areas is transported by open drainage swales and enclosed storm sewers to one of five primary outfall areas. Three outfalls drain to Park Creek. These are: (1) the ARF Detention Basin, (2) the Northern Ponding Area, and (3) the Recreational Pond. The fourth outfall is an intermittent stream that empties into Pennypack Creek. The fifth outfall is a direct connection to the Northern Storm Sewer System at Easton Road.

The receiving waters for stormwater runoff derived from the activity are fished. Pennypack Creek is designated a warmwater fishery by the Pennsylvania Department of Environmental Resources. Trout stocking is practiced in the Little Neshaminy Creek.

Stormwater runoff from much of the area west of Runway 15/33, including the hangars and aircraft parking ramps, drains to the ARF Detention Basin. The pond has oil booms and a sluice gate outlet device which allow the primary outlet to be closed. The sluice is used to contain spills of hazardous materials and prevent them from continuing on to Park Creek.

2.3.5 Geology

NAS Willow Grove is underlain by bedrock belonging to the Stockton Formation of Late Triassic age (Figure 2-2; Rima et. al. 1962). The Stockton Formation lies uncomformably over undifferentiated basement rocks of Paleozoic and Precambrian ages. It is overlain stratigraphically by the shale beds of the Lockatong and Brunswick formations, also of Late Triassic age. The sedimentary strata that constitute the Stockton Formation were deposited as coalescing alluvial fans. They consist of arkosic sandstone, siltstone, and conglomerate with interbeds of red shale. Locally, strata of different texture are interbedded irregularly. Over short lateral distances (several hundred feet) the bedding layers are continuous and can be traced. However, when examined over larger distances, beds commonly pinch out or grade laterally into different texture and color (Rima et al. 1962).

The Stockton Formation is divided into lower, middle, and upper members. NAS Willow Grove occupies the outcrop of the middle member (Figure 2-2), which is approximately 4,200 ft thick in this location. The middle member consists of fine to medium grained arkosic sandstone with interbedded lenticular shale and siltstone layers. Beds of shale and siltstone are more common in the upper portion of the middle member. Porosity is typically higher in the middle member than in either of the other two members of the Stockton Formation due to the weak cementation and fairly good sorting of the sandstone units within this member (Rima et al. 1962). The middle member of the Stockton Formation typically weathers to a depth of 15 to 35 ft.

The lower member of the Stockton Formation consists principally of coarse grained arkosic sandstone and conglomerate. It contains lesser amounts of interbedded silty and sandy red shale. Beds of fine to medium grained arkosic sandstone are common but much less abundant than coarse grained rock. The contact between the lower and middle members is transitional. The lower member attains its maximum thickness near Ambler, Pennsylvania. In the vicinity of NAS Willow Grove it is less than 1,500 ft thick.

The upper member consists chiefly of red shale, siltstone, and very fine grained arkosic sandstone. Beds of fine grained sandstone, never abundant, are most common in the lower portion of the upper member. It is less than 1,000 ft thick in the vicinity of NAS Willow Grove.

In the Stockton Formation, water is transmitted primarily through joints, fractures and along bedding planes. Due to the comparative brittleness of sandstone relative to shale, fracture permeability is generally much better developed in the sandstone layers than in the intervening shale and siltstone layers. As a result, the Stockton Formation is generally much more transmissive to ground-water movement parallel to sandstone layers than perpendicular to them (Rima et al. 1962).

The continuity of the bedding layers is broken by small displacement normal faults which trend northeast-southwest, approximately parallel to the strike of the formation. The upthrown sides of the faults are to the northwest. Two sets of vertical joints are well developed at NAS Willow Grove. These joints are oriented approximately parallel and perpendicular to the strike direction. A third, less well-developed set of joints strikes northwest-southeast. Topographic expressions of joints in the vicinity of NAS Willow Grove have been mapped from stereo-pair aerial photos by Earth Data, Inc. (1985). The effects of geologic structures like these on ground-water migration can be unpredictable. However, no hydraulic barriers or recharge boundaries were encountered during pump tests of Navy Supply Wells 1 and 2 (Earth Data, Inc. 1985).

Immediately south of the NAS Willow Grove boundary, the Stockton Formation is cut by a nearly vertical diabase dike. The dike, which is 90 ft thick, trends northeast-southwest (Rima et al. 1962).

2.3.6 Hydrogeology

The middle member of the Stockton Formation is the most prolific water-producing unit in the Triassic basin. This unit contains 70 percent of all wells drilled in the Stockton Formation to depths greater than 100 ft. Further, the average yield of wells penetrating the middle member is 131 gallons per minute (gpm), compared to 106 gpm in the lower member and 19 gpm in the upper member (Rima et al. 1962). Well depths in this area range between 300 and 600 ft.

The hydraulic properties of the middle member control patterns of ground-water movement beneath NAS Willow Grove. Recharge to the middle member derived from the activity is expected to discharge to a surface waterbody or a well without encountering any other water-bearing units.

The Stockton Formation contains two aquifer systems: water table and artesian. Water table conditions are reported to extend to a depth of between 75 and 100 ft below ground surface at NAS Willow Grove. As water infiltrates into the water table, the horizon of saturation will rise. In this manner, the water-table aquifer is capable of storing water that infiltrates from the surface. It serves as an underground reservoir that supplies the underlying artesian aquifer.

The transmissivity of the formation is typically derived from one or more bedding horizons that have well-developed secondary permeability. The hydraulic properties of these discrete zones are difficult to measure directly. However, the characteristics of the aquifer can be described by determining average hydraulic properties from tests of wells which penetrate a finite thickness of the unit. The average permeability of the water table below the weathered zone has been measured as approximately 1.5 ft/day at a nearby locality in the middle member (Satterthwaite Associates, Inc. 1984). The storage coefficient measured in the same study was 0.05. Storage coefficients as high as 0.30 have been measured in some Stockton Formation wells (Rima et. al. 1962).

The piezometric head measured within the water table remains constant with depth. The piezometric surface of the water-table aquifer tends to be a subdued reflection of surface topography. The presence of recharge zones for pumping centers in the artesian aquifer may distort this pattern, however. The orientation of the piezometric surface in the water-table aquifer beneath NAS Willow Grove is ambiguous from existing measurements (Earth Data, Inc. 1985). However, north of Runway 06/24 it appears to trend in a generally north or northeasterly direction with a gradient of 0.01. The Darcy velocity of the ground water would then be approximately 5.5 ft/year. Using a typical effective porosity of 0.07 the associated linear velocity is 78 ft/year. The direction of flow is toward Park Creek.

Fully developed artesian conditions are generally encountered below 150 ft. In the artesian aquifer, the water surface is not free to rise when water is added because the water-bearing beds are confined by multiple overlying layers with low permeabilities. The artesian aquifer has a very small capacity to store water. As ground water is withdrawn from artesian aquifers by wells, it must be replenished by water entering the aquifer from its recharge zone.

The average permeability of the artesian aquifer parallel to the plane of bedding in the middle member has been established by several studies (Earth Data, Inc. 1985; Rima et. al. 1962) as approximately 5 ft/day. The associated storage coefficient is about 0.0001, reflecting a very low capacity for water storage. The leakance factor (L), which measures the induced flow across bedding layers, has been determined by one study to be at least 5,000 ft (Satterthwaite Associates, Inc. 1984). This value reflects confinement of the aquifer with negligible cross-strata flow. In fact, the influence of wells pumping from the middle member has been observed to propagate preferentially along bedding horizons (Sloto and Davis 1983). Most deep wells penetrate several major water-bearing zones. In general, each zone has a different piezometric head.

The water level measured in such a well represents some weighted combination of individual heads. The permeability of discrete horizons may also be much greater than the formation average of 5 ft/day.

In the absence of pumping, the gradients in individual artesian horizons are controlled by the head of the water table in the up-dip recharge zone. Consequently, the magnitude of hydraulic gradients will be similar to those which prevail in the water table. However, pumping centers may locally induce steep gradients that are unrelated to water-table conditions. Ground water will frequently have a different flow velocity and direction in the artesian zone than in the immediately overlying water table. Furthermore, the velocity of ground water in different artesian zones may differ. The velocity of ground water in the artesian zones depends upon the distance from the active pumping centers which penetrate them. East of Runway 15/33 and south of Runway 06/24, ground water in the artesian aquifer is reported to migrate toward the activity's supply wells. West of Runway 15/33 and south of Runway 06/24, insufficient data exist at this time to determine the distribution of ground-water velocities in the artesian aquifer.

Between the water-table and artesian aquifers lies a transitional zone, commonly referred to as the semi-artesian zone. The hydraulic properties of the semi-artesian zone are similar to the artesian zone, with the exception that the semi-artesian zone sustains a lower leakance factor (less than 500 ft). Unlike the artesian zone, it does not behave like a completely confined aquifer. A drop in pressure in the semi-artesian zone will induce a release of water from storage from the overlying water-table aquifer. The semi-artesian zone is, in effect, the locus of recharge for the artesian aquifer.

The diabase dike that cuts across the southern end of the activity may be regarded as an effective hydraulic barrier. Diabase dikes in the Triassic basin are typically weakly fractured and for this reason are highly impermeable. The average specific capacity of diabase dikes in the Stockton Formation is about 0.1 gallons per minute per foot, assuming

a typical maximum drawdown of 50 ft (Earth Data, Inc. 1985). This is one to two orders of magnitude less than specific capacities measured in the adjacent middle member of the Stockton Formation.

NAS Willow Grove lies on a recharge area for the Stockton aquifer. The moderately well-drained soil and low slopes found on the activity suggest that nearly all of the rainfall that falls on pervious surfaces will infiltrate. Water remaining after losses due to evapotranspiration will percolate to the water-table aquifer. In this locality, between 30 and 60 percent of rainfall that percolates to the water table will furnish recharge to the artesian aquifer, after which it will migrate toward pumping centers (Satterthwaite Associates, Inc. 1984). The remaining water will migrate in the shallow water-table aquifer until it discharges as base flow to one of the nearby streams. The direction of ground-water movement in the water table is expected to roughly reflect topography in this area.

2.3.7 Ground-Water Quality

The quality of ground water produced from the Stockton aquifer is generally good. In Montgomery County, total dissolved solids range between 124 and 1,040 mg/L. Total hardness, reported as $CaCO_3$, ranges between 29 and 647 mg/L. Sulfate occurs at concentration ranges from 8 to 558 mg/L. The ground water is mildly alkaline, with pH values reported within the range of 7.2 to 8.5. However, incidents of ground-water quality degradation from contamination, primarily with synthetic organic chemicals, have been documented in the region surrounding the NAS.

The primary contaminants of concern are trichloroethylene (TCE) and tetrachloroethylene (PCE). These constituents have been found in the NAS and ARF supply wells. The concentrations detected at Willow Grove are lower than found elsewhere in the region (Weston 1984).

The potable water supply for NAS Willow Grove and tenant activities is provided by three wells (NW1, NW2, and AFW3) that penetrate the middle member of the Stockton Formation. These wells are at least 300 ft deep. The specific capacity of the three wells ranges between 3.7 and 9.0 gpm/ft. The total combined average production from these wells in 1984 was 177,000 gallons per day (Earth Data, Inc. 1985). The wells are operated intermittently. When operating, they produce at the rate of approximately 250 gpm. The NAS water supply system is equipped with a packed column aeration tower for removal of volatile organic compounds.

In addition to contamination with volatile organic compounds, there has been relatively localized ground-water contamination in the area with other organic compounds, particularly hydrocarbons spilled or leaking from storage tanks. Among inorganic parameters, iron, manganese and sulfate are locally found at elevated concentrations, but these are generally attributable to natural sources. Sloto and Davis (1983) indicated a widespread increase in nitrate levels in ground water since the 1950s, probably attributable to contamination in rural areas from application of nitrogen fertilizers and use of on-lot sewerage systems. They noted that lead concentrations in 26 wells sampled in the Warminster area in 1979 to 1981 ranged from 0 to 55 µg/L, with a median of 17 µg/L. Although only one sample exceeded the current EPA maximum contaminant level (MCL) of 50 µg/L, the median was higher than reported nearby and national medians. They attributed this to the urbanized character of the area, and the widespread occurrence of lead presence as a component of automobile exhaust. EPA has proposed revising the MCL for lead to 5 µg/L at the treatment plant or 10 µg/L at the tap.

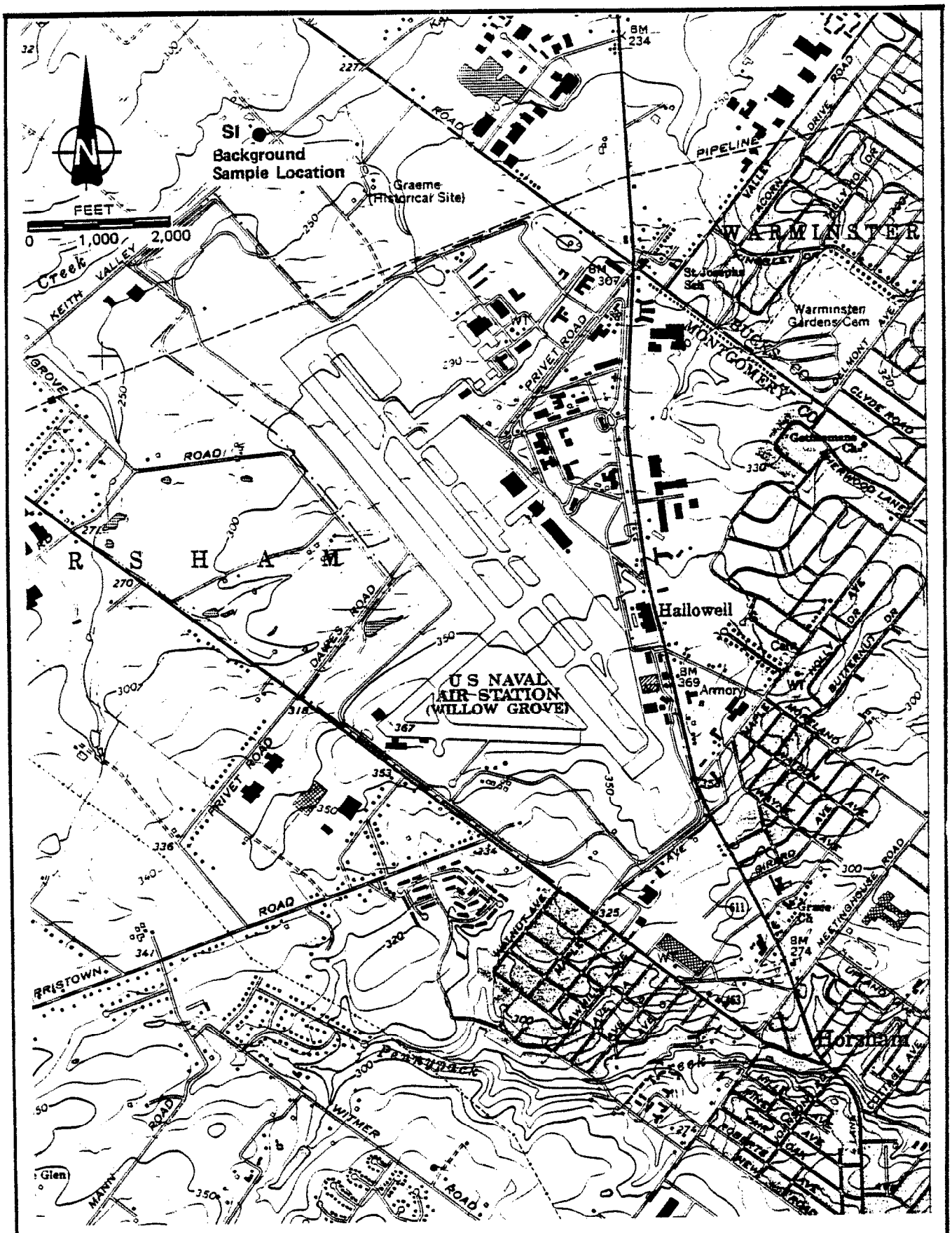
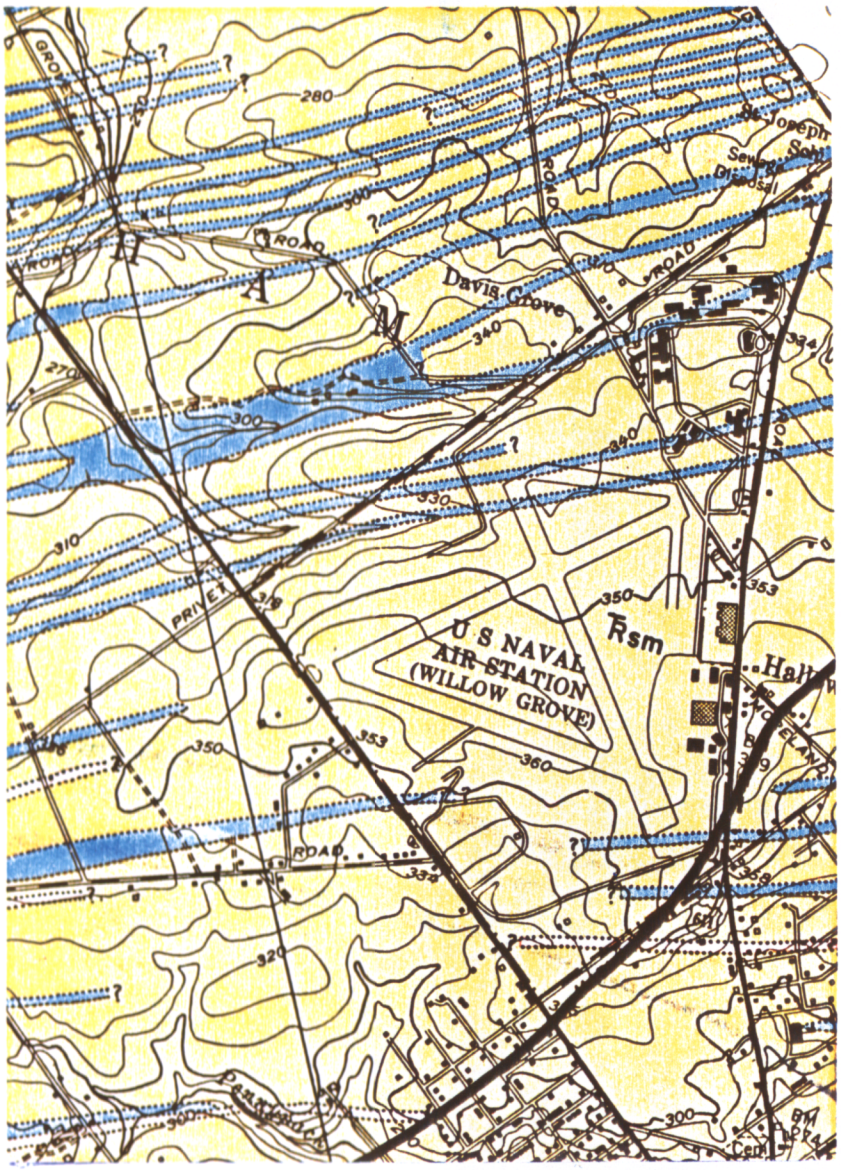


Figure 2-1. Site topography. (Source: Ambler Quadrangle, U.S.G.S. 7.5 minute series (topographic) 1966, photorevised 1983.)



Middle Member
Stockton Formation

Fine- and medium-grained arkosic sandstone, containing beds of coarse-grained arkosic sandstone (shown in pink) and red shale and siltstone (shown in blue); reported yields from wells in this member range from 10-800 gpm and average 130 gpm; average specific capacity of wells is 5.0 gpm per foot of drawdown.

FEET
0 24000

Figure 2-2. Geologic map of Willow Grove (Rima et al. 1962).

3. MONITORING NETWORK DESIGN AND RATIONALE

This chapter contains descriptions of the site-specific sampling programs and the rationale used in their design for four Remedial Investigations (RI) and two Extended Site Inspection (ESI) studies. The field tasks proposed in this work plan are considered to be only the first phase of the RI investigation. A second phase of work is anticipated to fill in data gaps identified in Phase 1 and to prepare an adequate database for the Feasibility Study (FS).

3.1 NAS SITE 1--PRIVET ROAD COMPOUND (RI)

3.1.1 Significant Findings of the PA

The Privet Road Compound consists of an open enclosure located north of and immediately across Privet Road from the Steam Plant, Building No. 6 (Figure 3.1-1). The site is about 1 acre in size. The compound was constructed to serve as a transfer station for wastes following closure of the 9th Street Landfill. However, between 1967 (when it was first used) and 1975, appreciable quantities of wastes were burned and buried at the site. During this time, the compound was essentially an open disposal area.

In general, wastes disposed at the compound were those not accepted by the regular trash pickup and off-base disposal service that was instituted in 1967. Materials reported to have been disposed at the compound are summarized in Table 3.1-1.

The site is immediately adjacent to an open storm drainage swale. During the time that the site was an open disposal area (1967-1975), transport of contaminants due to stormwater runoff may have occurred. The storm drainage swale outfalls to the Air Reserve Facility Detention Basin.

The direction of ground-water movement in the water table was estimated to be to the north and northwest. Unpaved areas of the site are susceptible to surface water infiltration and subsequent percolation through buried waste materials to the water table. The depth of the water table in this area was estimated to be about 20-25 ft.

3.1.2 SI Investigation

SI investigations at the Privet Road Compound included sampling of ground water, subsurface soil, and drainage ditch sediment. Four, 4-in. monitoring wells were installed at the site (Figure 3.1-1) with well PRW-4 being the designated upgradient well. Ground-water samples were collected from these wells in June, September, and December 1989 and analyzed for VOC, SVOC, pesticides/PCB, total and dissolved metals, TOC, TPH and cyanide. Two test borings were drilled at the site. From each boring a discrete sample (VOC) and a composite sample (SVOC, pesticides/PCB, metals, TOC, TPH, cyanide) were submitted for laboratory analysis. Three sediment samples were collected from ditches bordering the north and east boundaries of the site. Each sediment sample was analyzed for the TCL parameters, TOC and TPH. Soil and sediment samples were collected in February 1989.

Data from borings in the downgradient locations (PRW-1,2,&3) suggest that the site is underlain by 4 ft of fill consisting of clayey silt with intermixed debris of variable nature. The debris content of the fill decreases westward. The fill grades into an underlying silty clay which probably represents the original site surficial material. A sandier soil underlies the silty clay and overlies sandstone or siltstone bedrock. The average depth to bedrock is 12-18 ft. The south (PRB-1) and southeast (PRW-4) portions of the site are underlain by a hard, tan to light grey resistant sandstone with a relatively higher water yield than the red sandstone and siltstone.

Depth to ground water averaged 12-18 ft below the surface. In most cases the water table was encountered within competent bedrock or the overlying weathered zone. Ground-water flow direction in the water-table aquifer is to the northwest. Water level data collected during the third round of sampling suggest that ground-water flow may be more northerly at times.

3.1.2.1 Ground Water

Volatile Organic Compounds

Trichloroethene (TCE) and tetrachloroethene (PCE) were detected in samples from the downgradient wells, PRW-1 and PRW-2 at levels above the drinking water maximum contaminant level (MCL) during the first round of sampling. The highest concentrations were present in the PRW-2 sample (110 µg/L PCE, 8 µg/L TCE). 1,1,1-trichloroethane (TCA), 1,1-dichloroethene and 1,2-dichloroethene were detected at levels below the MCLs. Trace levels (2 µg/L) of TCA, TCE, and PCE were found in the sample from the upgradient well, PRW-4.

Results from the second and third round of sampling showed PCE (20-40 µg/L) present in the PRW-1 and PRW-2 samples in concentrations above MCLs. TCA and TCE were detected at levels below MCLs in the PRW-1 sample. No other VOC were detected in any other wells during the second or third round of sampling.

Semivolatile Organic Compounds

N-butylbenzenesulfonamide was tentatively identified in samples from PRW-2,3,4 during the first round of sampling. No SVOC were detected during the second or third round of sampling.

Pesticides/Polychlorinated Biphenyls

No pesticides or PCB were detected during the first round of sampling. PCB Aroclor 1260 was detected in downgradient well samples PRW-2 (1.5 µg/L) and PRW-3 (9.5 µg/L), and dieldrin (0.1 µg/L) was detected in the PRW-2 sample during the second round of sampling. PCB Aroclor 1260 was detected again at comparable levels in wells PRW-2 and PRW-3 during the third round of sampling.

Metals

No dissolved metal concentrations exceeding MCLs were detected in samples of ground water during any round of sampling. Total lead concentrations exceeded the current MCL (50 µg/L) in two of the downgradient well samples (PRW-1 and PRW-2) and the proposed MCL (5 µg/L) in an upgradient sample (PRW-4) during the first and second round of sampling. The proposed MCL for lead was exceeded in samples from PRW-1 and PRW-2 during the third round of sampling.

Total Cyanide

Cyanide was not detected in samples of ground water during any round of sampling.

Total Petroleum Hydrocarbons

TPH concentrations were below detection limits except for the samples from PRW-2, which had TPH concentrations of 1.4 mg/L and 1 mg/L for the first and second rounds of sampling respectively.

3.1.2.2 Sediment

Volatile Organic Compounds

No VOC were detected in sediment samples collected at the site.

Semivolatile Organic Compounds

Trace levels of tentatively identified compounds were detected in sediment samples PR/SS/1 and 3.

Pesticides/Polychlorinated Biphenyls

PCB were detected in each sediment sample at estimated (below CRDL) concentrations. The upstream (PR/SS/1) sample was reported to contain an order of magnitude higher concentration (500 µg/kg) than the downstream samples (41 and 54 µg/kg). Dieldrin, alpha chlordane, and gamma chlordane were detected in sediment samples PR/SS/2 and 3. The highest concentration of pesticide was 55 µg/kg of dieldrin in the PR/SS/2 sample. Pesticides were not detectable in the upstream sample.

Metals

Chromium concentrations above regional background levels were detected in samples PR/SS/2 and 3 (415 and 259 mg/kg respectively).

Total Cyanide

A total cyanide concentration of 0.14 mg/kg was detected in sample PR/SS/3.

Total Petroleum Hydrocarbons

Concentrations of this parameter exceeded the level of the NAS background sample (81 mg/kg) in all sediment samples analyzed. Values ranged from 404 to 695 mg/kg with the upstream sample at about the middle of the range.

3.1.2.3 Soil

Volatile Organic Compounds

No VOC were detected in soil samples from the site.

Semivolatile Organic Compounds

Numerous polycyclic aromatic hydrocarbons (PAH) were detected in soil samples from borings PRW-1, 2, and 4 at levels below CRDL. Methylbenzene was tentatively identified in the composite sample from PRB-1.

Pesticides/Polychlorinated Biphenyls

PCB were detected in soil samples from PRW-1, 2, and 3 at levels ranging from 39 to 7500 µg/kg. Dieldrin was detected at estimated values (below CRDL) in soil samples from PRW-3 and 4. DDT (31 µg/kg) and its derivatives were detected in soil from PRW-3.

Metals

Chromium was present at levels above regional background concentrations in samples from PRB-1 and 2 (581 and 626 mg/kg respectively). Arsenic levels were also elevated in these two samples (19.5 and 22 mg/kg respectively) and elevated cadmium levels were present in the PRB-1 sample (11 mg/kg).

Total Cyanide

No cyanide was detected in soil samples from the site.

Total Petroleum Hydrocarbons

Values for this parameter ranged from 158 to 906 mg/kg with the highest value being that for the sample from the upgradient well boring.

3.1.2.4 Discussion

Samples of ground water from the downgradient wells showed increases in concentrations of VOC, PCB, and pesticides relative to levels detected in the upgradient well samples. PCB and pesticides were also detected in the soil and sediment samples collected at the site. These results suggest that the site is a contributing source of these contaminants to the environment. Migration of contaminants off the site could occur via ground water, surface water, or sediment transport.

3.1.2.5 SI Conclusions

Samples of ground water obtained at the Privet Road Compound were found to contain trichloroethene (TCE) and tetrachloroethene (PCE) at levels above MCLs during one or more rounds of sampling. The VOC detected in the upgradient well sample were found at significantly lower levels than the levels in the downgradient samples. PCB, dieldrin, 1,1,1-trichloroethane (TCA), 1,1-dichloroethene, 1,2-dichloroethene, and lead are also of potential concern with regard to ground-water quality.

Soil samples from test borings at the Privet Road Compound contained the PCB Aroclor 1260 (2.7-7.5 mg/kg), dieldrin, and DDT which supports the interpretation that the site is a source for these components in ground water. Lead concentrations in the soil samples obtained were not high. However, sampling of the interior of the suspected fill area was beyond the scope of this investigation.

Sediment samples taken from ditches bordering the site contain PCB and dieldrin which is consistent with ground water and subsurface soil data for the site. These sediment concentrations indicate the potential for migration of these hazardous constituents offsite. The PCB level in the upstream sample also suggests the possibility of an offsite source of this contaminant.

3.1.3 RI Field Sampling Plan

3.1.3.1 Rationale

The contaminants of primary concern at this site are volatile organic compounds (VOC) including PCE and some of its breakdown products, which include TCE, 1,1- or 1,2-dichloroethene, and vinyl chloride; PCB, chromium; and lead. The VOCs were detected only in samples of ground water, whereas PCB, dieldrin, and lead were detected in both ground water and soil samples. Chromium was detected in soil samples from the site at levels above published background values.

Although previous investigations have indicated that both VOC and PCB may have sources upgradient, the increase in these contaminants downgradient and/or their detection in soil samples indicate that the Privet Road Compound may be a contributing source. Test borings are planned to further characterize this source area. Continued assessment of the ground-water plume is needed for both vertical and horizontal extent of plume migration. This will entail the installation of additional shallow and intermediate wells. The intermediate wells should be screened in the upper "transitional zone" (Section 2.3.6) between 80 and 100 ft deep.

To assess the effect of pumping production wells on the distribution of the contaminant plume underlying Privet Road, three of the intermediate/shallow well clusters, 4/4B, 5/5B, and 6/6B are going to be positioned approximately midway in a direct line between the production wells and the site.

The results from sediment sampling in the drainage ditch suggest that PCB and dieldrin may be migrating via drainage ditches although the current data are indicative of an upgradient source. Both contaminants are present at levels considered background for the installation but their migration potential should be further assessed.

3.1.3.2 Sampling Plan

In order to characterize the source areas at NAS Site 1, evaluate the nature and extent of the ground-water plume, and assess the potential for contaminants to migrate in the drainage swales bordering the site, the following tasks are planned.

- Install three shallow wells and five intermediate wells in clusters at the locations shown in Figure 3.1-1.

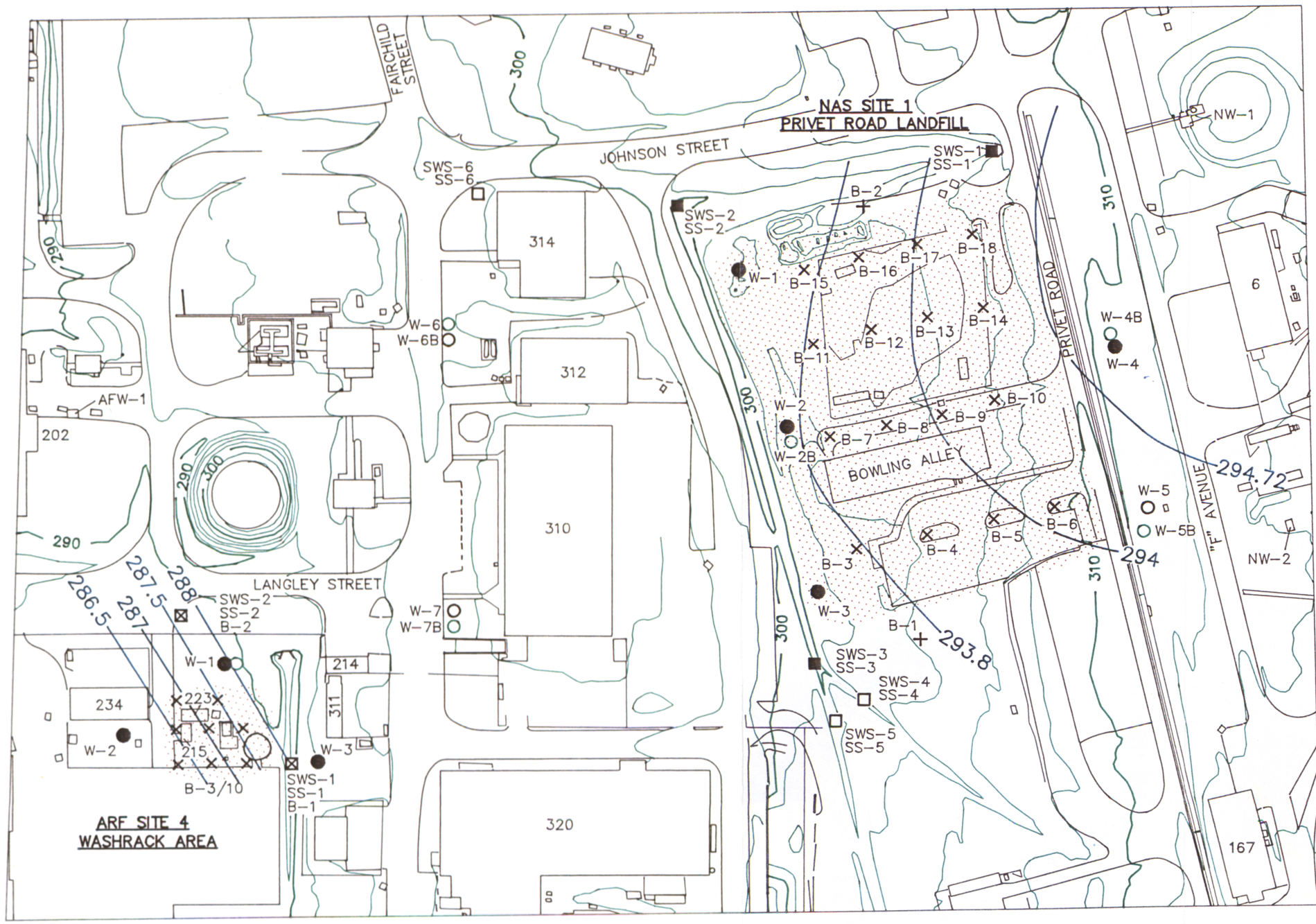
- Sample sixteen test borings within the potential source area as shown in Figure 3.1-1.

- Sample sediment at five locations in the drainage swales during dry conditions and sample surface water at these locations during a rain event. Locations are shown in Figure 3.1-1. Sample stations PR/SWS3/3 and SS/3 will not be sampled during the RI.

- Sample all original SI and new RI wells, and the ARF and Navy production wells (AFW-1, NW-1, and NW-2).

All samples will be analyzed for the TCL VOC, pesticides, and PCB, and the TAL metals (total and dissolved for ground water) and cyanide.

In addition to the above work, three separate 48-hour pump tests will be conducted on the three production wells (NW-1, NW-2, and AFW-1). Pump tests will be separated in time by a minimum of 1 week. Each production well will be pumped continuously for 48 hours while the other production wells are shut down. All wells within 1,000 ft of the pumping well will have their water levels monitored to determine the impact of pumping on ground-water gradients. Water levels in the pumping well and any wells within 200 ft will be monitored with an In Site Hermit Data Logger. All other wells will be monitored by hand with an electronic water level indicator. After pumping, all wells will be monitored for 24 hours to



LEGEND

	PROPOSED	EXISTING
WELL		
SHALLOW	○	●
DEEP	○	●
INTERMEDIATE	○	●
BORING	×	+
SURFACE WATER/ SEDIMENT	□	■

—294— WATER TABLE CONTOUR (17 MAY 1989)

SUSPECTED WASTE AREA

NOTE:

ALL SAMPLE DESIGNATIONS PREFIXED BY WR AND PR (WASHRACK & PRIVET ROAD) IN TEXT.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

ARF4 – WASHRACK AREA AND NAS SITE 1 – PRIVET ROAD

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
BCL	PMS	8-22-91	10388.07	17NAS1
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	
GTC	CWH	1"=100'	FIGURE 3.1.1	

TABLE 3.1-1 WASTES DISPOSED AT THE PRIVET ROAD COMPOUND, 1967-1975

Waste Type	Total Estimated Quantity
Paint wastes	220 gal
Paint stripper (methylene chloride)	2 gal
Xylene and toluene	2 gal
Isopropyl and methyl alcohol, acetone, methyl ethyl ketone (MEK)	2 gal
Freon	1 gal
Trichloroethylene (TCE)	120 gal
Polychlorinated biphenyls (PCB)	360 gal
Battery acid (sulfuric)	96 gal
Asbestos	110 lb
General refuse	1,560,000 lb
Sewage sludge	20,000 lb
Industrial pretreatment plant sludge	20,000 lb
Petroleum, oils, and lubricants (POL)	55 gal
Oil and grease emulsion (separators)[a]	26,000 gal
Lead (sewage sludge)	40 lb
Silver (sewage sludge)	160 lb
Mercury (dental amalgam)	2 lb
Chromium (sewage sludge)	10 lb

(a) Assume 10 percent POL.

Source: Initial Assessment Study, NAS Willow Grove, February 1986.

record recovery to equilibrium conditions. Details concerning pump test methods are discussed in Section 5.8.

Prior to pump testing, all well water levels at sites NAS1 and ARF-4 will be monitored for 1 month to evaluate the effect of normal pumping schedules on water levels and ground water underlying these sites. Measurements will be made by hand twice a day at 12 hour intervals.

3.2 NAS SITE 2--ANTENNA FIELD LANDFILL (RI)

3.2.1 Significant Findings of the PA

The Antenna Field Landfill is located southwest of Runway 10/28 and about 100 yd south of the Marine Reserve Compound. The Antenna Field Landfill was the exclusive disposal area for solid waste generated by NAS Willow Grove activities between 1948 and 1960. The landfill consisted of trenches in which wastes were first burned and then buried. The boundaries of the landfill have been obscured by more recent regrading activities. However, a steep berm that roughly parallels the north side of a wooded swale has been identified as the southern edge of the fill (Figure 3.2-1). A preliminary estimate of the boundaries of the site indicated that the landfill is about 9 acres in size. Hazardous materials which were suspected of having entered the site are listed in Table 3.2-1. The northern extent of the landfill is unknown.

The overburden in the area of the landfill was reported to contain a perched water table that rises to within 2.5 ft of the ground surface. As a result, it was thought likely that wastes buried within the landfill are periodically saturated. The potential for migration of contaminants from the landfill into the water table was considered high. Percolation of contaminated ground water to the underlying artesian aquifer and subsequent migration of contaminants were also considered possible. The direction of ground-water flow in the water table was estimated to be south-southeast. The direction of ground-water flow in the artesian aquifer could not be ascertained from existing information.

Discharges of contaminated base flow from the perched zone into the adjacent drainage swale were also considered possible during and immediately following rainfall. The drainage swale flows into Pennypack Creek. Potential receptors identified were humans consuming fish taken from Pennypack Creek.

3.2.2 SI Investigation

Three 4-in. monitoring wells were installed at the Antenna Field Landfill to assess ground-water quality at the site (Figure 3.2-2). Well, ALW-2 is the designated upgradient well. After development, all wells were sampled for VOC, SVOC, total and dissolved metals, TOC, TPH, pesticides/PCB, and cyanide in June, September, and December of 1989. During each sampling event, 4 surface water samples were collected along the stream due south of the landfill. Sediment samples were collected in conjunction with surface water samples. Sample analytes were the same as for ground water with the exception of dissolved metals.

The Antenna Field Landfill eastern boundaries are delineated by a steep berm. An 8 ft deep ditch bisects the landfill. Discharge from the ditch is to the south into an unnamed stream which discharges into Pennypack Creek 1/2 mi beyond the NAS boundary. Due to the clay cover atop the landfill, standing water after a precipitation event may exist on top of the landfill for an extended period of time.

The eastern half of the site is underlain by red siltstone and sandstone. Depth to bedrock is 14 ft. The overburden consists predominantly of silty clay with local lenses of silty sand overlying 7.5 ft of saprolite. Moving south and westward across the site the overburden thins to only 6 ft thick at the western edge of the site. The character of the overburden remains similar but the underlying bedrock changes to a resistant cream/yellowish/brown, fine to medium grained sandstone.

Ground-water flow according to water level measurements is towards the southwest. This is similar to the general direction of flow for surface water at the site. Water loss during drilling indicated that effective permeability was noticeably higher in the resistant sandstone unit. Increased loss of water at discrete intervals during drilling within this resistant sandstone unit indicates that occasional fracture zones account for the increased permeability observed within this unit.

3.2.2.1 Ground Water

Volatile Organic Compounds

During the first round of ground-water sampling, traces of trichloroethene (TCE), benzene, 1,1 dichloroethene, toluene, and chlorobenzene were detected in samples of ground water from the upgradient well, ALW-2. None of the detected compounds were present at levels exceeding MCLs. No volatile organic compounds were detected during the second or third round of sampling; except for trace levels of methylene chloride, a common laboratory contaminant.

Semivolatile Organic Compounds

No SVOC were detected in ground-water samples during any round of sampling.

Pesticides/Polychlorinated Biphenyls

Dieldrin was detected at concentrations below CRDL; 0.04 and 0.01 µg/L respectively in samples from downgradient wells ALW-1 and ALW-3 during the first round of sampling. No pesticides were detected during the second or third round of sampling.

Metals

Dissolved lead was reported to exceed the proposed MCL for lead in the sample from the upgradient well, ALW-2, during the first round of sampling. This value is suspect in that the dissolved lead value was twice as high as the total lead value for this sample. During the second and third round of sampling, total lead levels in the ALW-2 sample exceeded the proposed MCL but the dissolved level was well below this limit. Downgradient well samples generally had lower lead levels in both total and dissolved aliquots.

Total Cyanide

Cyanide was not detected in samples of ground water from the site during the first or third round of ground-water sampling. During the second round of sampling the sample from well ALW-1 contained 20 µg/L total cyanide.

Total Petroleum Hydrocarbons

TPH values were below detection limits during the first and third round of sampling. Second round samples had TPH values ranging from 0.9 mg/kg in the upgradient well to 2.5 mg/kg in ground water from ALW-3.

3.2.2.2 Surface Water

Volatile Organic Compounds

No VOC were detected in surface water samples from this site.

Semivolatile Organic Compounds

No SVOC were detected in surface water samples from this site.

Pesticides/Polychlorinated Biphenyls

Dieldrin was detected in all surface water samples at the site during the first round of sampling at concentrations ranging from 0.05 to 0.3 µg/L. During the second round of sampling, dieldrin was detected only in sample AL/SWS/3 at a concentration of 0.24 µg/L. Dieldrin was not detected in surface water at this site during the third round of sampling.

Metals

Manganese was detected at levels above the state ambient water criteria in one sample, AL/SWS/4, during the second round of sampling. During round 3 sampling manganese exceeded ambient water criteria in all samples. Total iron exceeded ambient water criteria in sample AL/SWS/3.

Total Cyanide

Cyanide was not detected in any of the surface water samples from this site.

Total Petroleum Hydrocarbons

TPH were detected (0.31-1 mg/L) in the AL/SWS/4 sample during the first and second rounds of sampling. No other samples were found to contain detectable levels of TPH.

3.2.2.3 Sediment

Volatile Organic Compounds

No VOC were detected in sediment samples from this site.

Semivolatile Organic Compounds

Numerous polycyclic aromatic hydrocarbons (PAH) were detected in all sediment samples from this site. Total PAH concentrations were in the range 2.5-8.2 mg/kg during round 1, 15.6-536 mg/kg during round 2, and 0.8-104 mg/kg during round 3. The highest concentrations of these compounds were consistently found at location AL/SS/4 where the second round sample was the only sample to exceed urban background levels (IARC 1973; Blumer 1961; White and Vanderslice 1980).

Pesticides/Polychlorinated Biphenyls

Dieldrin was detected in all round 1 sediment samples from this site. First round results ranged from 7.8 µg/kg in sample AL/SS/4 to 510 µg/kg in sample AL/SS/3. Second round results showed dieldrin only in sediment from AL/SS/3 at a concentration of 220 µg/kg. DDT and its derivatives were also detected in sediment from AL/SS/1 and AL/SS/3 during round 2. Dieldrin (250 µg/kg) and Heptachlor epoxide (63 µg/kg) were detected in sediment sample AL/SS/3 during round 3 sampling. Traces of DDT compounds and PCB were noted as well in this sample.

Metals

Sample AL/SS/4 contained lead at 715 mg/kg during round 1 sampling. The EPA interim guidance cleanup level for lead in residential areas is 500-1,000 mg/kg. Elevated cadmium was noted in samples AL/SS/2, 3, and 4 during the third round of sampling.

Total Cyanide

No cyanide was detected during the first round of sampling. Second round samples were found to contain total cyanide concentrations in the range 0.19-0.93 mg/kg in samples AL/SS/1, 2, and 4. During round 3, samples AL/SS/1, 2, and 3 were reported to contain 0.2 mg/kg total cyanide.

Total Petroleum Hydrocarbons

TPH values for sediment samples ranged from 20 to 2240 mg/kg over three rounds of sampling. Values were consistently higher for all sites during the second round of sampling.

3.2.2.4 Discussion

Ground-water results indicate a source upgradient of well ALW-2 for VOC and lead. A possible source for these compounds may be runoff from the runway, or the results may indicate that the former landfill extended further to the northeast than was assumed.

The pesticide dieldrin was detected in samples of ground water, surface water, and sediment downgradient of the site. Surface water and sediment levels of dieldrin were highest in a small drainage ditch which bisects the landfill. These data suggest that the landfill is a source of dieldrin. The levels of dieldrin detected in surface and ground water exceed by several orders of magnitude the chronic toxicity level for fresh water aquatic organisms (1.9×10^{-3} µg/L) and the carcinogenicity protection level (7.1×10^{-2} ng/L) for human health as set by EPA Ambient Water Quality Criteria (EPA 1986).

PAH levels in sediment samples were highest at station AL/SS/4 and showed a marked decrease downstream. From this it can be inferred that station AL/SS/4 is closest to the source of these compounds. AL/SS/4 is just downstream from a large culvert which extends east toward the runway. Runoff from the runway is a possible source for these compounds.

3.2.2.5 SI Conclusions

Dieldrin was detected (below CRDL) in samples of ground water from the site. Dieldrin was also detected in the stream adjacent to the site at levels several orders of magnitude above the chronic toxicity level for fresh water aquatic organisms and the suggested carcinogenicity protection level in ambient water.

Dieldrin was detected at levels ranging from 7.8 to 510 µg/kg in sediment samples from all sampling locations at the site. The highest surface water and sediment levels of dieldrin were consistently detected at station AL/SWS/3. This station was located along a ditch which bisects

the landfill and discharges to the unnamed stream bordering the landfill. DDT and its breakdown products were also detected in sediment at two stations. Numerous PAH were detected from sediment at all locations at concentrations exceeding the level of total PAH in the NAS background sample. Elevated TPH levels were present in all sediment samples.

3.2.3 RI Field Sampling Plan

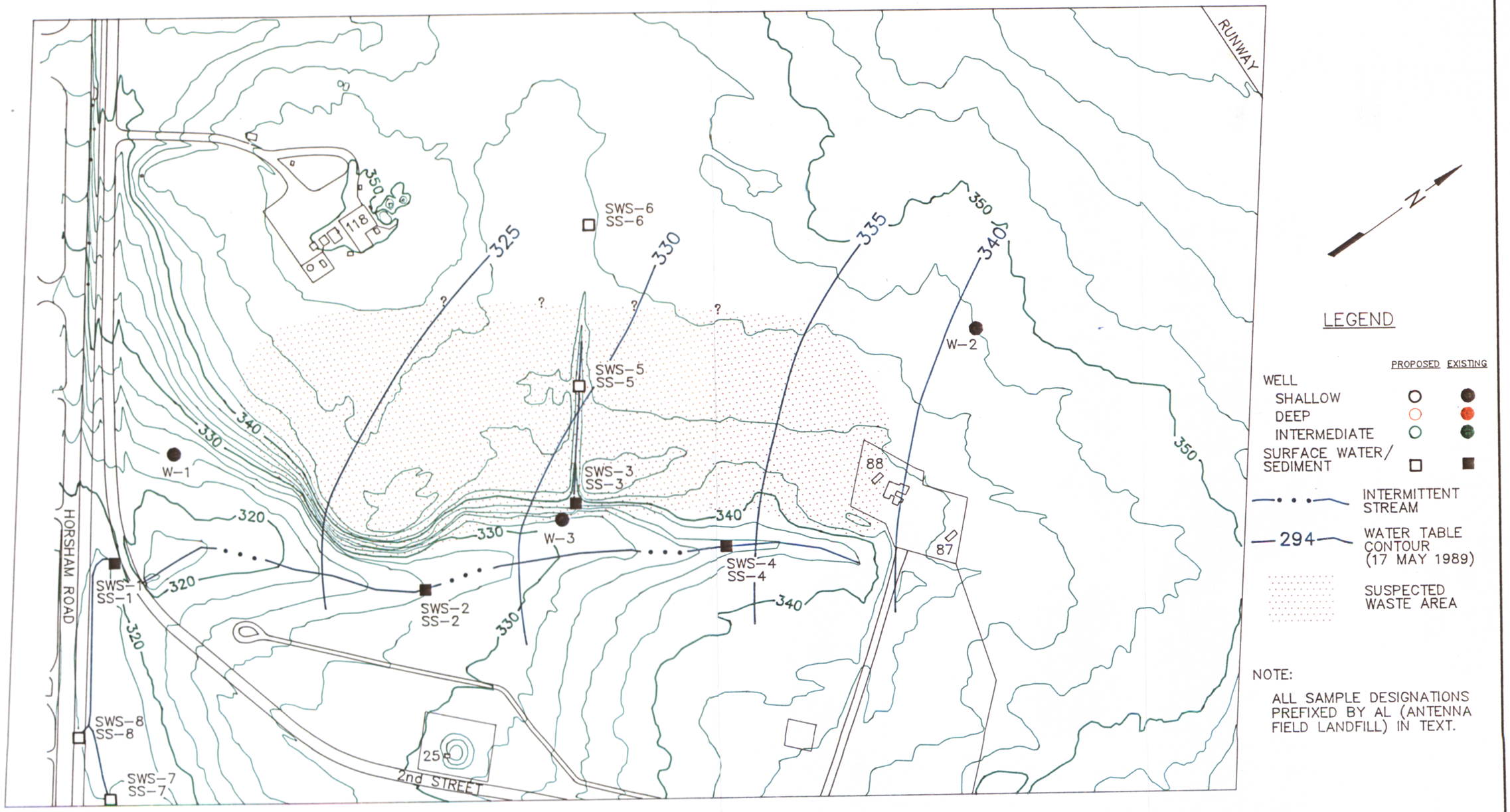
3.2.3.1 Rationale

Results of previous investigations suggest that the old landfill may be a source for dieldrin and possibly other pesticides. Migration of these contaminants from the site is primarily via surface water flow and sediment migration. Additional sampling of sediment within the ditch bisecting the landfill, both within the landfill and upgradient, is necessary to assess whether the landfill is the actual source of the pesticide. Additional sampling of surface water and sediment between where the stream exits the installation and where it enters Pennypack Creek will be undertaken to assess potential migration of pesticides offsite.

3.2.3.2 Sampling Plan

In order to locate the source of contaminants and assess the potential for impact to the surface water ecosystem, the following tasks are planned.

- Sample eight surface water/sediment locations as shown in Figure 3.2-1. Three additional samples (AL/SWS/9-11) will be collected between where the stream exits the base and its junction with Pennypack Creek. All samples will be tested for TCL VOCs, SVOCs, TAL metals (total metals only), pesticides, and PCBs.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	NAVAL AIR STATION WILLOW GROVE HORSHAM TOWNSHIP, PENNSYLVANIA	NAS SITE 2 ANTENNA FIELD LANDFILL	DESIGNED BY BCL	DRAWN BY PMS	DATE 8-22-91	PROJECT NO. 10388.07	FILE NAME 17NAS2
			CHECKED BY GTC	PROJECT MGR. CWH	SCALE 1"=150'	DRAWING NO. FIGURE 3.2.1	

TABLE 3.2-1 WASTES DISPOSED AT THE ANTENNA FIELD LANDFILL, 1948-1960

Waste Type	Total Estimated Quantity
Paint wastes	1,000 gal
Paint stripper (methylene chloride)	17 gal
Xylene and toluene	16 gal
Isopropyl and methyl alcohol, acetone, MEK	12 gal
Carbon tetrachloride	100 gal
Freon	8 gal
Trichloroethylene (TCE)	25 gal
General refuse (includes shingles and wood)	10,400,000 gal
Sewage sludge	18,000 lb
Industrial pretreatment plant sludge	12,000 lb
Petroleum, oils, and lubricants (POL)	370 gal
Oil and grease emulsion (separators)[a]	15,000 gal
Coal ash	unknown
Metal scrap (includes empty drums)	132,000 lb
Lead (sewage sludge)	40 lb
Silver (sewage sludge)	140 lb
Mercury (dental amalgam)	10 lb
Chromium (sewage sludge)	9 lb

(a) Assume 10 percent POL.

Source: Initial Assessment Study, NAS Willow Grove, February 1986.

- If leachate from the landfill is observed at seepages along the base of the landfill berm adjacent to the unnamed creek, it will be sampled for the same parameters as above. Leachate will be collected during a dry period during which no precipitation has fallen for 3 days and during a rain event when at least 0.5 in. of rain falls within a 4-hour period. Analytes will be as above.

- Sample all SI wells to confirm the SI conclusions. Analytes will be same as above with the addition of dissolved metals.

3.3 NAS SITE 3--9TH STREET LANDFILL (RI)

3.3.1 Significant Findings of the PA

The 9th Street Landfill occupies about 9 acres against the western boundary of NAS Willow Grove and immediately north of 9th Street (Figure 3.3-1). This landfill was opened to replace the Antenna Field Landfill, which was phased out in 1960. The method of disposal used at the Antenna Field Landfill, which involved burning the refuse and burying the residue in trenches, was also used at the 9th Street Landfill. The types of materials disposed at this site are also assumed to be similar to those that were previously sent to the Antenna Field Landfill. The rate of waste generation was, however, greater over this period. A summary of wastes reportedly disposed at this site is presented in Table 3.3-1.

In addition to its use for the landfilling activities of the Public Works Department, the site was also used as an open disposal ground by various operations at NAS Willow Grove, as well as by reservists who disposed of household rubbish there. Material that had been disposed of at random was periodically buried by the Public Works Department. Most of the waste was reported to be buried in the southwest and east-central position of the site; however, the entire area was suspected to have been used for waste disposal.

In 1967, the landfill was officially closed. One of the primary landfill areas (east-central) was covered and a salvage yard was established in the same location. In addition to empty drums and discarded equipment, PCB transformers were also stored and serviced at the salvage yard.

The site adjoins the recreational pond, which was identified as the apparent discharge zone for the water-table aquifer. It was also considered that contaminants may enter the underlying artesian aquifer

with recharge from the water table. The direction of ground-water movement in the artesian aquifer could not be evaluated with existing data.

3.3.2 SI Investigation

A total of seven monitoring wells was installed at the 9th Street Landfill (Figure 3.3-1). Four of the wells are shallow, 4-in. wells screened to intercept the water table. Three 2-in. wells were installed as deeper, well cluster companions with wells 9SL-1, 3, and 4. Wells, 9SLW-1 and 9SLW-1B are the designated upgradient wells.

The 2-in. monitoring wells were drilled to 80 ft depth using a 4-3/4-in. air hammer and screened from 60 to 80 ft. The purpose of the deeper wells was to intercept the deeper portion of the aquifer under semi-confined conditions. Two of these wells, 9SLW-3B and 9SLW-4B, were artesian upon completion in May 1989. Ground-water samples were collected from all wells in June, September, and December. Samples were analyzed for VOC, SVOC, Pesticides/PCB, total and dissolved metals, TOC, TPH, and cyanide.

Four surface water and sediment samples were taken at the 9th Street Landfill site during each ground-water sampling event with the exception of the December event during which ice prevented sampling at stations 9SL/SWS/1 and 2. Surface-water and sediment samples were analyzed as above with the exception of dissolved metals.

Six soil test borings were completed in the 9th Street Landfill with a CME 750 drill rig equipped with a 5-ft continuous sampler; the purpose of these borings was to characterize subsurface materials in the vicinity of EM and SVCA anomalies (EA 1989a). A discrete interval soil sample with the highest headspace reading was submitted for analysis of VOC from each boring. A composite sample from each boring was submitted for analysis of SVOC, Pesticides/PCB, metals, TOC, TPH, and cyanide.

Six surficial soil samples were collected from the baseball field at the 9th Street Landfill picnic area. Soil samples were collected in pairs with a hand auger from 0-0.5 ft and 2-2.5 ft intervals at 3 locations. Analytes for surficial soil samples are as above.

The top several feet of overburden at the site are clayey silt which grades into a sandier unit ranging from silty sand to sandy silt at depth between 2 and 4 ft. An exception to this occurs at well 9SLW-3 where the sandier facies is encountered directly overlying bedrock at only 6-ft depth. Depth to bedrock averages between 8 and 15 ft below grade over the rest of the site. The bedrock consists of interbedded red sandstone and tan to light grey sandstone.

Downgradient shallow wells have shown water levels between 2 and 10 ft below grade. The bedrock wells at both downgradient locations are artesian. The upgradient shallow well, 9SLW-1, encounters water between 18 and 20 ft below grade and the upgradient bedrock well is not artesian. Water level data over the site suggest that ground-water flow in the water-table aquifer is to the northwest (Figure 4.3-1) while flow within the semi-confined zone appears to be more northerly. However, accurate water level data were not obtainable for the artesian wells.

3.3.2.1 Ground Water

Volatile Organic Compounds

Tetrachloroethene (PCE) was detected in all ground-water samples except those from 9SLW-2 in concentrations ranging from 13 to 75 µg/L during the first round of sampling. Trichloroethene (TCE) and 1,1,1-trichloroethane were also detected in the sample from 9SLW-3. Similar results for PCE at slightly higher concentrations were obtained during round 2 sampling. The deep wells in clusters 9SLW-1 and 3 consistently showed higher levels of PCE than the shallow wells, whereas the opposite was observed in well cluster 9SLW-4 samples. PCE was detected in similar concentrations and patterns in round 3 with the exception that only a trace level (below

CRDL) of PCE was detected in ASL W-3. No other VOC (except methylene chloride, a common laboratory contaminant) were detected above CRDL during the third round of sampling.

Semivolatile Organic Compounds

N-butylbenzenesulfonamide was tentatively identified in the sample from 9SLW-3 during the first round of sampling.

Pesticides/Polychlorinated Biphenyls

Traces of dieldrin (0.01-0.02 µg/L) were found in samples from wells 9SLW-2 and 3 during the first round of sampling. No pesticides were detected in second or third round samples.

Metals

Dissolved cadmium (11.5 µg/L) exceeded the current MCL (10 µg/L) in sample 9SLW-4 during the third round of sampling. No other samples during any round of sampling exceeded current MCLs for dissolved metals. Dissolved cadmium exceeded the proposed MCL (5 µg/L) in the 9SLW-1, 4B and 3 samples during the third round of sampling.

The total lead levels in round 1 and 2 samples from the upgradient shallow well (9SLW-1) exceed the proposed MCL for lead. While total lead in the second round sample from 9SLW-3 was reported to exceed the current MCL for lead, the second round value (55.8 µg/L) was significantly higher than the first (3.3 µg/L) and third (12.6 µg/L) round samples.

Total Cyanide

No cyanide was detected during the first round of sampling. The second round 9SLW-1 sample contained 0.01 mg/L and the third round 9SLW-2 sample contained 0.02 µg/L of total cyanide.

Total Petroleum Hydrocarbons

TPH concentrations were below the detection limit in all samples analyzed.

3.3.2.2 Surface Water

Only samples 9SL/SWS/3 and 4 were collected during the third round of sampling due to frozen conditions.

Volatile Organic Compounds

No VOC (except a common laboratory contaminant) were detected during any round of sampling.

Semivolatile Organic Compounds

No SVOC (except a common laboratory contaminant) were detected during either round of sampling.

Pesticides/Polychlorinated Biphenyls

Dieldrin was detected in all surface water samples during the first round of sampling at concentrations below CRDL in the range 0.03-0.06. No pesticides were detected in round 2 or 3 surface water samples.

Metals

Total cadmium, iron, and manganese were detected at levels exceeding ambient water criteria during round 3 sampling.

Total Cyanide

No cyanide was detected in any surface water sample from this site.

Total Petroleum Hydrocarbons

TPH concentrations were below detection level in all samples analyzed.

3.3.2.3 Sediment

Only samples 9SL/SS/3 and 4 were collected during round 3 due to frozen conditions.

Volatile Organic Compounds

No volatile organic compounds (excluding common laboratory contaminants) were detected in sediment samples collected at this site.

Semivolatile Organic Compounds

Numerous polycyclic aromatic hydrocarbons (PAH) and unknown alkanes were detected in sediment samples from this site during both rounds of sampling. Station 9SL/SS/4 had consistently the highest levels of PAH with concentrations of 194.6 mg/kg (round 1) and 101.2 mg/kg (round 2) total PAH. Second round sample results were noticeably lower than the first round (5.6 to 65.7 mg/kg total PAH).

Pesticides/Polychlorinated Biphenyls

Trace levels of PCB were detected in the 9SL/SS/3 sample during round 1. Dieldrin was detected in all sediment samples during round 1 and samples 9SL/SS/2 and 3 in round 2. Dieldrin concentrations ranged from below CRDL to 300 µg/kg.

Metals

Regional background levels were not exceeded in any sediment sample analyzed except for sample 9SL/SS/4 during round 3 which showed elevated cadmium levels.

Total Petroleum Hydrocarbons

TPH concentrations ranged from 43 to 11,000 mg/kg. The highest levels detected were consistently found in samples from stations 9SL/SS/3 and 4.

3.3.2.4 Soil

Volatile Organic Compounds

Toluene (180 µg/kg), 1,1,1 trichloroethane (below CRDL at 22 µg/kg), and a variety of tentatively identified and unknown alkanes were detected in the soil sample from 9SLB-3.

Semivolatile Organic Compounds

Polycyclic aromatic hydrocarbons (PAH) were detected in surficial soil samples 9SLS-1A, 1B, 2A, 2B, and 3B in the range 2 to 16.6 mg/kg. Trace levels of alkanes and organic acids were detected in several test boring samples.

Pesticides/Polychlorinated Biphenyls

Dieldrin was detected in all surficial soil samples (89-1300 µg/kg) and in samples from borings 9SLB-1,2,3, and 5 at concentrations ranging from 1.4 to 129 µg/kg. A variety of other pesticides including DDT and it's derivatives, alpha and gamma chlordane, heptaclor epoxide, and delta - BHC were detected in the surficial soil samples. PCB (Aroclor 1260) was detected in samples from borings 9SLB-1, 3, and 4 at concentrations ranging from 24 (below CRDL) to 61 µg/kg.

Metals

Regional background levels were not exceeded in the soil samples analyzed.

Total Cyanide

Cyanide was detected in soil samples from borings 9SLB-1,2,3, and 4 as well as in surficial soil samples 9SLS-1B, 2A, and 3A. Concentrations ranged from 0.12 to 0.24 mg/kg in the test borings and from 0.25 to 0.35 mg/kg in the surficial samples.

Total Petroleum Hydrocarbons

TPH levels ranged from 36 to 1440 mg/kg in soil samples collected at the site.

3.3.2.5 Discussion

The presence of PCE in the upgradient well indicates an upgradient source of this compound. While PCE has not been detected in site soil samples obtained to date, this does not preclude the landfill as an additional source. Higher levels of PCE at well cluster 9SLW-4 than at the upgradient well cluster suggest that a source for PCE may be located within the west half of the landfill. The water table well sample from 9SLW-4 contained roughly twice the PCE level of the upgradient water table well while the semi-confined aquifer sample from 9SLW-4B showed roughly a 30 percent increase over the upgradient bedrock well.

The presence of dieldrin in test boring samples as well as samples of surface water, sediment, and ground water suggests that the 9th Street Landfill is a source of this pesticide.

The pesticide and cyanide levels detected in surficial soil samples are of concern since they were taken at a currently used baseball field. A potential risk from dermal or respiratory exposure to these contaminants exists.

3.3.2.6 SI Conclusions

Samples from the water-table aquifer at the site contain levels of TCE and/or PCE above potential ARARs (drinking water MCLs). PCE has also been detected in samples from the semi-confined zone. The existence of contaminants in the upgradient wells indicate another possible source upgradient although the increase in concentration downgradient is indicative that the landfill is a contributing factor.

Pesticides, especially dieldrin, are pervasive across the site. The samples from boring 9SLB-3 show the highest concentrations and greatest variety of contaminants including toluene, 1,1,1-trichloroethane, PAH, lead, and PCB.

3.3.3 RI Field Sampling Plan

3.3.3.1 Rationale

Ground water at this site has been shown to contain VOC above ARARs and soil samples taken at the site have shown pesticides and cyanide at levels of potential concern. Further evaluation of these contaminants is needed.

Data suggest that the landfill itself may be a source for VOCs but that an upgradient source is present. The only nearby upgradient activity known is the helicopter facility south of the site. A brief inspection of this facility revealed that compounds containing the contaminants of concern at this site have been stored behind the hanger building and are currently being used during washing and parts degreasing procedures within the hanger. Fluids lost during the washing procedures are discharged to the hanger storm drainage system which has a discharge point at the ground surface northeast of the hanger and upgradient of well cluster 9SLW-1, 1B.

Additional data are needed within the landfill itself to locate sources of VOC to ground water. Additional well clusters will be needed both upgradient and downgradient to evaluate the extent of the volatile plume.

The surficial soil at the ball field requires further sampling for purposes of risk assessment. Samples should be analyzed as before with the modification that free cyanide, i.e., bioavailable cyanide, should be analyzed as well.

Elevated levels of PAHs and dieldrin have been detected in sediments at the 9th street pond and the associated stream. Data suggests that the PAH do not migrate off-site via surface waters, but low levels of dieldrin may migrate from the site periodically. To assess the extent of migration and any possible health risks associated with these contaminants, further sediment and surface water sampling is required.

3.3.3.2 Sampling Plan

In order to characterize the volatile ground-water plume; characterize the volatile, pesticide, and cyanide content of landfill soil; and assess the extent of migration of PAH and dieldrin in stream/lake sediments, the following tasks will be carried out.

- Three deep wells, 9SLW-1C, 3C, and 4C will be installed as cluster companions to the existing clusters. These wells will be screened at a depth of 155-175 ft. The primary purpose of these wells will be to assess the vertical extent of VOC contamination at the site.

- One shallow well will be installed downgradient from the active drain at the helicopter hangar facility to assess the area as a possible source of volatile ground-water contamination.

- Four test pits excavated down to bedrock or no greater than 10 ft deep and approximately 100 ft long will be excavated within the landfill area. Up to four soil samples per test pit will be collected based on readings obtained with a HNU field PID or FID, or visual evidence of contamination.

- Thirty-two surficial soil samples, sixteen at surface and sixteen at 2-ft deep, will be collected on a 150 x 150 ft grid across the current ballfield. These samples will be analyzed for free cyanide in addition to the normal parameters used.

- Six sediment samples will be collected at locations shown on Figure 3.3-1. Station 9SL/SS/2 will not be sampled during the RI.

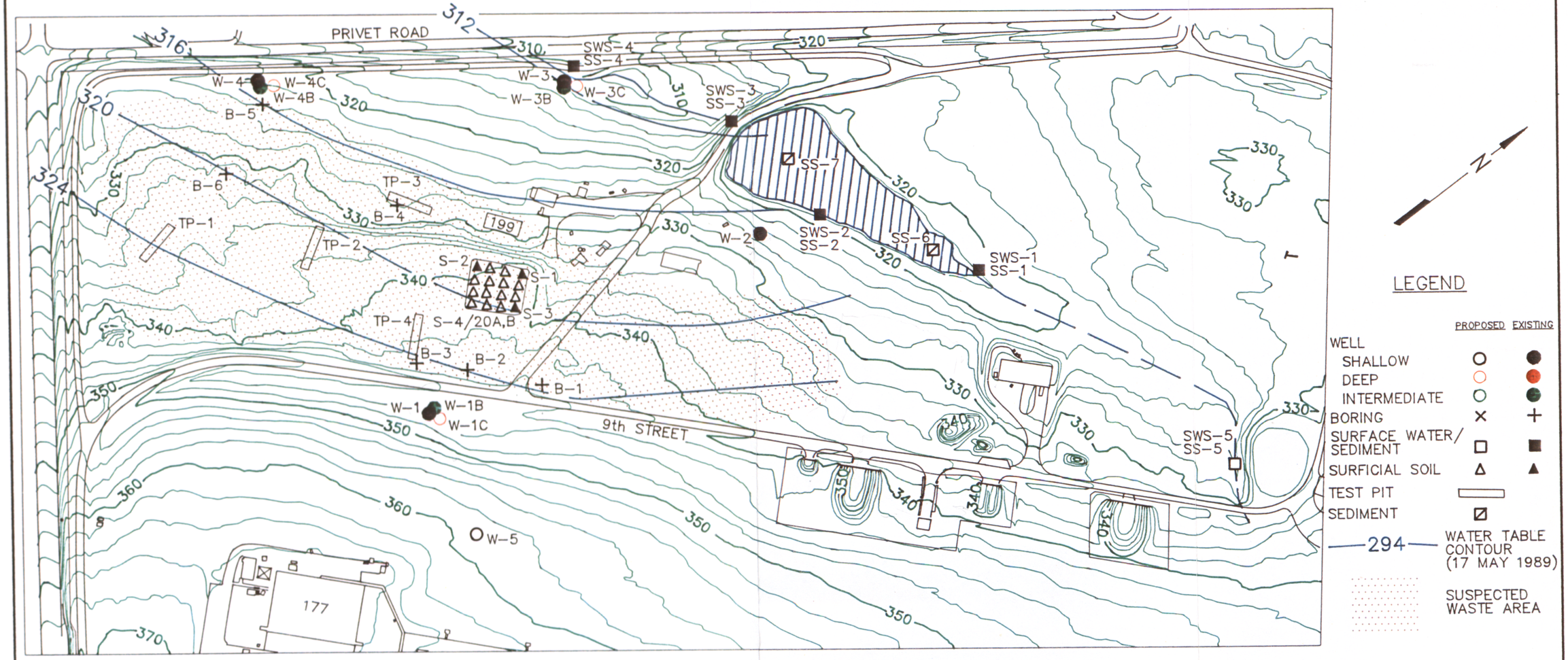
- Four surface water samples will be collected at the sediment sample sites indicated on Figure 3.3-1. Station 9SL/SWS/2 will not be sampled during the RI.

- All wells at the site will be sampled.

- Attempt to locate existing wells downgradient of the site (off NAS property) and obtain access for sampling.

All samples will be sampled for TCL VOCs, SVOCs, pesticides, PCB, TAL metals (total and dissolved for ground water), and cyanide.

The work proposed above is appropriate for Phase 1 RI activities. Phase 2 work will likely be required based on results obtained from Phase 1. Additional work may include further source characterization at the helicopter hangar, sampling and/or installation of wells further downgradient of the site and additional surface water/sediment sampling offsite and downgradient.



NOTE:

ALL SAMPLE DESIGNATIONS PREFIXED BY 9SL (9th STREET LANDFILL) IN TEXT.

Elev. Input Station

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.	NAVAL AIR STATION WILLOW GROVE HORSHAM TOWNSHIP, PENNSYLVANIA	NAS SITE 3 9th STREET LANDFILL	DESIGNED BY BCL	DRAWN BY PMS	DATE 8-22-91	PROJECT NO. 10388.07	FILE NAME 17NAS3
			CHECKED BY GTC	PROJECT MGR. CWH	SCALE 1"=200'	DRAWING NO. FIGURE 3.3.1	

TABLE 3.3-1 WASTES DISPOSED AT THE 9th STREET LANDFILL, 1960-1967

Waste Type	Total Estimated Quantity
Paint wastes	1,000 gal
Paint stripper (methylene chloride)	16 gal
Xylene and toluene	16 gal
Isopropyl and methyl alcohol, acetone, MEK	12 gal
Freon	8 gal
Trichloroethylene (TCE)	130 gal
PCB fluids (transformer servicing)	unknown
Asbestos	730 lb
General refuse (includes shingles and wood)	10,200,000 gal
Sewage sludge	16,000 lb
Industrial pretreatment plant sludge	12,000 lb
Petroleum, oils, and lubricants (POL)	4,400 gal
Oil and grease emulsion (separators)[a]	27,000 gal
Coal ash	unknown
Metal scrap (includes empty drums)	130,000 lb
Tires	unknown
Lead (sewage sludge)	30 lb
Silver (sewage sludge)	130 lb
Mercury (dental amalgam)	10 lb
Chromium (sewage sludge)	8 lb

(a) Assume 10 percent POL.

Source: Initial Assessment Study, NAS Willow Grove, February 1986.

3.4 NAS SITE 5--FIRE TRAINING AREA (RI)

3.4.1 Significant Findings of the PA

The Fire Training Area was used for large-scale fire fighting exercises from 1942 until 1975. During this 33-year period, these exercises were a primary method of disposal for flammable liquid wastes generated by the activity. Waste POL as well as various solvents and paint chemicals were consumed at the rate of at least 4,000 gal/year in fire fighting exercises. Between exercises, drums of these materials were stockpiled in the open area on the opposite side of the roadway from the burn area (Figure 3.4-1). Hundreds of drums and other large containers were reportedly stored in this area. Table 3.4-1 presents a summary of chemicals believed to have been spilled at this site.

It is possible that residual hydrocarbon contamination remains in this area. In this case, infiltrating rainfall may continue to release contaminants to ground water over time. Based on local topography, the direction of ground-water flow in the water-table aquifer was estimated to be towards the southwest. The depth to the water table was estimated to be less than 25 ft. Percolation of contaminated ground water from the water table to the underlying artesian aquifer and subsequent migration of contaminants were considered possible. The direction of ground-water flow in the artesian aquifer could not be ascertained from existing information.

3.4.2 SI Investigation

Four 4-in. monitoring wells were installed at the Fire Training Area (Figure 3.4-1). Well FTAW-3 is the designated upgradient well. Ground-water samples were collected from these wells in June, September, and December of 1989 and analyzed for VOC, TPH, and TOC.

Four test borings were drilled at the Fire Training Area. The purpose of these borings was to characterize subsurface materials in the vicinity of SVCA anomalies (EA 1989a). A discrete sample from each boring was submitted for analysis of VOC based on headspace readings with a photo-ionization detector. A composite sample was also submitted from each boring for TPH and TOC analysis.

Most of the site is underlain by 10-15 ft of sandy silt or silty sand overlying red sandstone and siltstone. The upgradient well at the north-east corner of the site is an exception. Sandy silt overburden of only 1 ft overlying tan sandstone was encountered during drilling at this well site.

Depth to water ranges from 12 to 15 ft below grade. Water level measurements suggest that ground-water flow is to the southwest.

3.4.2.1 Ground Water

Volatile Organic Compounds

Benzene, trichloroethene (TCE), tetrachloroethene (PCE), 1,1,1-trichloroethene (TCA), and related compounds were detected in FTAW-1 samples at levels above MCLs during all rounds of sampling. Traces of TCA and/or PCE or TCE were detected in the FTAW-2 and FTAW-3 samples. During the second round of sampling, PCE exceeded the MCL in the FTAW-2 sample. Well FTAW-4 samples contained only TCA at levels below the MCL in all rounds of sampling.

Total Petroleum Hydrocarbons

TPH concentrations were below detection limits for all ground-water samples analyzed.

3.4.2.2 Soil

Volatile Organic Compounds

Soil from FTAB-1 contained toluene, xylenes, TCE, PCE, and related volatile compounds in concentrations ranging from 36 to 5700 mg/kg. Trace levels of TCE and various benzene derivatives were found in FTAW-2.

Total Petroleum Hydrocarbons

The TPH concentration in FTAB-1 (830 mg/kg) was well above the NAS background sample. All other samples had concentrations ranging from 22 to 24 mg/kg.

3.4.2.3 Discussion

Ground-water analytical results agree well with test boring data in terms of compounds detected and the relative amounts in samples from wells FTAW-1 and FTAW-2. This indicates that the soil in the burn area is a source of ground-water contamination. Trace levels of VOC were detected upgradient of the burn area and in the vicinity of SVCA anomalies in the drum storage area.

3.4.2.4 SI Conclusions

Successive sampling events were consistent in showing the presence of several chlorinated and non-chlorinated hydrocarbons in samples of ground water from well FTAW-1. Trace levels of chlorinated hydrocarbons were detected in the other well samples.

Soil sample results agreed closely with ground-water data with the exception that no traces of TCE were found in the soil. From these data it can be concluded that significant residue from fire training activities exists in and around FTAW-1 and to a lesser extent FTAW-2.

The low levels of TCA found in the sample from wells FTAW-3 and FTAW-4 unassociated with detectable levels of other VOC suggest localized spillage of TCA in the drum storage area TCA levels in these wells are well below potential ARARs.

3.4.3 RI Field Sampling Plan

3.4.3.1 Rationale

The data appear to show two separate source areas. First is the area around FTAW-1 where soil samples and ground-water data indicate a source area is present and that the underlying ground water has been contaminated. Soil samples taken around FTAW-2 show much lower levels and signs of degradation indicating it may represent older exposure to the same soil contaminants. Further soil and ground-water sampling is necessary to assess the nature and extent of these contaminants in soil and ground water. Since TCE is a relatively dense contaminant which can migrate downward, deeper wells will be installed to assess the vertical extent of contamination.

The TCA detected in samples of ground water from FTAW-3 and FTAW-4 is upgradient of the old fire training area. It has only been detected at low levels in the ground-water samples; no TCA was detected in the associated soil samples. Previous SVCA sampling had indicated a possible source between wells FTAW-3 and FTAW-4 but the data were inconclusive. Considering the low levels of contamination detected, no further work in this area is planned pending the results of another round of ground-water sampling.

3.4.3.2 Sampling Plan

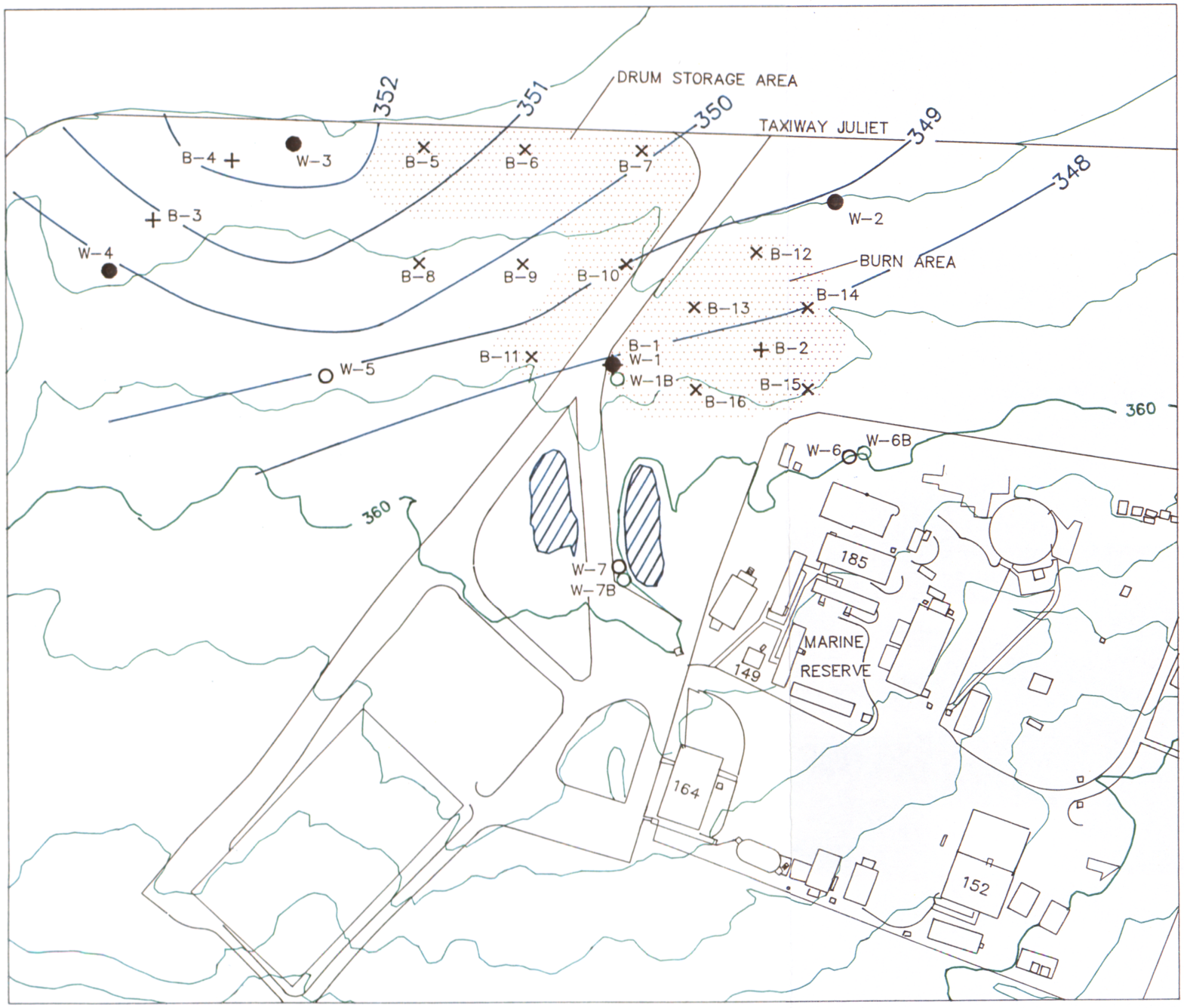
In order to characterize the nature and extent of soil contamination and assess the extent of ground-water contamination at the Fire Training Area the following tasks will be carried out.

- Twelve test borings will be sampled in the area around the old drum storage area and burn barrel to evaluate sources of VOC (Figure 3.4-1).

- Three intermediate wells (80-100 ft) and three shallow wells will be installed at the locations shown in Figure 3.4-1.

- All wells at the site will be sampled.

All soil and ground-water samples will be analyzed for the TCL VOC.



N

LEGEND

	PROPOSED	EXISTING
WELL		
SHALLOW	○	●
DEEP	○	●
INTERMEDIATE	○	●
BORING	×	+

—294— WATER TABLE CONTOUR (17 MAY 1989)

SUSPECTED WASTE AREA

NOTE:

ALL SAMPLE DESIGNATIONS PREFIXED BY FTA (FIRE TRAINING AREA) IN TEXT.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

NAS SITE 5
FIRE TRAINING AREA

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
BCL	PMS	8-19-91	10388.07	17NAS4
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	
GTC	CWH	1"=100'	FIGURE 3.4.1	

TABLE 3.4-1 WASTES DISPOSED AT THE FIRE TRAINING AREA, 1967-1969

Waste Type	Total Estimated Quantity
Paint wastes	64 gal
Paint stripper (methylene chloride)	1,300 gal
Xylene and toluene	1,000 gal
Petroleum, oils, and lubricants (POL)	4,000 gal

Source: Initial Assessment Study,
NAS Willow Grove, February 1986.

3.5 NAS SITE 7--ABANDONED RIFLE RANGE NO. 2 (ESI)

3.5.1 Significant Findings of the PA

Abandoned Rifle Range No. 2 is the more recent of two abandoned rifle ranges identified at NAS Willow Grove (Figure 3.5-1). It is located adjacent to land west of the north end of Runway 15/33. The area occupied by the earth rampart was approximately 1 acre in size. The range was constructed about 1965 and remained in use until about 1977, when the rifle range currently in use was constructed at the Army Reserve Compound, Building 176. Lead was not salvaged at this site. When the site was demolished, lead embedded in the earth rampart would have been distributed around the general area of the site.

Lead is removed from the existing rifle range by a contractor at the rate of 15 lb/year. Assuming a constant rate of lead accumulation, approximately 180 lb of lead may lie buried at the second abandoned rifle range site.

The site formerly occupied by the rifle range was subsequently occupied by a landfill used for disposal of inert construction and demolition materials. Clean earth, broken concrete, asphalt, and cinder blocks are the primary materials discarded in this area since the second rifle range was demolished in 1977. In addition, dry wastewater treatment sludge (19 tons) and emulsified oil and grease from the various oil separators (10,000 gal) have been disposed at the site since 1977. Also in 1977, 10 gal of oil and dirt that had been removed from the oil-water separator near Building 78 were buried at this site. The landfill has supposedly never received general refuse or hazardous materials. Although some incidences of disposal of household rubbish at the landfill by reservists have occurred, these were not considered to be of importance.

A very shallow depth to the seasonal high water table (less than 1 ft) was indicated for this area. Consequently, parts of the old rampart may be intermittently saturated at this site. These water table conditions

could promote the slow leaching of aqueous lead complexes from buried lead projectiles. Leaching is inhibited by alkaline water conditions which cause the precipitation of lead as stable lead carbonate species. Alkaline conditions typify ground water of the Stockton Formation. Due to this factor and natural attenuation from adsorption onto mineral grains, it was considered unlikely that lead would be released to the environment at this site.

Based on local topography, it was concluded that water in the water-table aquifer flows in a westerly direction toward a tributary of Park Creek. The discharge zone is located within 1,500 ft of the disposal site. Consequently, it was considered possible that contaminants derived from the disposal area might be released into the stream by baseflow discharge of ground water.

It was also considered that contaminants initially leached into the water table could enter the artesian aquifer with recharge and migrate toward pumping centers. Migration directions within the artesian aquifer could not be ascertained from existing information.

This site was not recommended for a Site Inspection study in the PA.

3.5.2 SI Investigation

A review of the PA findings indicated the presence of 10,000 gal of emulsified oil and grease, as well as 19 tons of wastewater treatment sludge. Additionally, during the EA site reconnaissance, a few 55-gal drums and several half-full 5-gal cans of industrial solvents were exposed at the surface. These containers were sealed and no organic vapors were detected (PID) in the atmosphere. In light of the information obtained from the PA and site reconnaissance, as well as the close proximity of the water table to the surface, Abandoned Rifle Range No. 2 was included in the Site Inspection.

An SVCA was conducted at Abandoned Rifle Range No. 2. The results are described in detail in the interim report (EA 1989a). Methane was detected in most of the samples obtained within the fill area. Methylene chloride was detected (0.5-3.3 ppm) at isolated locations in the southern portion of the site. No non-chlorinated hydrocarbons were detected.

Four 4-in. monitoring wells were installed at Abandoned Rifle Range No. 2 (Figure 3.5-1). The upgradient well, RR2W-2, differs from the other wells at the site in that it is an open rock well. Ground-water samples were collected from each well in June, September, and December 1989. Samples were analyzed for VOC, SVOC, pesticides/PCB, total and dissolved metals, TPH, TOC, and total cyanide.

The site is underlain by 4-10 ft of silty clay grading into silty sand with depth. Contact with the bedrock averages between 12 and 15 ft below grade. The bedrock is tan sandstone in the northern half of the site and interbedded tan and red sandstone in the southern half of the site.

Depth to ground water averages 15 to 20 ft below grade except in the northwest corner of the site (RR2W-4) where the water level was at 8 ft below grade. Water level data suggest that ground-water flow is towards the northwest.

3.5.2.1 Ground Water

Volatile Organic Compounds

No VOC were reported in round 1 ground-water samples from this site. Methylene chloride was detected (9-14 µg/L) in upgradient and down-gradient samples during rounds 2 and 3.

Semivolatile Organic Compounds

N-butylbenzenesulfonamide was detected in samples from RR2W-2 and 4 during the first round of sampling. No TCL SVOC (except a common laboratory contaminant) were detected during the second or third round of sampling.

Pesticides/Polychlorinated Biphenyls

None of these compounds were detected in ground-water samples from this site.

Metals

No dissolved metal concentrations exceeding MCLs were detected. For the total metal aliquots, one sample (93.8 µg/L) exceeded the current MCL (50 µg/L) for chromium but was less than the proposed MCL (100 µg/L). One sample (11.4 µg/L) exceeded the current MCL (10 µg/L) for cadmium and one sample (9.8 µg/L) exceeded the proposed MCL (5 µg/L). Total lead levels exceeded the proposed lead MCL, but were below the current MCL in samples from all wells during one or more of the sampling events. Lead concentrations declined from summer to winter.

Total Cyanide

No cyanide was detected in ground-water samples from this site.

Total Petroleum Hydrocarbons

The sample from well RR2W-1 had TPH values of 61 and 3.6 mg/L during the first and second rounds of sampling, respectively. All other samples had TPH concentrations below detection limits.

3.5.2.2 Discussion

Methylene chloride was detected in the second and third round samples of ground water at levels which can normally be attributed to laboratory contamination. However, methylene chloride was detected during the SVCA at this site. Based on the consecutive occurrence of methylene chloride in rounds 2 and 3, the possibility of low levels of this compound being present at this site becomes more likely.

The source for the anomalous, relatively high TPH concentration in the first round sample from RR2W-1 is unknown. This may have been a temporary phenomena in that the TPH concentration dropped significantly during the second sampling event. No TCL organic compounds of concern were identified.

While two total cadmium levels exceeded the proposed MCL, cadmium was not detected in the dissolved phase. One total chromium value exceeded the current, but not the proposed, MCL. Chromium was not detected in the dissolved phase in that sample. Total lead values which exceed the proposed MCL are within the range of regionally reported values (Section 2.3.7). All dissolved lead values are below the proposed MCL. These low values are present even through ground-water quality data indicate that pH levels are mildly acidic (6-6.8) and that lead carbonate inhibition of lead migration may not be substantive. This suggests that the landfill is not a major source of lead.

3.5.2.3 SI Conclusion

With the possible exception of methylene chloride, the SI study did not confirm the presence of contamination at Abandoned Rifle Range No. 2.

3.5.3 ESI Field Sampling Plan

3.5.3.1 Rationale

There is one contaminant of concern at this site, methylene chloride. It was present in samples of ground water at low but apparently consistent (2 out of 3 samples) levels. Continued monitoring is warranted to assess the problem. Soil sampling will be performed to confirm whether the site is the source. The SI ground-water data suggest a possible upgradient source. Water-level data from the center of the site are needed to further define ground-water contours and assess the potential presence of a ground-water mound which could explain the chemical data if the landfill is confirmed as a source.

3.5.3.2 Sampling Plan

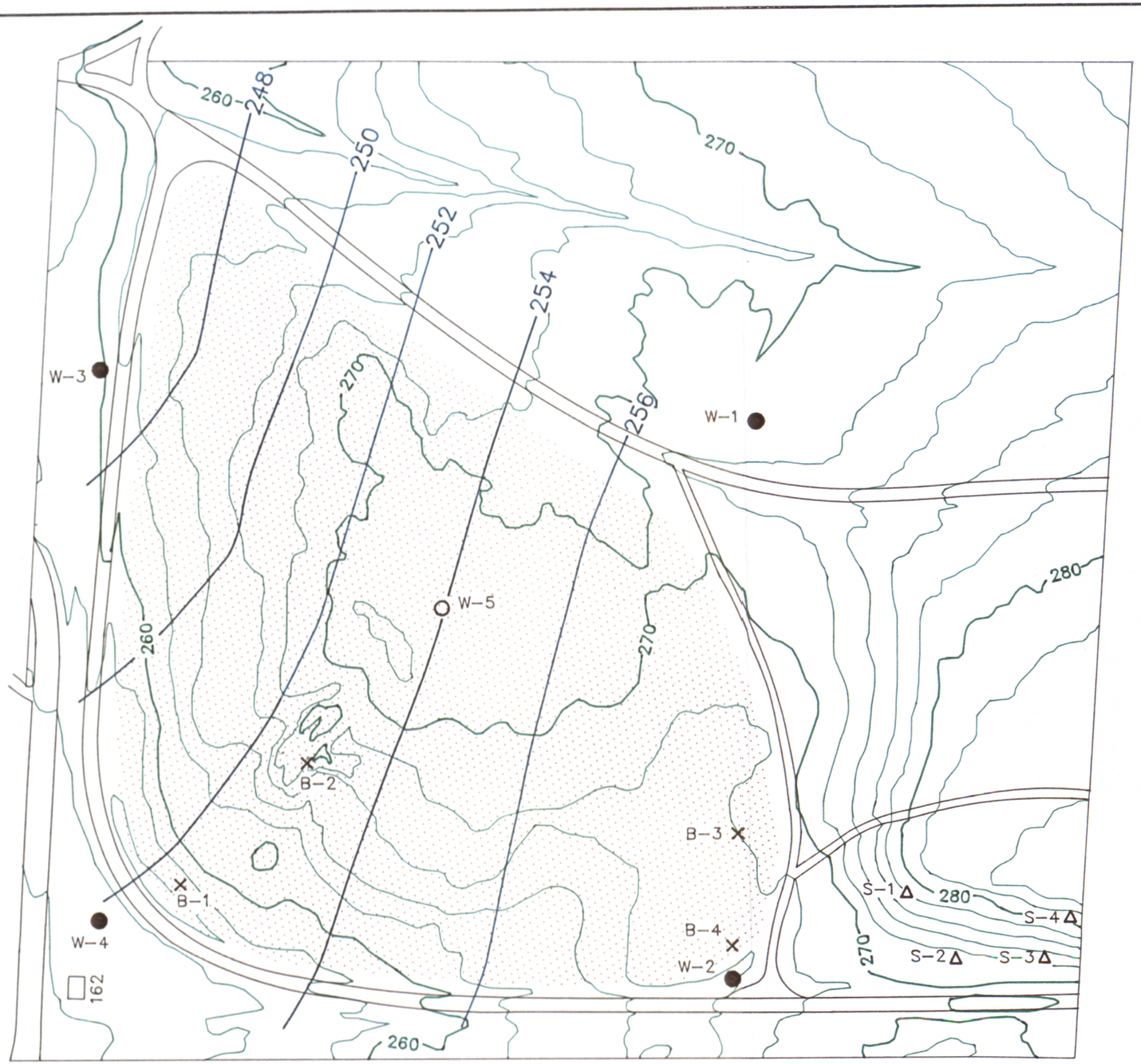
To evaluate the abandoned rifle range as a possible source of methylene chloride and refine the ground-water contour data at the site, the following tasks will be performed.

- Four test borings will be sampled, construction debris permitting, at the locations of SVCA methylene chloride detections (Figure 3.5-1). Samples will be analyzed for TAL metals and TCL VOCs.

- A shallow monitoring well will be installed at the center of the site to be used to gauge water levels.

- Visual reconnaissance will be made in the woods upgradient of the site to assess the potential for upgradient source areas. Up to four surficial soil samples may be collected. Samples will be analyzed as above.

- All Site 7 wells will be sampled and analyzed for TAL metals (total and dissolved) and TCL VOCs.



N

LEGEND

	PROPOSED	EXISTING
WELL		
SHALLOW	○	●
DEEP	○	●
INTERMEDIATE	○	●
BORING	×	+
SURFACE WATER/ SEDIMENT	□	■
SURFICIAL SOIL	△	

—294— WATER TABLE CONTOUR (17 MAY 1989)

SUSPECTED WASTE AREA

NOTE:

1. ALL SAMPLE DESIGNATIONS PREFIXED BY RR2 (RIFLE RANGE NO. 2) IN TEXT.
2. SURFICIAL SOIL SAMPLES S-1/S-4 LOCATIONS APPROXIMATE.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

NAS SITE 7
ABANDONED RIFLE RANGE NO. 2

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
BCL	PMS	8-19-91	10388.07	17NAS5
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	
GTC	CWH	1"=100'	FIGURE 3.5.1	

3.6 ARF SITE 4--WASHRACK AREA (ESI)

3.6.1 Significant Findings of the PA

The Washrack Area includes the washrack (located southeast of Hangar 201), and associated structures including an oil/water separator and filter bed, two paint storage buildings (Buildings No. 215 and No. 223), the grassy area (approximately 50 x 50 ft) contained between these structures, and a ditch to the east (Figure 3.6-1).

The washrack is used primarily for washing aircraft from both ARF and Pennsylvania Air National Guard (PaANG) facilities. Personnel from the paint shop in Hangar 201 are responsible for supervising aircraft washing for the 913th Tactical Air Group (TAG). Since 1979, aircraft washing has been done by a private contractor. Currently, approximately 20 aircraft per year are washed on the washrack. In the past, as many as 160 aircraft per year have been washed there. Since 1979, approximately 10 gal per aircraft of Super II Detergent (Mil. Spec. No. C-25769) have been used, as well as 2 gal per aircraft of "soil barrier," an anticorrosion agent painted behind the engines after washing. In the past, a cleanser/solvent (Mil. Spec. No. C-43616B) was used in combination with the detergent for aircraft cleaning. A small amount of the solvent PD-680 is still sprayed on parts of the aircraft to loosen dirt just before washing.

A secondary use for the washrack has been paint stripping. Parts too large to fit in a dip tank have been stripped directly on the washrack, then hosed down. Other small parts have been hosed off on the washrack after stripping in a tank. Solvents used in stripping include lacquer and enamel strippers, epoxy stripper, astrocoat stripper, and methyl ethyl ketone (MEK). Approximately 5 gal/month of strippers are used in the paint shop. It can be assumed that approximately 20 percent of these are not recovered, but are instead flushed into the washrack effluent treatment system, amounting to 12 gal/year.

Aqueous effluent from the oil/water separator was passed through a filter bed which is in direct connection with the subsurface, probably at or very close to the water table. The estimated depth to bedrock at this site is 6 ft, and the stone filter bed appears to have been excavated to that depth based on design drawings provided by ARF Civil Engineering. Assuming that an average of 30 aircraft per year were washed on the washrack over a 26-year period, and that 12 gal/year of paint strippers were discharged in the effluent, it was estimated that 7,800 gal of detergent (including some solvent) and 300 gal of paint strippers have been discharged to the disposal system in the operating life of the ARF. Of this, it was assumed that approximately 10 percent was lost to the ground. Thus, 780 gal of detergent/solvent and 30 gal of paint strippers were estimated to potentially have reached the ground-water system. In addition, it was felt that a small portion of the oils and fuel combustion by-products washed from the aircraft may have also reached the aquifer.

Immediately adjacent to the Washrack Area are two storage buildings (Buildings No. 215 and No. 223), historically used for storage of partially used containers of paint, paint thinners, paint strippers, solvents, and detergents. Since 1983, Building No. 215 has been used to house a cold dip tank containing the stripper B&B 121. Touch-up stripping using solvents such as MEK is also performed in the shed by the 913th TAG, and outdoors in back of the shed by the 111th PaANG. Evidence of vegetation stress around this building indicated that improper handling of these materials may have resulted in some spillage to the ground. It was not possible, however, to quantify those potential losses.

The PA concluded there is a potential that direct discharge to the subsurface occurs via the stone filter bed. This site was recommended for further investigation.

3.6.2 SI Investigation

An SVCA was conducted at the Washrack Area. The results are described in detail in the interim report (EA 1989a). Methylene chloride was detected (0.5-5 ppm) in three samples on the eastern side of the site and a trace level of PCE was detected in one sample on the south side. No non-chlorinated hydrocarbons were detected. The SVCA data provided no pattern which could be used to locate monitoring wells. The wells were therefore placed as per the original POA in anticipation of a ground-water flow direction to the north or northeast.

Three 4-in. monitoring wells were installed at the Washrack Area (Figure 3.1-1) to depths ranging from 20-29 ft. Each well was sampled in June, September, and December of 1989. Samples were analyzed for VOC, TPH, and TOC.

Overburden at the site is 3-6 ft thick and consists of sandy clay which pinches out westward and grades into silty sand. The underlying bedrock is red sandstone and siltstone. Depth to bedrock increases eastward.

Depth to water is quite shallow at the eastern edge of the site; WRW-1 has had water within 1-1/2 ft of the surface. The remaining two wells have had water levels averaging between 6 and 8 ft below grade. Water level data obtained during spring 1989 suggested that ground-water flow is towards the west-northwest. Wells WRW-1 and WRW-3 would, therefore, be considered upgradient wells (Figure 3.1-1). Water level data collected during the round three sampling event (December 1989) indicated ground-water flow toward the north (Figure 3.6-2). Whether this variation is seasonal and/or related to pumping cycles in the nearby ARF supply well is uncertain. However, it appears that well WRW-1 is effectively downgradient at least part of the time.

3.6.2.1 Ground Water

Volatile Organic Compounds

Trichloroethene (TCE) was detected in samples from all three wells during the first and third rounds of sampling and from wells WRW-1 and WRW-3 during the second round of sampling. The WRW-1 and WRW-2 samples contained concentrations of TCE above the MCL. During the first round of sampling, trace levels of tetrachloroethene (PCE) were detected in the WRW-2 sample and 1,1,1-trichloroethane (TCA) was detected in the WRW-3 sample. These compounds were not detected during the second round of sampling. TCA was detected in the WRW-1 sample during the third round of sampling. 1,1,Dichloroethene was detected in the WRW-2 sample during the third round of sampling.

Total Petroleum Hydrocarbons

TPH was detected only in the samples from wells WRW-2 and WRW-3 during all rounds of sampling at levels ranging from 1.1 to 7 mg/L. TPH levels were consistently lower during the second round of sampling.

3.6.2.2 Discussion

The VOC results for samples of ground water suggest that a source for these compounds exists upgradient. TCE concentrations in the downgradient wells are 2-3 times higher than those in the upgradient well, suggesting the site is a source of TCE.

3.6.2.3 SI Conclusions

TCE has been detected at levels above a potential ARAR (drinking water MCL) in downgradient wells WRW-1 and WRW-2. Traces of TCE and TCA have also been detected in the upgradient well WRW-3.

3.6.3 ESI Field Sampling Plan

3.6.3.1 Rationale

Low levels of TCE and PCE have been detected in the samples of ground water taken at this site. Several potential source areas exist including the filter bed of the oil/water separator facility, solvent and paint storage in Buildings 215 and 223, and runoff from the runway in the Washrack Area. Although all the wells at this site have shown contamination at different times, WRW-1 shows the most consistent pattern of detections. Under normal conditions this well is sidegradient to the site, but ground-water data demonstrate that WRW-1 may be downgradient periodically, possible due to pumping of Air Force Well No. 1. During non-active periods for this production well, ground-water flow returns to a northwest direction making WRW-2 downgradient. The suspected source areas could, therefore, account for contamination in WRW-2 and WRW-3. The upgradient well WRW-3 has shown trace levels of TCE. This could either be related to a migrating plume from the Privet Road site or due to infiltration of contaminated surface water introduced via the drainage ditch adjacent to WRW-3.

Additionally, further evaluation of ground-water flow paths and contaminant migration patterns will be performed on the basis of the results of pump testing to be performed as part of the Privet Road Compound RI (Section 3.1.3).

3.6.3.2 ESI Field Sampling Plan

To confirm the source(s) of contamination potentially responsible for ground-water contamination at ARF Site 4 the following work will be performed. Refer to Figure 3.1-1 for all sampling locations.

- One deep well (75-100 ft) will be installed as shown in Figure 3.6.1. This well will assess plume migration vertically.

- Eight subsurface soil (~3 ft) samples will be collected adjacent to the runway and Buildings 215 and 223 to assess runoff and surface spillage of contaminants.

- Two surface water/sediment samples at locations shown in Figure 3.6.1, will be taken during a dry period and a rain event. In the ditch directly north of well WRW-3, one soil sample will be collected 2 ft below the sediment sample from each sample location to assess the potential of contaminant infiltration from the ditch.

- All wells will be sampled as below.

A pump test will be conducted using AFW-1 to assess the effect this production well may have had on ground-water gradients at the Wash Rack. Details of this task are discussed in Section 3.1.3.2.

All samples will be analyzed for the TCL VOCs.

3.7 INSTALLATION-WIDE TASKS

In addition to the site specific tasks described above, several installation wide tasks will be undertaken during Phase 1 of the RI. investigation.

3.7.1 Background Soil Samples

Ten background surficial soil samples will be collected at undisturbed areas on the installation and land immediately adjacent to it. These samples will be analyzed for TAL metals and pesticides. Results will be used as background values to compare with site specific soil and sediment samples.

3.7.2 Upgradient Background Surface Water Sample

An additional upgradient surface water sample will be collected from Park Creek northwest of the installation at the Davis Road Bridge. This sample location is upgradient of an unnamed creek which may carry runoff from the 9th street landfill and abandoned rifle range #2. Previous sampling attempts to collect a background sample were constrained to points below this juncture due to high water conditions at the time of sampling. The sample will be analyzed for TCL VOAs, semivolatiles, pesticides, PCB, TAL metals (total only), and cyanide.

4. MONITORING PARAMETERS AND FREQUENCY OF COLLECTION

4.1 ANALYTICAL PARAMETERS

Table 4-1 summarizes the field sampling plan described in Section 3. Sampling methods are discussed in Section 5. All sampling and analysis will be performed in accordance with the Quality Assurance/Quality control Project Plan for Installation Restoration Program Studies at NAS Willow Grove. Samples obtained at these sites will be analyzed for the targeted compounds (Target Compound List--TCL) and analytes (Target Analyte List--TAL) of EPA's Hazardous Substance List (HSL). This parameter list is provided in Table 4-2. Quality assurance criteria are summarized in Table 4-3. Sample parameters are listed by site and matrix in Table 4-4.

4.2 FREQUENCY OF COLLECTION

One sample of the NAS Willow Grove potable water supply, planned for use in field cleaning sampling equipment, will be obtained for laboratory analysis.

Soil samples from test borings, surficial soil samples, and sediment samples at all sites will be obtained and analyzed once. Water samples from wells of surface water stations will also be analyzed once.

Further sampling may be required during future phases of the RI to assess temporal variation at various sites or provide additional information required to fill data gaps identified in Phase 1.

Table 4-4 summarizes the analytical program by site, sample matrix, parameter list, and QA/QC sample requirements.

4.3 CONTROL LIMITS

4.3.1 Analytical Laboratory

Analytical control limits are listed in Table 4-5. If any of the holding time elements listed in Table 4-5 are not met, that fraction of sample for which the holding time was missed will be re-sampled and analyzed.

If laboratory blanks show any components at levels greater than allowed as a control limit (Table 4-5) while the samples show that component within the control limits then re-sampling and analysis will not be performed, but a new blank will be analyzed to demonstrate that the initial difficulty is not a continuing problem. If the component identified in the blank is identified in the sample in excess of control limits, the effected samples will be re-sampled and analyzed for the out of control fraction.

If a surrogate recovery listed in Table 4-5 is outside of control limits in the laboratory blank, then the blank and associated samples will be re-extracted and analyzed. If there is not enough sample to re-extract and the surrogates are within limits in the samples, then no re-extract or analysis will take place. Re-extraction does not fall within holding-time restrictions. If surrogates in both sample and blank are outside control limits and there is insufficient sample to re-extract, the affected samples will be re-sampled and analyzed for the out of control fraction.

4.3.2 Topographic Survey

Survey field data (as corrected), to include loop closure for survey accuracy, will be included with the final report. Closure shall be within ± 1 m horizontal and ± 1.5 cm vertical limits as described in Section 5.

4.4 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are requirements needed to support decisions relative to the various stages of remedial actions. Throughout the project planning process, DQOs are supplied through qualitative and quantitative statements. They are specified in such documents as sampling plans, work plans, and QA plans. Five general levels of analytical options to support data collected are identified by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Navy has adopted five analytical levels as QC requirements. They are A, B, C, D, and E, which correlate with Levels 1, 2, 3, 4, and 5 described in Data Quality Objectives for Remedial Response Activities Development Process by the EPA. These levels are based on the type of site to be investigated, the level of accuracy and precision required, and the intended used of the data. The level of QC required at the site is decided by the Navy EIC. Table 4-6 outlines the Level C QC requirements for these studies.

TABLE 4-1 FIELD SAMPLING PLAN: REMEDIAL INVESTIGATION

		No. of Monitoring Wells	No. of Test Boring Samples	No. of Ground-water Samples	No. of Soil Samples	No. of Surface Water Samples	No. of Sediment Samples
NAS 1	Privet Road Landfill	8	80	12	--	5	5
NAS 2	Antenna Field Landfill	--	--	3	--	13	11
NAS 3	9th Street Landfill	4	16 (Test Pit)	11	32	4	6
NAS 5	Fire Training Area	6	60	10	--	--	--
NA 7	Abondoned Rifle Range #2	1	20	5	4	--	--
ARF 4	Washrack Area	1	2	4	8	2	2
Background		--	--	--	10	--	--
Upgradient		--	--	--	--	1	1
Drilling Water Supply		--	--	1	--	--	--
Total	(Exclusive of QA/QC blanks or duplicates)	20	178	45	54	21	23

TABLE 4-2 PARAMETER LIST

Field Determinations (aqueous samples only)

pH
Temperature
Specific conductance
Dissolved oxygen

Laboratory Determinations (all matrices)

Target Analyte List

Non-metals

Cyanide

Metals

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium (total)
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

Total (unfiltered) and dissolved (filtered) concentrations of metals in samples of ground water were determined. Total concentrations of metals in samples of surface water were determined.

TABLE 4-2 (Cont.)

VOLATILE ORGANIC COMPOUNDS

Parameter	CAS Number
Chloromethane	74-87-3
Bromomethane	74-83-9
Vinyl chloride	75-01-4
Chloroethane	75-00-3
Methylene chloride	75-09-2
Acetone	67-64-1
Carbon disulfide	75-15-0
1,1-Dichloroethane	75-35-4
1,1-Dichloroethane	75-35-3
trans-1,2-Dichloroethene	156-60-5
Chloroform	67-66-3
1,2-Dichloroethane	107-06-2
2-Butanone	78-93-3
1,1,1-Trichloroethane	71-55-6
Carbon Tetrachloride	56-23-5
Vinyl acetate	108-05-4
Bromodichloromethane	75-27-4
1,1,2,2-Tetrachloroethane	79-34-5
1,2-Dichloropropane	78-87-5
trans-1,3-Dichloropropene	10061-02-6
Trichloroethene	79-01-6
Dibromochloromethane	124-48-1
1,1,2-Trichloroethane	79-00-5
Benzene	71-43-2
cis-1,3-Dichloropropene	10061-01-5
2-Chloroethyl vinyl ether	110-75-8
Bromoform	75-25-2
2-Hexanone	591-78-6
4-Methyl-2-pentanone	108-10-1
Tetrachloroethene	127-18-4
Toluene	108-88-3
Chlorobenzene	108-90-7
Ethyl benzene	100-41-4
Styrene	100-42-5
Total Xylenes	

Unknown compounds--up to 15 peaks which exceeded 10 percent of the internal standard underwent computerized mass spectral library search for tentative identification.

TABLE 4-2 (Cont.)

SEMIVOLATILE ORGANIC COMPOUNDS

Parameter	CAS Number
N-Nitrosodimethylamine	62-75-9
Phenol	108-95-2
Aniline	62-53-3
Bis(2-chloroethyl)ether	111-44-4
2-chlorophenol	95-57-8
1,3-dichlorobenzene	541-73-1
1,4-dichlorobenzene	106-46-7
Benzyl alcohol	100-51-6
1,2-Dichlorobenzene	95-50-1
2-Methylphenol	95-48-7
Bis(2-chloroisopropyl)ether	39638-32-9
4-Methylphenol	106-44-5
N-Nitroso-dipropylamine	621-64-7
Hexachloroethane	67-72-1
Nitrobenzene	98-95-3
Isophorone	78-59-1
2-Nitropheonl	88-75-5
2,4-Dimethylphenol	105-67-9
Benzoic Acid	65-85-0
Bis(2-chloroethoxy)methane	111-91-1
2,4-Dichlorophenol	120-83-2
1,2,4-Trichlorobenzene	120-82-1
Naphthalene	91-20-3
4-Chloroaniline	106-47-8
Hexachlorobutadiene	87-68-3
4-Chloro-e-methylphenol (chloro-cresol)	59-50-7
2-Methylnaphthalene	91-57-6
Hexachlorocyclopentadiene	77-47-4
2,4,6-Trichlorophenol	88-06-2
2,4,5-Trichlorophenol	95-95-4
2-Chloronaphthalene	91-58-7
2-Nitroaniline	88-74-4
Dimethyl phthalate	131-11-3
Acenaphthylene	208-96-8
3-Nitroaniline	99-09-2
Acenaphthene	83-32-9
2,4-Dinitrophenol	51-28-5
4-Nitrophenol	100-02-7
Dibenzofuran	132-64-9
2,4-Dinitrotoluene	121-14-2

TABLE 4-2 (Cont.)

Parameter	CAS Number
2,6-Dinitrotoluene	606-20-2
Diethylphthalate	84-66-2
4-Chlorophenyl phenyl ether	7005-72-3
Fluorene	86-73-7
4-Nitroaniline	100-01-6
4,6-Dinitro-2-methylphenol	534-52-1
N-Nitrosodiphenylamine	86-30-6
4-Bromophenyl phenyl ether	101-55-3
Hexachlorobenzene	118-74-1
Pentachlorophenol	87-86-5
Phenanthrene	85-01-8
Anthracene	120-12-7
Di-n-butylphthalate	84-74-2
Fluoranthene	206-44-0
Benzidine	92-87-5
Pyrene	129-00-0
Butyl benzyl phthalate	85-68-7
3,3'-Dichlorobenzidine	91-94-1
Benzo(a)anthracene	56-55-3
Bis(2-ethylhexyl)phthalate	117-81-7
Chrysene	218-01-9
Di-n-octyl phthalate	117-84-0
Benzo(b)fluoranthene	205-99-2
Benzo(k)fluoranthene	207-08-9
Benzo(a)pyrene	50-32-8
Indeno(1,2,3-cd)pyrene	193-39-5
Dibenz(a,h)anthracene	53-70-3
Benzo(g,h,i)perylene	191-24-2

Unknown compounds--up to 25 peaks which exceeded 10 percent of the internal standard underwent computerized mass spectral library search for tentative identification.

TABLE 4-2 (Cont.)

PESTICIDES AND PCB

Parameter	CAS Number
alpha-BHC	319-84-6
beta-BHC	391-85-7
delta-BHC	319-86-8
gamma-BHC (Lindane)	58-89-9
Heptachlor	76-44-8
Aldrin	309-00-2
Heptachlor epoxide	1024-57-3
Endosulfan I	959-98-8
Dieldrin	60-57-3
4,4'-DDE	72-55-9
Endrin	72-20-8
Endosulfan II	33213-65-9
4,4'-DDD	72-54-8
Endrin aldehyde	7421-93-4
Endosulfan sulfate	1031-07-8
4,4'-DDT	50-29-3
Endrin ketone	53494-70-5
Methoxychlor	72-43-5
Chlordane	57-74-9
Toxaphene	8001-35-2
Aroclor-1016	12674-11-2
Aroclor-1221	11104-28-2
Aroclor-1232	11141-16-5
Aroclor-1242	53469-21-9
Aroclor-1248	12672-29-6
Aroclor-1254	11097-69-1
Aroclor-1260	11096-82-5

TABLE 4-3 QUALITY ASSURANCE CRITERIA

Volatile Organic Compounds

1. Holding Time
   Extract and anlyze within 10 days of receipt at laboratory.

2. Laboratory Blanks
   Methane chloride, acetone, or toluene < 5 x CRQL
   All other compounds ≤ CRQL

3. Surrogates

	Percent Recovery	
	H_2O	Soil
Toluene d8	88-110	81-117
4 Bromofluorobenzene	86-115	74-121
1,2 Dichloroethane-d4	76-114	70-121

4. Matrix Spikes and Matrix Spike Duplicates

	Percent Recovery	
	H_2O	Soil
1,1 Dichloroethene	60-145	60-172
Trichloroethene	71-120	62-137
Chlorobenzene	75-130	60-133
Toluene	76-125	59-139
Benzene	76-127	66-142

TABLE 4-3 (Continued)

Semivolatile Organic Compounds

1. Holding Times

   A. Extract water within 5 days and soil within 10 days of receipt at laboratory.

   B. Analyze extracts within 40 days.

2. Laboratory Blanks

   A. Phthalate esters < 5 X CRQL

   B. All other compounds $\leq$ CRQL

3. Surrogates

	Percent Recovery	
	H_2O	Soil
2-Fluorophenol	21-100	25-121
Phenol-d_5	10-94	24-113
2,4,6-Tribromophenol	10-123	19-122
2-Fluorobiphenyl	43-116	30-115
P-Terphenyl-d_{14}	33-141	18-137

TABLE 4-3 (Continued)

4. Matrix Spikes and Matrix Spike Duplicates

	Percent Recovery	
	H_2O	Soil
1,2,4-Trichlorobenzene	39-98%	38-107%
Acenaphthylene	46-118%	31-137%
2,4-Dinitrotoluene	24-96%	28-89%
Pyrene	26-127%	35-142%
N-Nitrosso-Di-N-Propylamine	41-116%	41-126%
1,4-Dichlorobenzene	36-97%	28-104%
Pentachlorophenal	9-103%	17-109%
Phenol	12-89%	26-90%
2-Chlorophenol	27-123%	25-102%
4-Chloro-3-Methylphenol	23-97%	26-103%
4-Nitrolphenol	10-80%	11-114%

TABLE 4-3 (Continued)

Pesticides and PCB

1. Holding Times

   A. Extract water within 5 days and soil within 10 days of receipt at laboratory.

   B. Analyze extracts within 40 days.

2. Laboratory Blanks

   All components $\leq$ CRQL

3. Surrogates

	Percent Recovery	
	H_2O	Soil
Dibutylchlorendate	24-154	20-150

4. Matrix Spikes and Matrix Spike Duplicates

	Percent Recovery	
	H_2O	Soil
Lindane	56-123	46-127
Heptachlor	40-131	35-130
Aldrin	40-120	34-132
Dieldrin	52-126	31-134
Endrin	56-121	42-139
4/4'-DDT	38-127	23-134

TABLE 4-3 (Continued)

Inorganic Analytes

1. Holding Times

   A. Cyanide - 12 days
   B. Mercury - 26 days
   C. Metals - 6 months

2. Laboratory Blanks

   All analytes $\leq$ CRDL

TABLE 4-4 ANALYTICAL PROGRAM: REMEDIAL INVESTIGATION

		Matrix	No. of Samples	Parameter List*	No. of Duplicates	No. of Field Blanks	No. of Trip Blanks
NAS 1	Privet Road Landfill	Ground water	12	A,C,D,E	2	2	5
		Soil	80	A,C,D,E	8	2	5
		Sediment	5	A,C,D,E	1	2	5
		Surface Water	5	A,C,D,E	1	2	5
NAS 2	Antenna Field Landfill	Ground water	3	A,B,C,D	1	1	2
		Surface Water	13	A,B,C,D	2	1	2
		Sediment	11	A,B,C,D	2	1	2
NAS 3	9th Street Landfill	Ground water	11	A,B,C,D,E	2	2	4
		Surface Water	4	A,B,C,D,E	--	2	4
		Sediment	6	A,B,C,D,E	1	2	4
		Soil	48	A,B,C,D,E	5	2	4
NAS 5	Fire Training Area	Ground water	10	A	1	2	3
		Soil	60	A	6	2	3
NAS 7	Abandoned Rifle Range No. 2	Ground water	5	A,C	1	1	2
		Soil	24	A,C	3	1	2
ARF 4	Washrack Area	Ground water	4	A	1	1	2
		Soil	10	A	2	1	2
		Sediment	2	A	--	1	2
		Surface Water	2	A	--	1	2
Background		Soil	10	C,D	1	--	1

* Parameter List

A - TCL VOCs
B - TCL SVOCs
C - TAL Metals
D - Pesticides/PCB
E - Cyanide

TABLE 4-5 ANALYTICAL CONTROL LIMITS

Holding Times

Volatile Organic Compounds

Extract and analyze within 10 days of receipt at laboratory.

Semivolatile Organic Compounds, Pesticides, and PCB

Extract water within 5 days and soil within 10 days of receipt at laboratory.

Analyze extracts within 40 days of extraction.

Cyanide - 14 days

Mercury - 26 days

Metals - 6 months

Holding times may be exceeded by up to and including 50%. Data so generated will be flagged as estimated values. Samples held in excess of 50% beyond holding times are out of control limits.

Laboratory Blanks

Methylene chloride, acetone, toluene, or phtalate esters < 5 x CRQL

All other compounds $\leq$ CRQL

Surrogate Recovery in Laboratory Blanks:

	Percent Recovery	
Volatile organic compounds	H_2O	Soil
Toluene d8	88-110	81-117
4 Bromofluorobenzene	86-115	74-121
1,2 Dichloroethane-d4	76-114	70-121

TABLE 4-5 (Continued)

	Percent Recovery	
	H_2O	Soil
Surrogate Recovery in Laboratory Blanks:		
Semivolatile Organic Compounds		
2-Fluorophenol	21-110	25-121
Phenol-d5	10-110	24-113
2,4,6-Tribromophenol	10-123	19-122
2-Fluorobiphenyl	43-116	30-115
P-Terphenly-D14	33-141	18-137
Pesticide		
Diburylchlorendate	24-154	20-150

TABLE 4-6 DATA QUALITY OBJECTIVES

DQC Level	Type of Site	QC Requirements						
C	Non-NPL	PE sample	Laboratory audit	QA Plan review	Use CLP procedures	Monthly review	10% field duplicates	10% CLP validation and review of final data

CLP = Contract laboratory protocol
PE = Performance evaluation samples
DQO = Data quality objective

5. FIELD METHODS AND SAMPLING PROCEDURES

5.1 MONITORING WELL INSTALLATION AND DEVELOPMENT

Locations of monitoring wells to be installed during this phase of the RI investigation were determined from data generated during the SI investigation.

Monitoring wells will be installed to assess the ground-water quality of the upper portion of the water-table aquifer the deeper transitional zone and the upper portion of the underlying confined zone. Shallow wells will be installed so as to screen above the water table to intercept potential floating non-aqueous phase liquid (NAPL) and extend 10 to 15 ft into the water table to intercept dissolved constituents. A nominal 20-ft-length screen is planned to meet these objectives and allow for seasonal water level fluctuations. Deeper wells will be screened at the depths identified in Section 3.

In light of the historical well drilling data on the base, it is anticipated that shallow monitoring wells will be completed in weathered and/or competent bedrock. Based on historical water level data, and for the purposes of this POA, nominal well depths are anticipated to be 40 ft for shallow wells, 100 ft for intermediate, and 175 ft for deep wells. It is assumed that upon commencement of drilling activities, the facility supply well treatment system will be installed and fully operational, and that the chemical analysis of the water will prove the water suitable for drilling operations. However, trace levels of VOC were detected in some SI field blanks. This water will be used for steam cleaning and grouting operations. A field blank sample will be taken during drilling operations at each site (Section 4).

Typical monitoring well specifications are shown in Figure 5.3-1.

The monitoring well boring will initially be sampled continuously to the top of the weathered bedrock (estimated at 10-15 ft). Soil samples will be obtained by advancing a 5 ft continuous split-spoon sampler with an auger rig. Split-spoon samplers will be steam-cleaned prior to each sample taken. Samples will be placed in clean glass jars. Within 1-3 hours each sample will have its headspace screened with an FID or PID for organic vapors and the results noted in the boring log. Approximately 10 percent of the samples will be retained by EA for grain size analysis. Remaining samples will be provided to the activity point of contact for retention onsite. For the purposes of this POA analysis of the monitoring well soil boring samples for chemical constituents is not a goal.

Upon encountering the weathered bedrock and/or split spoon refusal, the boring will be advanced from the surface to completion depth by the air rotary/percussion method. The nominal borehole diameter of 8 in. will be maintained with a 7-7/8 in. roller bit. In the event that excessively hard rock is encountered, it will be necessary to drill a 4-in. borehole with a down-hole air hammer, followed by reaming of the borehole to 8 in. with a roller bit. Any hole instability of the weathered or overburden zones will be controlled by installing temporary steam-cleaned casing.

No rock coring will be conducted during construction of the monitoring well borings, as drilling fluid (water) would be introduced into the borehole. The addition of drilling fluids into the borehole would inhibit accurate detection of the water table, especially in a low yielding ground-water zone. It is imperative that the depth of the static water table be known prior to monitoring well installation, so as to effectively place the well screen partially above the saturated zone. The drill rig and all drilling tools will be steam-cleaned between each monitoring well installation.

The design specifications for monitoring wells are as follows:

1. All monitoring well casings and screens will be constructed of 4-in. inner-diameter Schedule 40 polyvinyl chloride (PVC) plastic pipe. Flush joint, threaded casing and screen will be used. No glue or solvents will be used.

2. The screened interval for monitoring wells will consist of 20 ft of factory-slotted (0.01-in.) well screen of the same material and diameter as the casing. The screened interval will be such that it is located partially above the water table. The bottom of the screen will be capped.

3. All wells shall be filter-packed using a No. 2 quartz sand from the base of the well to a minimum of 2 ft above the top of the screen. An impervious 2-ft seal of bentonite pellets will be installed on top of the gravel packing.

   In the event that very shallow water tables are encountered the filter pack may be reduced by 1 ft, but in no case will any well be screened shallower than 6 ft even if water tables are higher.

4. All wells will be continuously grouted via tremie pipe from the top of the impervious seal to the ground surface with a 20:1 cement-bentonite grout with a maximum 10 gal of approved water per 94-lb bag of cement.

5. The drilling subcontractor shall be responsible for clearing the boreholes and wells of any fluids or substances which interfere with the free flow of ground water through the well screen. The monitoring wells shall be developed by pumping with a downhole submersible pump or in the event of low yield wells by hand bailing. Wells will be swabbed prior to pumping to promote cleansing of fine materials

from the screen and filter pack. During development, pH and specific conductance will be measured initially and for each well volume (nominal) removed and recorded on a log. Development will continue until three consecutive pH and conductivity readings do not vary by more than 10 percent or for a maximum of 3 hours.

6. All wells will have an outer 6-in. diameter, pre-painted, protective steel casing stickup, properly tagged and flagged, or otherwise made visible so that they can be readily located in the field, and avoided by onsite equipment. If the well is installed in a paved area, it will be flush-mounted in a water tight enclosure.

7. All wells will be provided with lockable caps, and will be located by surveying both vertically and horizontally as described in Section 5.6.

8. The drilling subcontractor (registered in Pennsylvania) will be responsible for performing all drilling and well installation work. This includes the requirement of steam cleaning of all tools and well completion materials, other than filter sand and grouting materials, that enter boreholes during the course of work. In cases where water or drilling fluids are required and not accessible from treated base supply wells, the drilling subcontractor shall be responsible for identifying sources and supplying water to the jobsite. Any such water must be obtained from a potable water source approved by the EA supervising geologist and stored in clean containers. EA will assist the drilling subcontractor in identifying a suitable water source. The drilling subcontractor shall provide adequate water tank capacities to minimize time required for hauling water. All water tanks shall be cleaned and maintained in a clean condition.

9. Drill cuttings and water resulting from monitoring well installation and development will be monitored for contamination using a portable photoionization detection (PID) meter. Drill cuttings evidencing no contamination based on visual inspection and PID meter readings will be spread on the ground surface at the boring location or used as backfill in the completed borehole at the discretion of the field geologist. Cuttings or well development water that displays elevated PID meter readings will be placed in DOT-approved 55-gal steel drums. A log of the amount and source of material drummed will be maintained.

5.2 SAMPLING OF MONITOR WELLS

One round of ground-water samples for chemical analysis will be obtained during Phase I. Samples will be collected approximately 2 weeks after the new wells are developed (Section 6). Upon arrival at each monitoring well, the sampling agent will thoroughly inspect the well and the immediate area. Well site conditions and any unusual observations will be noted. Particular attention will be paid to evidence of tampering or damage. The agent will than unlock the well and determine the water and well depth using an electronic water level sounder. The water level elevation will be referenced to the surveyed marking on the top of casing. These data will be used to prepare water level contour maps and to calculate the static volume of water in the casing. Next, a clean stainless steel submersible pump will be installed in the well, and a volume of water equal to, at a minimum, five well volumes (casing volume plus saturated filter pack assuming 30 percent porosity) will be evacuated in preparation for sampling. In order to ensure exchange of the entire static water column, the pumping level will be varied throughout the pumping interval. As water is purged, its physical character (i.e., odor, turbidity, and color) will be observed and noted. Evacuated water

will be discharged from the well in a downgradient direction to minimize the potential for surface infiltration. Between wells, the pump and associated plumbing will be pressure jetted with clean elevated-temperature water. Then clean water will be pumped through the system to preclude the potential for cross contamination.

If the well goes dry during pumping or bailing, one is assured of removing all water which had prolonged contact with the well casing or air. If the recovery rate is rapid, allow the well to recover to its original level and evacuate a second time before sampling. Samples will be obtained for chemical analysis within 24 hours after pumping or bailing is complete. If recovery is very slow, samples may be obtained as soon as sufficient water is available.

After the wells have been purged and have recovered, samples will be collected using dedicated (i.e., a separate bailer for each well) bottom-filling Teflon bailers and new lines. Bailers will be rinsed three times before sampling begins. The first aliquot for sampling will be used to fill the VOC containers (40-ml glass). Subsequent aliquots will be used to fill containers of appropriate composition containing preservatives for the parameters of interest, if necessary (as specified in the QA/QC Plan). Special care will be taken in collecting these samples to ensure that volatile organic constituents are not lost through off-gasing and turbulence. One of the two aliquots for trace metal determinations will be vacuum filtered in the field using a 0.45-μ membrane filter prior to preservation. The last aliquot of water removed will be used to determine pH, temperature, specific conductance, and DO. These determinations will be made with calibrated and standardized instrumentation. After collection, all sample aliquots will be labeled, security sealed, and placed in secure shipping containers for transport to the laboratory. To ensure sample integrity, all groundwater sampling will be accomplished under the protocol for chain-of-custody and sample handling established in the QA/QC Plan.

5.3 SURFICIAL SOIL SAMPLING

Soil samples will be collected at selected sites (Section 3) for chemical analysis. Samples collected will be used to characterize contaminant levels at or near the surface at each location.

The sampling agent will collect a surficial sample (0-6 in. below surface) and a subsurface sample (2-3 ft below surface) at each sampling station. Initially, a surficial sample will be collected with a cleaned stainless steel trowel or sampling trier. After the surficial sample has been placed in the laboratory-cleaned container and appropriately labeled, a 4-in. diameter hand auger will be advanced to the top of the subsurface sample interval. The sample will then be collected with a 3-in. diameter stainless steel hand auger and placed in a laboratory-cleaned container. Between each sample taken, all sampling equipment will be steam cleaned.

5.4 SUBSURFACE SOIL SAMPLING

Subsurface soil samples will be collected for chemical analysis from test borings using a 5 ft continuous split spoon at selected sites. If poor recovery occurs consistently using this method, hammer driven telescoping split spoons will be used instead. Samples will be collected at 2.5 ft intervals and placed in laboratory cleaned jars. Borings will be advanced until one of the following conditions is met: (1) auger refusal, i.e., bedrock is encountered, or (2) the water table is penetrated and enough water enters the hole to adversely affect sampling. Nominal depth of borings is anticipated to be between 10-15 ft. Split spoons will be steam cleaned between samples.

5.5 TEST PITS

Test pits will be excavated with a backhoe to a depth no greater than 10 ft along a transect not to exceed 100 ft. Each bucketful of material removed will be screened with an HNU or OVA to detect VOC contamination.

Visible waste or soil staining will be identified. Samples will be collected from soil which exhibits any of the above characteristics. In the event that more samples are obtained than the sampling program can accommodate, the samples with the highest headspace readings or most prevalent visible waste will be submitted for analysis.

After the test pit is excavated it will be photographed and the exposed section described by the site geologist. If drums are encountered during trenching, they will be examined for markings and integrity and then left in place with a soil overpack. Each drum will be marked with a stake to facilitate future location and removal activities. At the conclusion of sampling and description, the test pit will be backfilled and the area returned to its original grade.

5.6 SURFACE WATER AND SEDIMENT SAMPLING

Grab-type surface water samples will be collected in laboratory-cleaned wide-mouth glass bottles or Teflon bailers and placed in appropriate containers for the parameters to be determined. Sampling equipment will be rinsed once prior to sample collection with water from the sample site.

Sediment samples will be obtained with a stainless steel trowel, sampling trier, or sampling corer. Sampling equipment will be steam cleaned between samples.

Prior to sampling sediment in a stream, the sampling device shall be rinsed with stream water at a point downstream from the sampling location to avoid disturbing the sediment at the sampling point. Also, sampling shall be accomplished upstream of any disturbances in the stream caused by the sampler or sampling team. Twigs, leaves, pebbles, and debris that are not integral components of the matrix of interest must be removed by the sampling team.

Prior to sampling sediment in a pond or lagoon, the sampling device shall be rinsed with water near the sampling point. However, caution must be exercised to avoid disturbing the sediment at the sampling point by the rinsing activities.

5.7 SITE SURVEY

5.7.1 Horizontal Control

Each soil boring and/or well installed under this contract will be topographically surveyed by a Pennsylvania Licensed Surveyor to determine its map coordinates using Pennsylvania State Plane Coordinates to within ±3 ft (±1 m).

5.7.2 Vertical Control

Elevations for the natural ground surface (not the top of the coarse gravel blanket) and the highest point on the rim of the uncapped well casing (not protective casing) for each bore/well site shall be surveyed by a Pennsylvania licensed surveyor to within ±0.05 ft (±1.5 cm) using the National Geodetic Vertical Datum of 1929.

5.7.3 Field Data

The topographic survey shall be completed as near to the time of last well completion as possible, but not longer than five weeks after well installation. Survey field data (as corrected), to include loop closure for survey accuracy, will be included with the final report. Closure shall be within the horizontal and vertical limits given above. These data shall clearly list the coordinates (and system) and elevation (ground surface, top of well, and protective casings) as appropriate, for all borings, wells, and reference marks. All permanent and semi-permanent reference marks used for horizontal and vertical control (bench marks, caps, plates, chiseled cuts, rail spikes, etc.) shall be described in terms of their name, character, and physical location.

5.8 AQUIFER TESTING

In order to assess aquifer characteristics such as hydraulic conductivity, transmissivity, hydraulic boundaries, and storativity, constant rate pump testing is normally carried out in a well screened in the aquifer of interest. During a constant rate pump test, a chosen well is pumped at the maximum rate at which it can be pumped without dewatering. The purpose is to stress the aquifer and measure the water level changes in surrounding wells in order to determine the relationship between drawdown, duration of pumping, and distance from the pumping well. For unconfined aquifers, 72 hours pumping is considered nominal for identification of any hydraulic boundaries present. Hydraulic boundaries may consist of either a water source or an impermeable geologic unit which may result in either an increase or decrease, respectively, in a well's long-term yield capabilities. Confined aquifers normally show stress more rapidly then unconfined aquifers and tests of 24 to 48 hours may be sufficient. After pumping has been discontinued, the wells are monitored for an additional 12-24 hours to record recovery rate and a return to static equilibrium conditions.

While pumping is ongoing, water levels in the pumping well are monitored to record changes in water level. The pumping well and those wells nearest to it are normally monitored with an electronic water level data recorder such as the in situ SE-1000B Environmental Data Logger. An electronic data logger is necessary to record the rapid water level changes which occur in the pumping well and those wells close by (i.e., within 150 ft). Wells more distant from the pumping well may be monitored by hand with an electronic water level indicator since their water levels change more slowly.

Water removed from the well during pumping is discharged downgradient from the site to preclude influencing the pump test by local recharge. In the case of production wells, discharge water is sent to whatever reservoir or treatment plants are present to process production water.

After conclusion of the pump test, drawdown and recovery values obtained during the constant rate test are plotted and analyzed using established hydrological analytical methods. Normally the Cooper and Jacob modification of the Theis nonequilibrium equation is used to estimate hydraulic conductivity and transmissivity from time-drawdown graphs. Time-distance drawdown projections may then be calculated and drawdown predictions for various pumping rates made.

In addition to the above data, ground-water contour maps showing gradients and direction of ground-water flow during various pumping scenarios may be prepared in order to demonstrate the effect of pumping on natural gradients within the radius of effect of the pumping well. This is useful to evaluate the effect pumping may have had in the disposition of contaminant plumes migrating through the radius of effect of the pumping well.

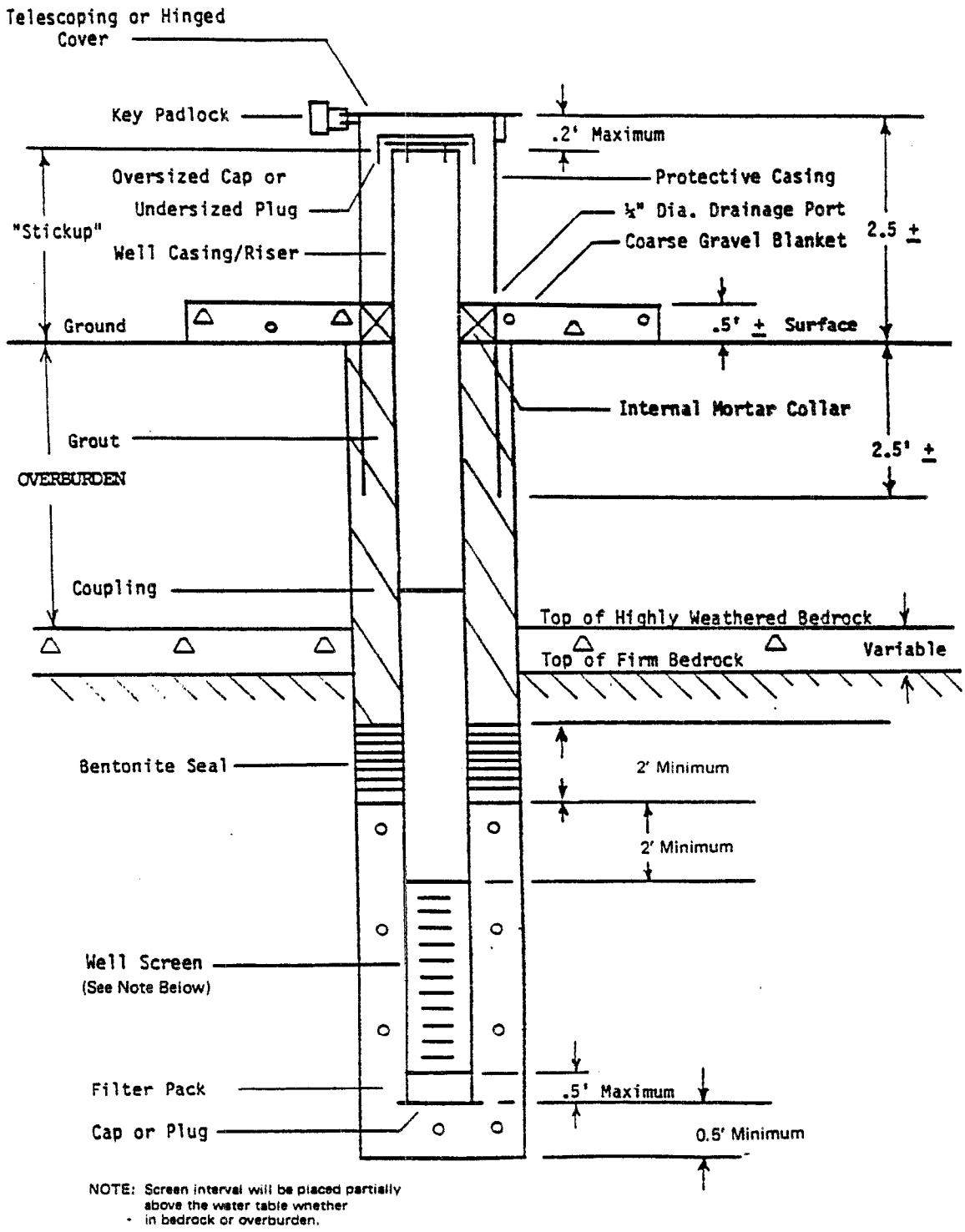


Figure 5.1-1. Schematic construction of monitoring well.

6. RI FIELD TASKS SCHEDULE

Figure 6-1 shows the schedule for completion of field work for the Phase 1 RI. The drilling schedule assumes two drilling rigs will be present onsite. Manpower requirements necessary to complete all RI field tasks as scheduled are approximately nine personnel. Sustained bad weather could delay activities and prolong field work beyond the scheduled completion times as shown on Figure 6-1.

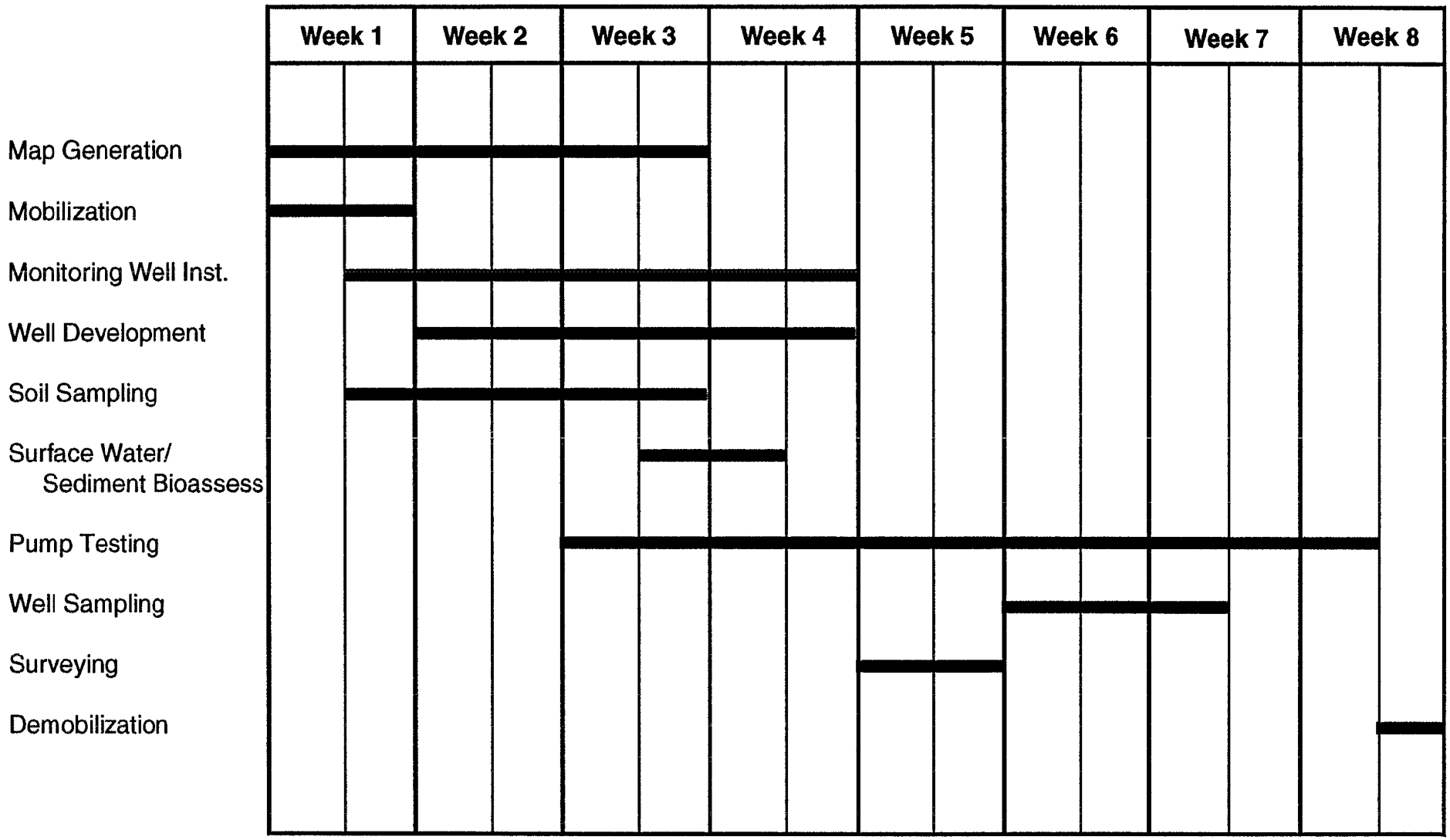


Figure 6-1. NAS - Willow Grove Schedule of Tasks - RI Field Work - Phase I

REFERENCES

Blumer, M. 1961. Benypyrenes in soil. Science 134(3477):474-475.

deChiaro, J., and L.E. Koppelman. 1984. Time-Saver Standards for Site Planning. McGraw-Hill Book Company, New York.

Dusen, H., 913th Tactical Airlift Group DEEV. November 21, 1989. Correspondence with J. Shafer concerning the Old Well House (Building #205).

EA Engineering, Science, and Technology, Inc. 1988a. Quality Assurance/ Quality Control Project Plan for Installation Restoration Program Studies, NAS Willow Grove, Pennsylvania. U.S. Navy, Naval Facilities Engineering Command, Philadelphia, Pa.

EA Engineering, Science, and Technology, Inc. 1988b. Plan of Action for Site Inspection NAS Willow Grove, Pennsylvania. U.S. Navy, Naval Facilities Engineering Command, Philadelphia, Pa.

EA Engineering, Science, and Technology, Inc. 1989a. Interim Report: Electromagnetic Survey, Soil Vapor Contaminant Assessment, and Revised Field Sampling Plan for Site Inspection Studies at NAS Willow Grove. U.S. Navy, Naval Facilities Engineering Command, Philadelphia, Pa.

EA Engineering, Science, and Technology, Inc. 1989b. Interim Report: Site Inspection Studies at the Navy Fuel Farm, NAS Willow Grove, Horsham Township, Pennsylvania. U.S. Navy, Naval Facilities Engineering Command, Philadelphia, Pa.

EA Engineering, Science, and Technology, Inc. 1989c. Final Report: Environmental Test Boring Investigation at the Air National Guard Facility, U.S. Naval Air Station Willow Grove, Horsham Township, Pennsylvania. U.S. Navy, Naval Facilities Engineering Command, Philadelphia, Pa.

EA Engineering, Science, and Technology, Inc. 1990. Final Report: Site Inspection Studies at NAS Willow Grove, Horsham Township, Pennsylvania. U.S. Navy, Naval Facilities Engineering Command, Philadelphia, Pa.

Earth Data, Inc. 1985. Hydrogeologist's Report, Potable Water Treatability Study, Willow Grove Naval Air Station. U.S. Navy, Naval Facilities Engineering Command, Philadelphia, Pa.

International Agency for Research on Cancer. 1973. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man: Certain Polycyclic Aromatic Hydrocarbons and Heterocyclic Compounds. Vol. 3. IARC, Lyon.

Kowalczyk, R., Department of the Navy. November 30, 1984. Correspondence with R. Thaubs concerning AFFF spill into storm drainage system at NAS Willow Grove.

National Oceanic and Atmospheric Administration (NOAA). 1979. Climatic Atlas of the United States. Form A. March 13, 1979. NPDES PA 0022411, U.S. Naval Air Station, Willow Grove, Pa.

Northern Division, Naval Facilities Engineering Command (NORDIVNAVFACENGCOM). October 1983. Final Willow Grove Master Plan. Philadelphia, Pa.

Rima, D.R., H. Meisler, and S. Longwill. 1962. Geology and Hydrology of the Stockton Formation in Southeastern Pennsylvania. Pennsylvania Topographic and Geologic Survey, Bul. W-14, 111 pp.

Rogers, Golden and Halpern. 1986. Initial Assessment Study, Naval Air Station, Willow Grove, Pennsylvania. U.S. Navy, Naval Energy and Environmental Support Activity, Port Hueneme, Calif.

Satterthwaite Associates, Inc. May 1984. Final Report on the Ground Water Monitoring and Hydrogeologic Investigation. U.S. Navy, Naval Air Development Center, Warminster, Pa.

Shacklette, H.T., and J.G. Boergnen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Continental United States. U.S. Geological Survey Professional Paper 1270. U.S. Geological Survey, Alexandria, Va.

Sloto, R.A., and D.K. Davis. January 1983. Effect of Urbanization on the Water Resources of Warminster Township, Bucks County, Pennsylvania. U.S. Geological Survey, Water-Resources Investigations 82-4020.

Soil Conservation Service (SCS). 1967. Soil Survey of Montgomery County. United States Department of Agriculture.

Ure, A.M., and M.L. Berrow. 1982. The elemental constituents of soils, in: Environmental Chemistry--Vol. 2. The Royal Society of Chemistry. Burlington House, London.

U.S. Department of the Interior (USDOI). 1985. National Wetlands Inventory. Ambler, Pa. 7.5-minute quadrangle.

U.S. Environmental Protection Agency (EPA). 1986. Quality Criteria for Water. EPA 440/5-86-001. Office of Water Regulations and Standards.

U.S. Environmental Protection Agency (EPA). 1989. Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites. OSWER Directive 9355.4-02.

Weston Consultants. 1984. Phase 1 Record Search, Willow Grove Air Reserve Facility, Willow Grove, Pennsylvania. U.S. Air Force Reserve, Robins AFB, Georgia.

White, J.B., and R.R. Vanderslice. 1980. POM Source and Ambient Concentration Data: Review and Analysis Research Triangle Park, N.C. U.S. Environmental Protection Agency.

Wild Resource Conservation Fund. 1985. Endangered and Threatened Species of Pennsylvania.

GLOSSARY

ARARs	applicable or relevant and appropriate requirements
ASW	antisubmarine warfare
ARF	Air Reserve Facility
EM survey	electromagnetic terrain conductivity survey
ESI	Extended Site Inspection
FID	flame ionization detector
FS	Feasibility Study
HRS	Hazard Ranking System
HSL	Hazardous Substance List
IAS	Initial Assessment Study
IR	Installation Restoration Program
MCL	maximum contaminant level
MEK	methyl ethyl ketone
NACIP	Navy Assessment and Control of Installation Pollutants Program
NAPL	Nonaqueous-phase liquid
NAS	Naval Air Station
NOAA	National Oceanic and Atmospheric Administration
NORDIVNAVFACENGCOM	Northern Division Naval Facilities Engineering Command.
PA	Preliminary Assessment
PaANG	Pennsylvania Air National Guard
PAH	polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PCE	tetrachloroethylene
PID	photoionization detector
POA	Plan of Action
POL	petroleum, oils, and lubricants
PVC	polyvinyl chloride
RA	Remedial Action Plans
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SCS	Soil Conservation Service
SI	Site Inspection
SVCA	soil vapor contaminant assessment
SVOC	semivolatile organic compounds
TAG	Tactical Air Group
TAL	Target Analyte List
TCA	1,1,1-trichloroethane

TCE	trichloroethylene
TCL	Target Compound List
TPH	total petroleum hydrocarbons
USDA	U.S. Department of Agriculture
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compounds