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NAS WILLOW GROVE
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Remedial Investigation Report

for

Sites 1, 2, 3, and 5

Naval Air Station

Willow Grove, Pennsylvania

Volume I

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0011

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REMEDIAL INVESTIGATION REPORT
NAS WILLOW GROVE
SITES 1, 2, 3, AND 5

VOLUME I

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EXECUTIVE SUMMARY

PROJECT PERFORMANCE AND REPORT PURPOSE

This project is being performed under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62472-90-D-1298, Contract Task Order Number 0011. The activities under the CLEAN contract are performed by a team of contractors with HALLIBURTON NUS Environmental Corporation (HALLIBURTON NUS), serving as the prime contractor. HALLIBURTON NUS is the lead technical firm for this CTO.

The work performed and described within this report includes Remedial Investigation (RI) and reporting associated with four site areas within Naval Air Station Willow Grove, located near Horsham, Pennsylvania. These areas include the Privet Road Compound (NAS Site 1), Antenna Field Landfill (NAS Site 2), 9th Street Landfill (NAS Site 3), and the Fire Training Area (NAS Site 5).

The work is part of the Navy's Installation Restoration Program, which is designed to identify contamination of Navy and Marine Corps lands and facilities resulting from past operations, and to implement corrective measures, if required.

SCOPE AND OBJECTIVES

The overall objective of this RI is to characterize the physical and chemical parameters of the site areas as related to potential existence, migration, and human and environmental exposure to chemical contamination which may have resulted from past activity operations. The compiled data can be used to determine the human and environmental risk associated with each site and as a basis for evaluation of potential remedial options. The Willow Grove RI Work Plan was developed to supplement data obtained during Site Inspection (SI) studies at the activity. Recommendations resulting from SI work included RI studies at Sites 1, 2, 3, and 5. In particular, the existence and extent of volatile and semivolatile organic, metals, pesticides/PCB, and cyanide contamination were investigated at each site. Subsurface physical characteristics were investigated to obtain information related to potential contaminant migration and human and environmental exposure pathways.

ACTIVITY BACKGROUND

NAS Willow Grove is located approximately 15 miles north of the City of Philadelphia, in southeastern Pennsylvania. The activity serves as a reserve Naval Air Station and support tenants such as the Marines, U.S. Army, and the Air Force. Activity at the four sites occurred at various time periods ranging from 1942 to 1975. Historic use of the sites, primarily for landfilling, fire training exercises, and material storage suggests that contamination related to previous operations is probable.

Site 1, the Privet Road Compound, was constructed to serve as a transfer station for wastes after closure of the 9th Street Landfill in 1967. The area was used from 1967 until 1975 as an open disposal area where wastes were buried and burned. The site consists of a compound area approximately 1/2 acre in size and a suspected waste handling area covering in excess of 2 acres. The site is located north of and immediately across Privet Road from the Steam Plant, Building No. 6.

Site 2, the Antenna Field Landfill, was used as a disposal area for solid wastes generated by the activity between 1948 and 1960. Landfilling activities at the site consisted of excavation and subsequent burning and burial of wastes in trenches. The site covers approximately 9 acres and is located near the south end of the activity.

Site 3, the 9th Street Landfill, was used as an alternate disposal area following phase-out of the Antenna Field Landfill in 1960. The site was operated as a landfill until 1967. Subsequent to closure of the facility it was used as a salvage yard for empty drums, discarded equipment, and transformers containing PCBs. The site occupies about 9 acres along the western boundary of NAS Willow Grove, immediately north of 9th Street.

Site 5, the Fire Training Area, was used for large scale fire fighting exercises from 1942 until 1975. Exercises included burning and disposal of a wide variety of flammable liquid wastes which were estimated to have been consumed at the rate of at least 4,000 gallons per year. The area was also reportedly used as a storage area for drums containing flammable liquids during periods between firefighting exercises. The site is located in the southern portion of the activity near the Marine Reserve Compound.

GEOLOGY AND HYDROLOGY

Surface soils in the vicinity of the activity consist primarily of loam and silt loam deposits. Soil thicknesses observed in borings installed during the RI work ranged from approximately 7 to 22 feet.

The underlying bedrock consists of the middle arkose member of the late Triassic age Stockton Formation. The Stockton Formation is underlain by Ordovician to Precambrian age basement rocks.

The middle member of the Stockton Formation consists of fine- to medium-grained arkosic sandstone interbedded with shale and siltstone. The rock is generally weakly cemented and well sorted, resulting in relatively high porosity, compared to the upper and lower members of the formation. The middle member has been reported to be in excess of 4,000 feet thick in the vicinity of the activity, with the upper surface weathering to a depth of 15 to 35 feet.

Groundwater within the Stockton Formation is transmitted through primary porosity and along bedding planes and fractures. Shale and siltstone units commonly restrict vertical movement of groundwater due to low primary porosity and poorly developed secondary porosity. The RI and earlier studies have provided evidence that some interconnection exists between shallow and deeper portions of the aquifer underlying the activity. The primary groundwater production aquifer in the vicinity of NAS Willow Grove is the fractured bedrock of the Stockton Formation. Groundwater beneath the activity occurs under both water table and confined conditions.

The activity is located in an upland area lying between two local drainage basins. The majority of the base drains toward the north into Park Creek, a tributary of the Little Neshaminy Creek. The remainder of the base surface drainage flows to Pennypack Creek on the south side of the activity. Both local drainage basins lie within the regional drainage basin of the Schuylkill River. Drainage within the activity is controlled primarily through natural flow to ephemeral streams and constructed drainages, with runoff being influenced locally by surface grading, pavement, constructed ditches, and storm sewer lines.

FIELD ACTIVITIES

Field activities at the four RI sites included the installation of 18 monitoring wells, completion of 28 soil borings, 16 hand auger borings, and excavation of 4 test pits. Field activities conducted during the investigation included groundwater pumping tests, water level measurement, and borehole logging. During the course of the investigation a total of 222 samples were collected and forwarded to an analytical laboratory. These included 139 soil, 40 groundwater, and 43 surface water and sediment samples. Field and laboratory QA/QC samples were also included in the laboratory analysis.

With only minor deviations, the work performed was completed in accordance with the Plan of Action developed for the site by EA Engineering Science and Technology (August 1991).

NATURE AND EXTENT OF CONTAMINATION - PRIVET ROAD COMPOUND (NAS SITE 1)

Groundwater and soil samples were collected from the site during SI work in 1989 and groundwater, soil, surface water, and sediment samples were obtained during the RI. During the SI several volatile organic compounds were found in groundwater samples at concentrations exceeding drinking water standards. Soil and sediment samples collected during the SI did not contain volatile organics but were observed to be contaminated with PCBs and dieldrin. The presence of these chemicals and the potential for offsite migration resulted in recommendation of a Remedial Investigation.

Soil

Subsurface soil samples collected during the RI were not found to contain significant concentrations of volatile organic compounds. This observation is consistent with the SI findings. Therefore it may be concluded that site soil is not an important contributor of these contaminants to groundwater. A PCB (Aroclor-1260) was found in several samples collected from within the compound area at concentrations ranging from 220 to 230,000 µg/kg. With the exception of one soil sample from a depth of 6 to 7.5 feet below the ground surface, PCB-contaminated soils were found to be limited to the upper 4 feet of soil material. Dieldrin was found in only one of the 73 soil samples obtained from the site. Metals (cobalt and selenium) were observed in site soils at concentrations somewhat higher than those found in background samples.

Groundwater

Analysis of groundwater samples from the site during the RI indicated that, as in the SI sampling, volatile organics were the primary contaminants of concern. The areal extent of these compounds was found to be limited, with the maximum concentrations being observed in an upgradient well screened in a relatively deep zone within the local aquifer. The most significant contaminant was trichloroethene, which was detected at a concentration of 120 µg/L in a sample obtained from well PRW-7B located approximately 200 feet northeast of the vehicle washrack. Groundwater flow within this deeper portion of the aquifer is controlled by pumping from two Navy production wells, which may serve to draw soluble contaminants from an upgradient source area.

Surface Water/Sediment

No distinct patterns of surface water and sediment contamination were observed during evaluation of RI data. Slightly elevated metals concentrations were detected within the site, however some metals were found at their maximum concentrations in sediment samples collected from upstream of the site.

Therefore the data do not indicate that the site is a significant source of contaminants in either runoff water or soils.

NATURE AND EXTENT OF CONTAMINATION - ANTENNA FIELD LANDFILL (NAS SITE 2)

Groundwater, surface water, and sediment samples were collected from the Antenna Field Landfill Site during both the 1989 SI and 1991 RI. Analysis of groundwater samples collected during 1989 indicated that several volatile organic compounds were present in an upgradient well and that two other wells located adjacent to the landfill area contained dieldrin and/or phthalate esters at very low concentrations. No volatile organics were detected in surface water or sediment samples collected during 1989.

A second round of groundwater, surface water, and sediment samples was collected during the RI. No organic chemicals were detected in the the groundwater samples and only isolated occurrences of volatile organics were detected at levels below MCLs in surface water samples. With the single exception of one downstream sample, no volatile organics were detected in sediment samples. Based on these observations, and the fact that volatile organic compounds were only detected in an upgradient well during the SI, it may be assumed that the landfill is not a significant source of these contaminants. However, only three groundwater sampling wells have been installed at the site, and none have been located in the vicinity of the central portion of the fill area.

The primary contaminants noted at the site included polynuclear aromatic hydrocarbons, metals, and dieldrin, which were detected in sediment samples. This contamination appears to be limited in extent and was primarily detected near the center of the landfill area. These contaminants are relatively insoluble and subject to transport from the site chiefly through erosion or other bulk movement of sediment.

NATURE AND EXTENT OF CONTAMINATION - 9TH STREET LANDFILL (NAS SITE 3)

Site inspection work at the 9th Street Landfill determined that volatile organic compounds were present in site groundwater but were not of significant concern in site soils. Cyanide was considered to be of concern and its presence in soils at a baseball field on site was largely responsible for recommendation of RI work.

Soil

Soil samples were collected during the RI from 16 surface and 16 shallow (3-foot depth) subsurface locations within the baseball infield. Several test pits were also excavated at locations adjacent to the

baseball field and within the vicinity of former landfilling activities. In general, soil samples obtained during the RI did not indicate that any significant contaminants of concern were prevalent at the site. Some PAHs were detected, probably resulting from past burning of wastes at the site. Dieldrin was also detected in several samples but at concentrations consistent with background samples. PCBs were detected in 2 of the 39 samples at a maximum concentration of 810 µg/kg. A small number of volatiles were detected in site soils at very low concentrations of 2 to 3 µg/kg. Cyanide was not detected.

Groundwater

Groundwater samples were found to contain tetrachloroethene in concentrations ranging from 7 to 61 µg/L. This compound had previously been detected in the upgradient well during SI work and was again detected at this location, as well as at a newly installed well located farther upgradient. Since no onsite source has been identified and the contaminant is consistently detected upgradient, it may be assumed that the source has not been identified.

Surface Water/Sediment

Consistent with the SI, no significant concentrations of organic chemicals were detected in any surface water samples. Sediment samples collected from the bottom of the recreational pond adjacent to the site had the highest concentrations of PAHs observed at the site, probably resulting from erosion of PAH-contaminated soils from the site and subsequent settlement to the pond bottom. The concentrations of PAHs outside the pond were much lower. Several metals were also found at their maximum concentrations in pond sediment samples.

NATURE AND EXTENT OF CONTAMINATION - FIRE TRAINING AREA (NAS SITE 5)

Soil and groundwater samples obtained from the immediate vicinity of the burn area during the SI were found to contain several monocyclic aromatic hydrocarbons and halogenated aliphatics. These compounds were either nonexistent or occurred at significantly lower concentrations in samples collected from outside the burn area.

Soil

Soil samples obtained during the RI were found to be relatively clean with only sporadic detections of organic compounds, generally at concentrations below 10 µg/kg. No soil samples were obtained from

the immediate vicinity of a burn area well, which was found to contain higher levels of contamination during the SI.

Groundwater

Ten monitoring wells were sampled during the RI, including 7 shallow wells and 3 deeper wells. Three of the shallow wells were observed to contain volatile organic compounds. Two of these three wells were located adjacent to deeper wells, which were also found to be contaminated, but at lower concentrations. The most notable concentrations of contaminants in groundwater, however, were found to be limited to a single shallow/deep well cluster located in the immediate vicinity of the burn area.

In general the data indicate that the contamination at the site is limited to a relatively small area on site. Contaminants in soil and groundwater have not migrated far downgradient. The vertical extent of contamination in the groundwater at the one contaminated well location and the precise extent of soil contamination have not been determined.

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

HALLIBURTON NUS Environmental Corporation, under CLEAN Contract Number N62472-90-D-1298 performed remedial investigation (RI) activities at Naval Air Station (NAS) Willow Grove in accordance with the requirements of Contract Task Order No. 11. Field investigation and reporting activities associated with the NAS Willow Grove RI are performed as part of the Navy's Installation Restoration Program (IRP). This program is designed to identify environmental concerns resulting from past operations at Navy and Marine Corps facilities, and to implement corrective measures if required.

IRP activities are typically performed in four distinct phases. Phase 1 consists of a Preliminary Assessment (PA). Phase 2 is a Site Inspection (SI). Phase 3 is a Remedial Investigation/Feasibility Study (RI/FS), which is intended to characterize the physical and chemical (contaminant) parameters of the site and the risks associated with the site. Phase 4 consists of remedial action designed to control and mitigate site contamination. This RI Report is prepared under Phase 3 IRP activities.

1.2 SCOPE AND OBJECTIVES

The RI was conducted in accordance with a Plan of Action prepared by EA Engineering, Science, and Technology, Inc., in August 1991. The Plan of Action included extended site inspections and remedial investigations at six site areas within NAS Willow Grove. The scope of work performed under CLEAN Contract Task Order No. 11 was limited to RI work at four of the six sites. Extended Site Inspections and subsequent reports for the remaining two sites are included under a separate contract.

The objectives of the RI are to further characterize the nature and extent of the contaminants at four site areas and to gain additional understanding of the physical parameters affecting contaminant fate and transport. Specific objectives for each of the four sites are presented in Sections 4 through 7 of this report.

1.3 SITE BACKGROUND

1.3.1 Location and Description

Naval Air Station Willow Grove is located in Montgomery County in southeastern Pennsylvania, approximately 15 miles north of the City of Philadelphia, as shown on Figure 1-1. The activity is immediately north of the town of Horsham, and is generally bordered by State Route 611 on the east, State Route 463 on the southwest, and Keith Valley Road on the north.

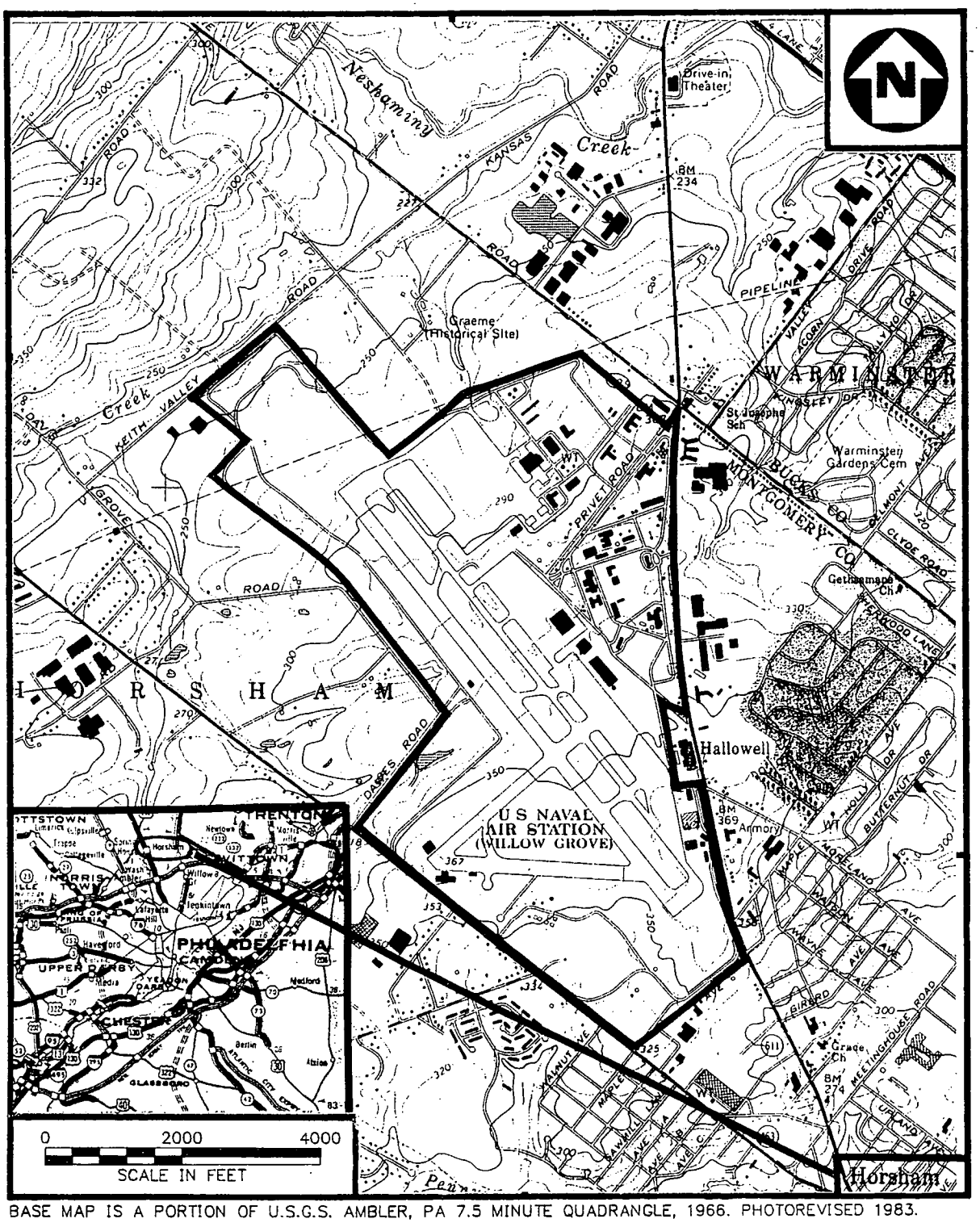
In addition to its primary use as a reserve Naval Air Station, NAS Willow Grove supports other tenants such as the Marines and the U.S. Army. The U.S. Air Force also has property holdings within the activity boundaries and shares common facilities with the NAS. The four sites included within the scope of this Draft RI Report include two landfill areas [Antenna Field Landfill (NAS Site 2) and 9th Street Landfill (NAS Site 3)], a waste transfer station [Privet Road Compound Site (NAS Site 1)], and a fire protection training area [Fire Training Area (NAS Site 5)]. The relative locations of the sites are shown on Figure 1-2. Activities resulting in potential site contamination occurred at different time periods between 1942 (first Fire Training Area exercises) and 1975 (last use of Privet Road compound). Descriptions of the individual sites are provided in Sections 4.1, 5.1, 6.1, and 7.1.

1.4 PREVIOUS INVESTIGATIONS

Prior to initiation of RI activities at NAS Willow Grove, Preliminary Assessment (PA) and Site Inspection (SI) work was completed. The PA, formerly identified as the Initial Assessment Study, identified 16 sites, including seven sites at the Air Reserve Facility in 1984 (Weston, 1984) and nine additional sites at the NAS in 1986 (RGH, 1986). One additional site, the Navy Fuel Farm, was added to the program in 1988. Of the 17 sites included within the PA program, SI work was performed at 12 sites and RI/FS activities have subsequently been completed or are underway at 8 sites. In addition, Extended Site Inspections were performed at two sites, NAS Site No. 7 (Abandoned Rifle Range No. 2) and ARF Site No. 4 (Washrack Area). Work at three of the eight RI/FS sites was completed under a program managed by the Air Force. Work is currently being performed at the five remaining NAS sites requiring RI/FS activities. Four of these sites are included within the scope of this report.

1.5 REPORT ORGANIZATION

This report provides information related to field activities, the physical characteristics of the study areas, and chemical analytical results associated with remedial investigation activities performed at NAS Willow Grove during 1991. Data obtained during the field investigation and laboratory analysis is



BASE MAP IS A PORTION OF U.S.G.S. AMBLER, PA 7.5 MINUTE QUADRANGLE, 1966. PHOTOREVISED 1983.

FIGURE 1-1

LOCATION MAP
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PA

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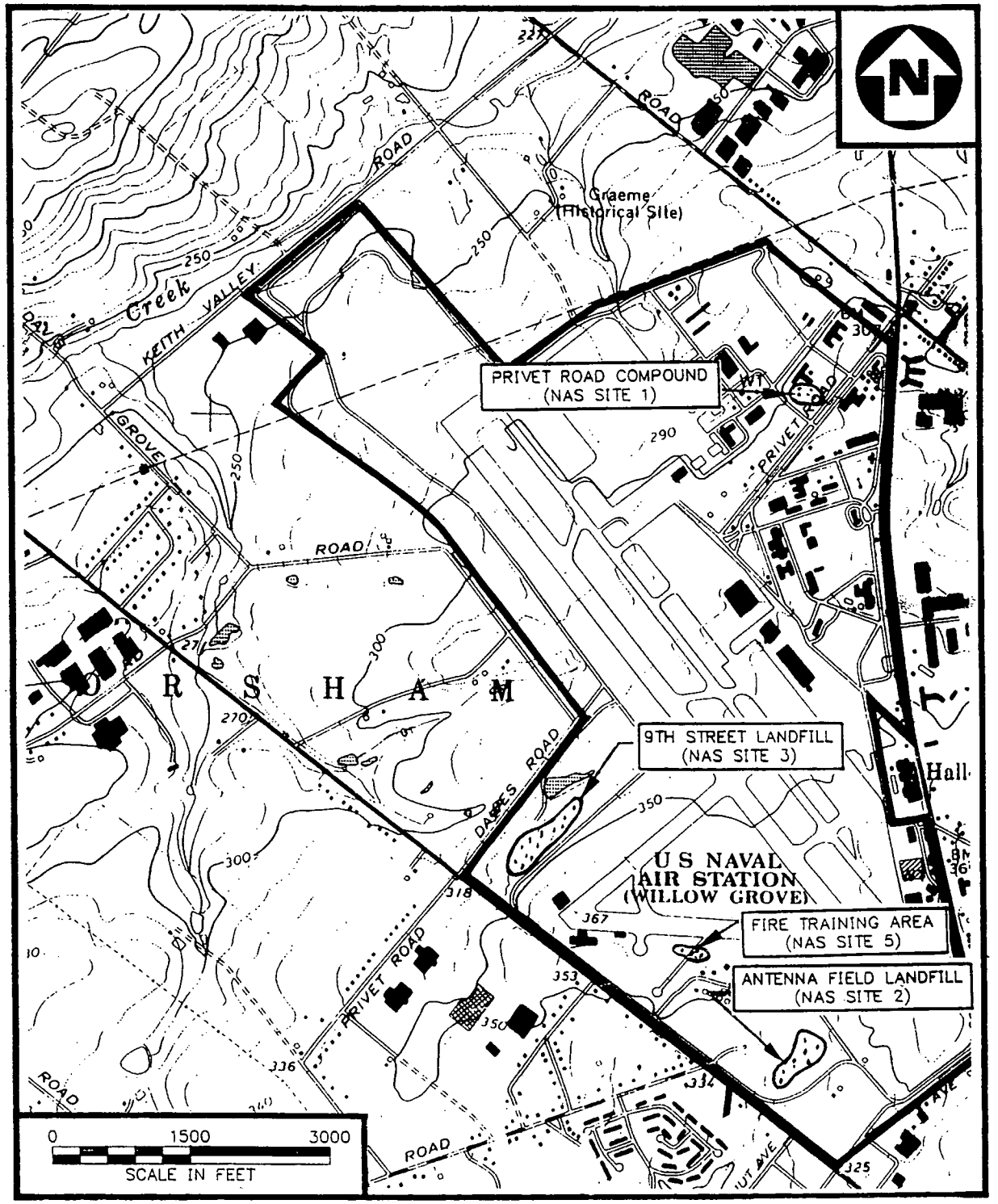

FIGURE 1-2

BASE PLAN – RI SITE AREAS
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PA

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summarized and interpreted to provide information concerning the nature and extent of contamination, potential contaminant migration pathways, and preliminary information on potential human or environmental receptors.

Section 1.0 discusses the purpose, scope and objectives of the report and provides a brief background summary for the NAS Willow Grove, and the four RI sites in particular. Section 2.0 details the field activities performed during the RI. Section 3.0 presents the base-wide physical characteristics based on existing literature, previous investigation findings, and recently developed information and conclusions derived from the RI site work. Sections 4.0 through 7.0 present a summary of historical and current investigations, analytical results, and contaminant migration pathways, as well as a summary and recommendations for each site.

2.0 STUDY AREA INVESTIGATION

Field investigation activities were performed at four sites at NAS Willow Grove between August 27 and October 11, 1991. The work was performed in accordance with a Draft Plan of Action (May 1991) prepared by EA Engineering under Contract N62472-856-C-1037. A Final Plan of Action was not available until September 3, 1991. However, variation between the draft and final versions of the plan was minimal and the completed work is considered to be consistent with the general requirements of the Final Plan of Action (EA, August 1991).

Field activities at the four Remedial Investigation (RI) sites generally included the installation of 18 monitoring wells; completion of 28 test borings and 16 hand auger sample locations; excavation of four test pits; and collection of groundwater, soil, surface water, and sediment samples. Additionally, field measurement and testing, including groundwater pumping tests, water level measurements, and logging and interpretation of drilling activities, was performed during the field effort. A total of 222 samples were collected, including 139 soil samples, 40 groundwater samples from new and existing wells, and 43 surface water and sediment samples. Analysis also included field and laboratory QA/QC samples in accordance with the Plan of Action objectives.

Minor deviations from the Plan of Action occurred as a result of unexpected conditions encountered in the field, most notably a small reduction in leachate and surface water sampling due to extremely dry weather conditions. Minor modifications to borehole locations were also made to accommodate field conditions. Site-specific deviations from the plan are discussed in greater detail in the following sections.

2.1 GENERAL FIELD INVESTIGATION PROCEDURES

2.1.1 Soil Boring Investigation

Soil samples were obtained from a total of 44 locations during the course of RI site activities. Sampling at 16 locations was completed using hand auger boring techniques. The remaining 28 borings were advanced using truck-mounted drilling equipment. All borings were performed by, or in the presence of, a HALLIBURTON NUS geologist who was responsible for obtaining and classifying samples as detailed in the Plan of Action.

Hand auger boring locations were completed by first obtaining a near-surface soil sample from a depth of approximately 3 to 6 inches below the ground surface. A stainless steel hand bucket auger was then used at each location to advance the boring to a second sample interval at a depth of approximately 3 feet below the ground surface. All sampling equipment, including the stainless steel sampling trowels and bucket auger, were decontaminated prior to use at each location and all samples were collected in factory new, certified clean sample containers supplied by the laboratory.

Deeper borings were advanced using 6-inch inside-diameter (ID) hollow-stem auger drilling techniques and an Acker Model 82 drill rig. This drilling was performed by a subcontractor under the direct supervision of a HALLIBURTON NUS geologist. Borings were continuously sampled from the ground surface to the top of bedrock using split-spoon sampling techniques in accordance with ASTM D 1586-84 designation. The total depth of each boring (top of bedrock) was determined on the basis of split-spoon refusal. One soil sample was obtained for laboratory analysis from each 2-foot sample interval. In borings less than 10 feet in depth, as many 2-foot sample intervals as possible were collected for chemical analysis. In borings having greater than five 2-foot intervals (i.e., borings greater than 10 feet in depth), a maximum of five soil samples were collected on the basis of the three samples having the highest organic vapor analyzer (OVA) instrument readings, along with the shallowest and deepest sample obtained. Soil lithologies, color, density, and OVA readings were determined and documented for all boreholes. Boring logs are included in Appendix B. Prior to initiation of drilling at each borehole location all downhole drilling equipment, as well as the back end of the drill rig, were decontaminated by steam cleaning. Steam cleaning was performed at a centralized location near the Public Works Building and all decontamination fluids and solids were collected and drummed.

2.1.2 Test Pit Excavation

Four test pits were excavated in the vicinity of the 9th Street Landfill Site. Test pits were excavated with a backhoe to a maximum depth of 10 feet, and were approximately 100 feet in length. Excavated material was scanned with a portable organic vapor analyzer (OVA) and inspected for visual signs of contamination. Subsurface soil samples were collected on the basis of field screening and/or visual observation of potential contamination. If no evidence of contamination was noted, one representative sample of the prevalent soil condition was obtained. A maximum of four soil samples were collected from each excavation.

2.1.3 Monitoring Well Drilling and Installation

Remedial Investigation activities included the installation of 18 monitoring wells within three of the site areas (no new wells were installed at the Antenna Field Landfill Site). All wells were drilled and installed

using two subcontracted Mobil B-80 drill rigs under the supervision of a HALLIBURTON NUS geologist. Drilling included hollow-stem auger methods to the top of competent bedrock followed by air percussion drilling to the total depth of the well boring. Each well, or the deeper of two wells at well cluster locations, was logged from the ground surface to the total depth of the borehole for lithologic and geologic/hydrogeologic characteristics. Overburden materials were collected and placed in sample jars and field screened within 1 to 2 hours using a portable photoionization detector (PID) for determination of relative headspace volatile organics concentrations. Borehole characteristics and headspace readings were documented on boring logs. Boring logs are included in Appendix B. Drill cuttings were screened with a PID and disposed in the immediate vicinity of the borehole since no significant PID readings were recorded at any of the well locations.

All wells were constructed of 4-inch-ID Schedule 40, flush-jointed, threaded PVC casing and factory-slotted (0.01-inch) well screen. A 6-inch unslotted sediment trap was installed at the bottom of the screened interval. Sand pack material consisting of clean No. 2 quartz sand was emplaced from the bottom of the well boring to a depth approximately 2 feet above the top of the screened interval. A minimum 2-foot-thick bentonite pellet seal was installed above the sand pack and allowed to hydrate. The remaining annulus was then backfilled with a 20:1 cement-bentonite grout mixture to within 2 feet of the ground surface. The top of each well was completed by installing an 8-inch-diameter steel protective casing rising approximately 2 feet above the ground surface. The steel casing was cemented in place, fitted with a locking cover, and painted yellow on the outside to increase visibility. Details for all wells are provided on the well construction diagrams included in Appendix B.

Wells installed during the RI consisted of three general types, designated as shallow, intermediate, and deep wells. The relative depth of the three types of wells varied from site to site in order to target specific depth intervals of interest at each area. Depths for all wells completed during the RI, are included along with other well construction information in well completion data tables provided in Sections 4.0, 6.0, and 7.0. In general, well depths are as follows:

- Shallow: 28 to 41 feet
- Intermediate: 84 to 90 feet
- Deep: 171 to 180 feet

Shallow wells were installed for the purpose of monitoring the groundwater under water table conditions. These wells included 20 feet of well screen installed such that the screened interval intersected the water table (allowing for seasonal water table fluctuation). Intermediate-level wells were installed for the purpose of monitoring deeper portions of the water table aquifer and/or a semi-confined zone (observed at some site areas).

Deep wells were installed at the 9th Street Landfill Site for the purpose of monitoring groundwater under confined conditions. Intermediate and deep wells were installed by placing 8-inch steel casing extending from approximately 2 feet above the ground surface to approximately 5 to 10 feet into competent bedrock. The casing was grouted in place via tremie pipe and the grout allowed to hydrate for a minimum of 24 hours prior to drilling through the casing with a 7-7/8-inch drill bit to accommodate placement of the 4-inch PVC well casing. Ten-foot screen lengths were used for intermediate and deep wells. All downhole drilling equipment, as well as the back end of the drill rig, were decontaminated prior to beginning drilling at any locations.

All wells were developed using a submersible pump. The volume of the well and sandpack were calculated and pH and specific conductance were measured for each well volume removed. Development continued until pH and conductivity readings did not vary by more than 10 percent, or for a maximum of 3 hours.

2.1.4 Monitoring Well Sampling

All wells installed during the RI, as well as pre-existing wells installed during SI work and two Navy production wells, were sampled during RI site activities. All monitoring wells were purged prior to sample collection. Purging was performed using stainless steel pumps, stainless steel bailers, or teflon bailers and consisted of removal of five well volumes. Calculations of well volumes were based on measurements of water level elevation and well depth and included both the casing volume and the volume of the sand pack, assuming a 30 percent sand pack porosity. Wells that were purged dry were allowed to recover and then purged a second time prior to sampling. Monitoring wells were sampled using dedicated bottom-filling teflon or stainless steel bailers and new bailer lines. The first aliquot for sampling was used to fill the volatile organic analysis (VOA) containers. Production wells were sampled during pumping conditions by collecting water through existing ball valves located along system piping.

2.1.5 Aquifer Testing

Aquifer testing during RI work was limited to completion of pumping tests using Navy production wells and monitoring wells located in the vicinity of the Privet Road Compound Site. Details of the qualitative aquifer testing are included within Section 4.3.2.2.

2.1.6 Surface Water and Sediment Sampling

Grab samples of surface water and sediment were collected in accordance with the Plan of Action. Minor deviations from the work plan are discussed in the representative RI Report section for each site. Surface water samples were collected in appropriate glass bottles and corresponding sediment samples were collected from the same location using clean (decontaminated) stainless steel trowels. All sampling occurred upstream of any disturbances caused by the sampler or sampling team. Downstream samples were collected first and samples from locations farthest upstream were collected last.

2.1.7 Documentation

All samples were collected in approved sample containers provided by the laboratory. Immediately upon collection each sample was sealed in the appropriate bottle, labeled, and placed on ice in an insulated container. All samples were forwarded to the laboratory under approved United States Environmental Protection Agency (EPA) procedures for chain of custody and sample handling. Copies of the chain-of-custody forms for all samples are included in Appendix D.

2.2 SURVEYING

Site surveying was performed by a subcontracted State of Pennsylvania Licensed Professional Land Surveyor. All wells, borings, and test pits completed during RI phase work were surveyed for horizontal and vertical position. United States Coast and Geodetic Survey monuments "Willow and Prospectville, Tower of Chimes, 1942" were used to establish Pennsylvania State Plane coordinates (south zone, 1927 datum) for horizontal control. Vertical control was established using United States Coast and Geodetic survey monument "Pitcairn A" elevation 368.949 (NGVD of 1929). At test boring locations the ground surface immediately adjacent to each boring was determined. Ground surface elevation was determined at each end of the test pits. Three elevations were recorded at each monitoring well, including the top of the steel protective casing, a notch at the top of the PVC riser pipe, and the ground surface adjacent to each well. Tabulated survey data is included in Appendix E.

2.3 ANALYTICAL PROCEDURES/DATA VALIDATION

2.3.1 Analytical Procedures

A subcontracted NEESA-approved laboratory analyzed aqueous and solid matrix samples collected at NAS Willow Grove for volatile and semivolatile organics, pesticides and PCBs, and inorganics. The analytical methods employed for the the analyses are defined in Table 2-1.

2.3.2 Data Validation

The results of data validation have been transmitted to the Navy under separate cover. The following provides a discussion of the data validation process.

The data validation process serves three basic functions as follows:

- An independent quality assurance check of the veracity of laboratory results.
- A means of evaluating laboratory performance and determining the impact of noncompliances to the data.
- Through the use of data qualifiers, it lends interpretive guidance as to the proper usage and limitations of the data.

The data validation process is a systematic review and evaluation of the data conducted according to the applicable relevant quality control criteria, such as

- The USEPA National Functional Guidelines for Evaluating Laboratory Analyses
- Method-specific quality control criteria
- Navy-specified technical guidelines
- HALLIBURTON NUS data validation formats and standard operating procedures

Organic data are evaluated based on

- Data completeness
- Holding times
  GC/MS tuning and mass calibration (when applicable)
- Initial and continuing calibrations

TABLE 2-1

ANALYTICAL METHODS SUMMARY
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Parameter	Method
Volatile organics	1/87 and 2/88 CLP SOW[1]
Semivolatile organics	1/87 and 2/88 CLP SOW
Pesticides/PCBs	1/87 and 2/88 CLP SOW
Inorganics[2]	7/88 CLP SOW

(1) EPA Contract Laboratory Program Statement of Work

(2) Both filtered and unfiltered groundwater samples were analyzed for metals at most sites.

- Laboratory blank analyses
- Field blank analyses (when applicable)
- Internal standards performance
- Surrogate spike recoveries
- Matrix spike/matrix spike duplicate results
- Field duplicate precision (when applicable)
- Compound detection limits
- Compound identification
- Compound quantitation
- Tentatively Identified Compound (TIC) evaluation (when applicable)

Inorganic data are evaluated on the basis of

- Data completeness
- Holding times
- Initial and continuing calibrations
- Contract Required Detection Limit (CRDL) standard analyses
- Laboratory blank analyses
- Field blank analyses (when applicable)
- Matrix spike results
- Laboratory control sample results
- Laboratory duplicate analyses
- Field duplicate precision (when applicable)
- ICP interference check sample results
- ICP serial dilution analyses
- Furnace atomic absorption results
- Analyte detection limits
- Analyte quantitation

Data validation memoranda (i.e., reports) are generated from the results and conclusions drawn from the validation process described above. These reports are submitted to the Project Manager, and the narrative portions are contained in Appendix F. The specific format of the data validation report varies with the applicable protocol, but all data validation memoranda address the following:

- Explanation of the findings of the data evaluation process, giving interpretations of actions taken on the data and limits of data usability.

- Presentation of the qualified analytical results.

- A validation worksheet and/or support documentation section depicting the problem areas and noncompliances addressed in the data validation memoranda, and supporting the validation actions taken.

The formal data validation process and the subsequent memoranda and supporting documentation generated thereby, is essential for the following reasons:

- To ensure the accuracy and integrity of the analytical data.
- To ensure the defensibility of the data.
- To provide a secure platform from which remediation and risk assessment issues can be addressed.

2.4 BACKGROUND SAMPLES

The previous contractor for NAS Willow Grove collected ten background soil samples from the locations shown in Figure 2-1. The samples were analyzed for Target Analyte/Compound List metals, pesticides and PCBs. Sample quantitation limits (sample-specific quantitation limits adjusted for soil moisture, interferences, etc.) were not available to HALLIBURTON NUS, however, method detection limits were presented. Therefore method detection limits, which are those specified by the method under ideal conditions, are used for the nondetected values. Sample-specific analytical results are presented in Table 2-2 for ten background samples and one duplicate. Only those analytes that were found in at least one sample are included in this table.

A goodness-of-fit test (the Shapiro-Wilk W-Test) was performed on each analyte identified in the background samples to determine whether the distribution of the analyte in the soil is normal or lognormal. This test is performed on both the values (to test for normal distribution) and the logarithms of the values (to test for lognormal distribution). A sample calculation is presented in Appendix G. Depending on the results of the test, the best fit for either the geometric mean (for lognormally distributed data) or the arithmetic mean (for normally distributed data) is presented in Table 2-2 as the mean of all values. The upper 95 percent confidence limit on the mean (two-sided, which is the same as the one-sided upper 97.5 percent confidence limit) was then determined as per current EPA guidance (EPA, December 1989). Sample calculations of the confidence limit for both normally and lognormally distributed data are presented in Appendix G. The results for duplicate samples were averaged and counted as one sample for all calculations, and one-half the sample detection limit was used for all nondetected values.

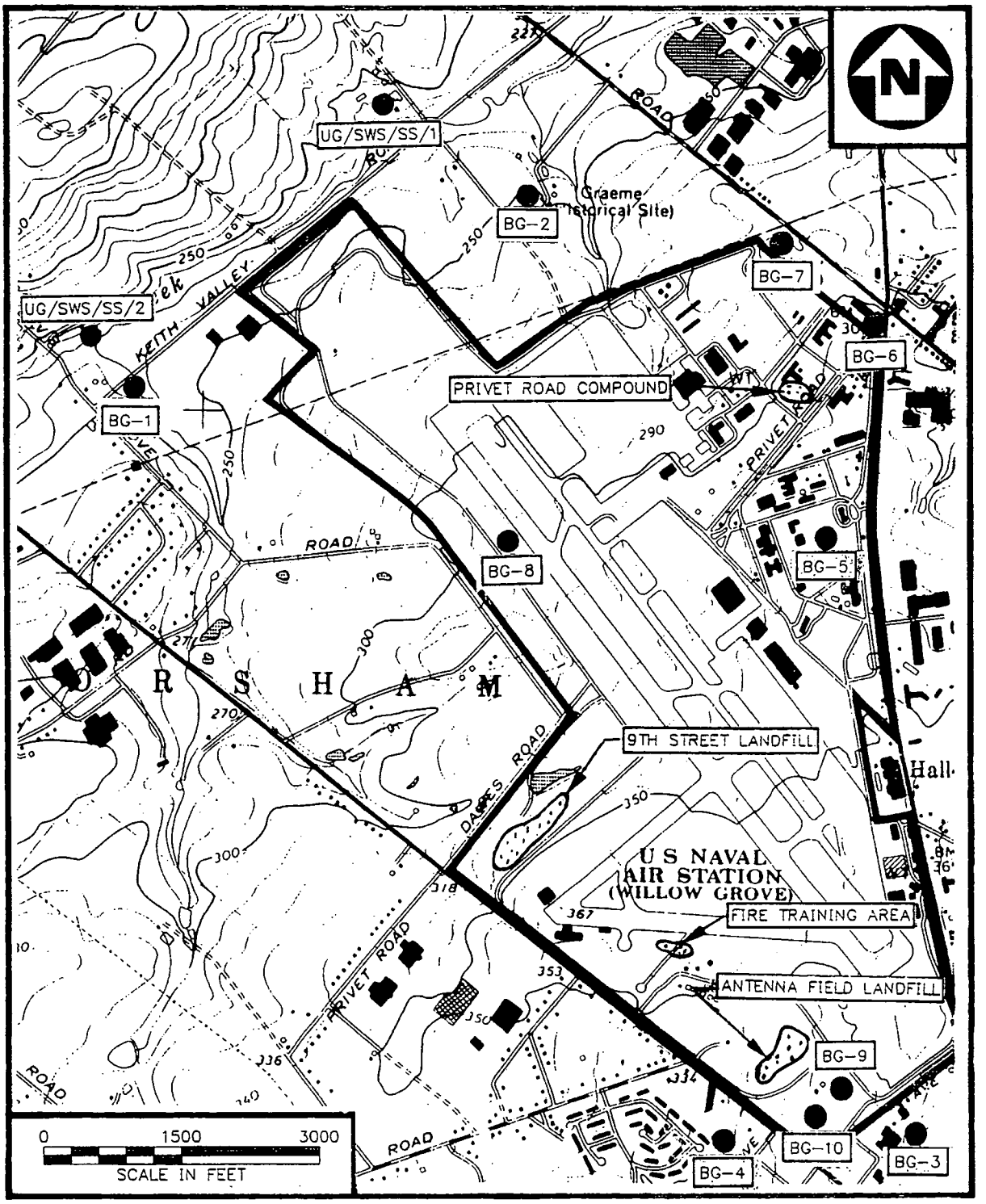

FIGURE 2-1

BACKGROUND SAMPLE LOCATIONS
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PA

HALLIBURTON NUS
Environmental Corporation

TABLE 2-2

SUMMARY OF ANALYTICAL RESULTS - BACKGROUND SOIL SAMPLES (mg/kg)[1]
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Analyte	BG-1	BG-2	BG-3	BG-4	BG-5	BG-6	BG-7	BG-8	BG-9	BG-10	BG-10 Duplicate	Mean of All Values[6]	Standard Deviation of Samples	Upper 95% Confidence Limit on Mean
Aluminum	19,500	20,500	23,100	19,600	26,500	21,500	18,200	20,300	19,500	22,000	20,100	21,000	2,356	22,700
Antimony	3.3U[3]	3.3U[3]	3.3	3.3U[3]	4.9	3.1	3.3U[3]	3.3U[3]	4.3	4.0	3.3U[3]	2.5	1.25	3.5
Arsenic	4.0	50.7	3.3	2.3	5.2	3.0	5.1	5.9	4.6	3.4	3.9	4.1	1.17	5.0
Barium	217	139	80.2	107	120	50.3	92.9	134	131	98.2	130	111[7]	44.0	156[7]
Beryllium	1.3	1.3	0.86	1.0	1.3	0.61	0.99	1.2	0.98	1.1	0.92	1.1	0.22	1.2
Cadmium	4.7	4.4	5.3	4.6	6.0	4.4	4.7	4.3	4.7	4.4	4.6	4.7[7]	0.52	5.1[7]
Calcium	1,640	1,240	828	1,290	2,150	829	2,340	1,010	1,570	1,070	1,530	1,420	514	1,790
Chromium	23.1	23.5	26.8	23.5	27.9	18.8	20.8	23.5	27.9	24.4	26.4	24.1	2.96	26.2
Cobalt	7.5	8.8	9.2	9.7	8.3	6.3	7.9	7.8	8.3	8.4	8.3	8.2	0.94	8.9
Copper	21.7	27.5	11.7	11.8	19.4	11.5	16.0	13.5	15.0	13.5	14.2	15.5[7]	5.2	19.7[7]
Iron	18,900	20,300	25,700	22,800	26,100	20,300	21,400	19,500	20,600	22,400	21,000	21,700	2,460	23,500
Lead	155	36.3	16.2	199	52.4	34.5	28.9	0.2U[2]	33.6	25.9	37.5	58.8	64.6	105
Magnesium	1,740	1,950	2,130	2,170	2,460	1,580	2,440	2,050	2,080	2,140	2,020	2,070	272	2,260
Manganese	1,360	921	370	497	358	256	523	667	369	648	404	519[7]	331.3	844[7]
Mercury	0.19	0.1U[4]	0.1U[4]	0.1U[4]	0.12	0.1U[4]	0.1U[4]	0.1U[4]	0.1U[4]	0.1U[4]	0.1U[4]	0.06[7]	0.047	0.1[7]
Nickel	17.7	16.1	15.6	15.3	19.2	13.5	14.6	14.6	15.6	17.7	15.9	15.8[7]	1.66	16.9[7]
Potassium	857	864	937	1,220	1,390	740	819	804	783	999	731	928	209.6	1,080
Selenium	0.40	0.3U[2]	0.16	0.17	0.18	0.08	0.25	0.30	0.27	0.26	0.24	0.22	0.091	0.29
Silver	1.4	1.0	1.0	0.81	1.1	0.99	0.80	0.82	0.81	1.2	0.83	0.96[7]	0.18	1.1[7]
Sodium	67.6	51.8	38.5	51.0	79.6	47.8	35.1	29.5	47.2	43.6	41.9	49.1	15.0	59.8
Thallium	0.26	0.3U[2]	0.25	0.3U[2]	0.3U[2]	0.3U[2]	0.03	0.35	0.3U[2]	0.3U[2]	0.26	0.18	0.087	0.25

TABLE 2-2
SUMMARY OF ANALYTICAL RESULTS - BACKGROUND SOIL SAMPLES (mg/kg)[1]
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA
PAGE 2

Analyte	BG-1	BG-2	BG-3	BG-4	BG-5	BG-6	BG-7	BG-8	BG-9	BG-10	BG-10 Duplicate	Mean of All Values[6]	Standard Deviation of Samples	Upper 95% Confidence Limit on Mean
Vanadium	30.7	31.2	35.8	31.1	40.6	27.5	28.2	31.4	36.7	32.9	34.7	32.5[7]	44.0	35.2[7]
Zinc	170	58.2	40.1	42.3	109	43.5	48.7	67.5	69.5	44.4	65.5	63.1[7]	40.4	97.6[7]
Dieldrin	0.016U	0.016U	0.016U	0.016U	0.400	0.025	0.026	0.056	0.020	0.030	0.023	0.022[7]	0.12	0.200[7]

(1) Analytical results reported in EA, January 1992.
(2) Analytical method not specified; detection limit shown is for graphite furnace.
(3) Analytical method not specified; detection limit shown is for ICP.
(4) Detection limit for cold vapor method.
(5) Analytical method not specified; detection limit shown is CRQL.
(6) Calculated using one-half the detection limit for nondetects.
(7) Geometric mean presented; data are log normally distributed.

These sample results are used in the succeeding chapters of this report to eliminate from further consideration those metals (or dieldrin, which was the only pesticide detected) that are present at the individual sites at concentrations that exceed background, assuming the population variances are the same. This process involves a series of steps, the first of which is to compare the arithmetic average concentrations of each onsite chemical to the mean concentrations presented in Table 2-2. Because the arithmetic average is greater than the geometric mean for a given sample set, comparison of site arithmetic means with background geometric means is conservative and does not result in incorrect elimination of a metal from further consideration. In some cases, the difference between the background and the site concentrations is minimal, and in those cases the site samples were also tested for distribution and the appropriate means and confidence limits (normal or lognormal) were then compared for greater accuracy. Those chemicals that are present on site at elevated concentrations are considered to be potential chemicals of concern. Some of the more notable occurrences of metals in the background samples are discussed below.

Arsenic was detected in nine samples at concentrations that ranged from 2.3 to 5.9 mg/kg, and the tenth sample was found to contain 50.7 mg/kg. This result was considered an anomalous value which was excluded from all subsequent calculations both in the RI and the SI.

Lead was detected in nine of ten samples, at a maximum concentration of 199 mg/kg in sample BG-4, which is located off base in a residential area. No other analytes were found at the maximum concentrations in this particular sample.

Background sample BG-5 contained the highest concentrations of several metals (antimony, cadmium, chromium [same concentration as in sample BG-9], nickel, and vanadium) and dieldrin. This sample is located in the base industrial area south of Privet Road. Several other metals were found at their maximum concentrations in samples BG-1 and BG-2, which are located off base. These metals are barium, copper, manganese, silver, and zinc.

In addition, it should be noted that the discussion of exceedances is limited to those metals that are considered to be toxic to humans or animals. Therefore, metals such as aluminum, calcium, magnesium, iron, potassium, and sodium are not discussed in this or succeeding sections. These six metals are basic components of natural soil and are essential nutrients.

2.5 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

Only a portion of the data (approximately 25 percent) for NAS Willow Grove was validated by HALLIBURTON NUS Environmental Corporation personnel. The only data qualifiers applied to unvalidated data were actions taken by HALLIBURTON NUS for laboratory method and/or field quality control blank contamination. Unvalidated data considered to be false positives (i.e., nondetects) due to blank contamination were assigned a "BB" qualifier. The laboratory, however, may qualify data results as estimated ("J") if the result is less than the CRQL.

The following sections are discussions of the field and laboratory QA/QC samples associated with the validated data.

2.5.1 Field QA/QC

Field quality assurance/quality control samples consist of eighteen field duplicates, six rinsate blanks, and ten trip blanks. All samples were analyzed under NEESA Level D QA/QC criteria. NEESA requirements for Level D field QA/QC samples are as follows:

QA/QC Type	NEESA Requirement
Field Duplicate	One duplicate in 10 samples per sample matrix.
Rinsate Blank	One sample of the final rinse during decontamination of sampling equipment per day. Initially, samples from every other day are analyzed. If analytes pertinent to the project are found in the rinsate, the remaining samples are analyzed.
Trip Blank	One sample of analyte-free water per day, for each shipment of samples for volatile organic analysis.

Four volatile organic chemicals were detected as contaminants in the trip blanks. Two volatile organics, one semivolatile organic, and five metals were found as contaminants in the rinsate blanks. A summary of the maximum contaminant concentrations detected in the field quality control blanks is presented in Table 2-3. The table does not reflect blank contaminant concentrations regarded as false positives due to laboratory blank contamination. In addition, the table does not reflect false positives found in rinsate blanks that are attributable to trip blank contamination.

Positive sample results are considered to be false positives based on blank contamination if the concentration of the compound is less than or equal to action levels of 10 times (10X) the amount in

TABLE 2-3

FIELD QUALITY CONTROL BLANK CONTAMINATION SUMMARY
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	Maximum Blank Concentration[1] (μg/L)	
	Trip	Rinsate
Acetone	48	36
Methylene chloride	3J[2]	ND[3]
Toluene	1J	ND
Trichloroethene	1J	1J
Diethylphthalate	NA[4]	1J
Calcium	NA	206
Magnesium	NA	60.0
Manganese	NA	2.0
Nickel	NA	12.0
Sodium	NA	4450

(1) Blank values specified due to laboratory method or field QC blank contamination are not considered.
(2) J - Value is estimated due to data limitations specified in data validation.
(3) ND - Chemical not detected.
(4) NA - Chemical not analyzed.

any blank for the common laboratory contaminants (acetone, methylene chloride, 2-butanone, phthalates), or 5 times (5X) the amount for other compounds.

2.5.2 Laboratory QA/QC

Table 2-4 contains a list of the maximum contaminant concentrations found in the laboratory method blanks. Several organic and inorganic chemicals were detected as contaminants in these blanks resulting in the qualification of associated sample data. Qualified sample data are considered to be false positive results (i.e., nondetects). The reader is referred to the "Minor Problems" sections of all organic/inorganic data validation report narratives found in Appendix F.

An initial calibration response for 2-butanone was extremely low. Associated sample data were considered to be unreliable and were rejected on this basis. See the "Major Problems" section of the organic data validation narrative for SDG: PRB-3-002.

Some matrix spike samples exhibited extremely poor recovery for 4-nitrophenol, 2-chlorophenol, arsenic, antimony, selenium, and silver. The associated sample data were considered to be unreliable and were rejected for this reason. The reader is referred to the "Major Problems" section of the organic data validation narrative for SDG: AL-SWS-4B and inorganic narratives from SDGs: 9SL-S1, AL-SWS-4B, PRW-1F, 9SLW-1B, PRB-7-0002, and PRB-3-0002.

Other problems were noted with the analysis of several QA/QC samples such as calibration standards, laboratory duplicates, ICP serial dilutions, and ICP interferences. These data were either estimated or assigned a directional bias.

TABLE 2-4

LABORATORY METHOD BLANK CONTAMINATION SUMMARY
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	Maximum Blank Concentration
Acetone	48 μg/L
Bromoform	1 μg/L
Methylene chloride	12 μg/kg
Tetrachloroethene	2 μg/L
Toluene	1 μg/L
Xylenes	2 μg/L
1,1-Dichloroethene	1 μg/kg
1,1,1-Trichloroethane	2 μg/kg
1,1,2,2-Tetrachloroethane	1 μg/kg
2-Hexanone	2 μg/kg
Di-n-butylphthalate	34 μg/kg
Aluminum	129 μg/L
Antimony	48.0 μg/L
Arsenic	2.5 μg/L
Barium	2.0 mg/kg
Beryllium	5.0 μg/L
Cadmium	5.0 μg/L
Calcium	187 μg/L
Chromium	9.0 μg/L
Copper	20.0 μg/L
Iron	46.0 μg/L
Magnesium	77.0 μg/L
Manganese	1.0 μg/L
Nickel	16.0 μg/L

TABLE 2-4
LABORATORY METHOD BLANK CONTAMINATION SUMMARY
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA
PAGE 2

Chemical	Maximum Blank Concentration
Sodium	40.8 μg/L
Thallium	1.2 μg/L
Vanadium	4.0 μg/L
Zinc	19.0 μg/L

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

A description of the physical characteristics of NAS Willow Grove has been prepared on the basis of published information, reports of previous site studies, and information obtained and interpreted during the course of the RI study. Section 3.0 provides information related to physical characteristics which are considered to be consistent throughout the activity. Site-specific physical characteristics are discussed in Sections 4.0 through 7.0.

3.1 METEOROLOGY

NAS Willow Grove is located in southeastern Pennsylvania, approximately 10 miles north of Philadelphia, as shown on Figure 1-1. Precipitation recorded 5 miles north of the study area at Doylestown, Pennsylvania by the National Oceanic and Atmospheric Administration indicates that a range of 30.20 to 67.08 inches was recorded annually between 1965 and 1989. An average annual precipitation of 45.16 inches is recorded for the period, with distribution being fairly even throughout the year (Sloto and Davis, 1983).

3.2 SURFACE WATER HYDROLOGY AND TOPOGRAPHY

The activity is situated within an upland area divided between two local drainage basins, the Little Neshaminy Creek Basin on the north and the Pennypack Creek Basin on the south. The greater portion of the activity drains toward the north through several unnamed ephemeral, intermittent, and perennial drainages into Park Creek, which is a tributary of Little Neshaminy Creek. The southern tip of the activity, including the Antenna Field Landfill (NAS Site 2) and a portion of the Fire Training Area (NAS Site 5) flows toward Pennypack Creek, which is located approximately 1/2 mile south of the activity. Both local drainage basins lie within the regional drainage basin of the Schuylkill River.

Surface topography, as depicted by the U.S. Geological Survey quadrangle for the vicinity (Ambler, Pennsylvania quadrangle, 1966) indicates that the activity represents a relative topographic high, precluding surface water flow onto the facility from surrounding properties. Surface elevations range from a high of approximately 370 feet MSL in the vicinity of Taxiway Juliet to a low of approximately 240 feet at the north end of the activity.

Drainage within the activity is controlled primarily through natural flow to ephemeral streams and through constructed drainage systems. A significant portion of precipitation runoff is directed by surface

grading to constructed ditches or storm sewer lines. Discussion of constructed drainage was presented in the SI Report for the activity (EA, May 1990).

3.3 SOILS

A soil survey of Montgomery County (U.S. Department of Agriculture, 1967) shows four major soil series mapped within NAS Willow Grove. These series include the Lansdale, Lawrenceville, and Readington loam and silty loam soils, and shaley, silty loams of the Reaville Series. Minor areas of other series, chiefly silt loam materials, are developed in small, low-lying areas. The silt loam soils developed on higher ground have been reported to have a moderate to high permeability, limiting runoff in favor of infiltration on vegetated lands during normal precipitation events.

3.4 REGIONAL GEOLOGY

The bedrock underlying NAS Willow Grove consists primarily of the middle arkose member of the late Triassic age Stockton Formation. The Stockton Formation is underlain by basement rocks of Ordovician to Precambrian age and overlain by the shale-rich Lockatong Formation, also of late Triassic age, outcropping north of the activity.

The Stockton Formation is composed of fine- to coarse-grained arkosic sandstone and conglomerate, interbedded with shale and siltstone. These rocks have been interpreted to have been deposited by coalescing alluvial fans which deposited sediment eroded from highlands to the south (Sloto and Davis, 1983). Throughout the Stockton Formation, units of varying lithology are irregularly interbedded, with coarse-grained units commonly overlying fine-grained units. Beds commonly pinch out or form gradational contacts with overlying or underlying beds over lateral distances greater than several hundred feet (Rima et al., 1962). The Stockton Formation is divided into lower, middle, and upper members, with NAS Willow Grove located in the outcrop of the middle member.

The lower member of the Stockton Formation is dominated by coarse-grained arkosic sandstone and conglomerate. Beds of medium-grained arkosic sandstone are common, although less abundant than coarser-grained units. In the vicinity of NAS Willow Grove, this unit is less than 1,500 feet thick, and has a maximum thickness of approximately 2,700 feet west of the site near Ambler, Pennsylvania. The transition between lower and middle members is transitional (Rima et al., 1962).

The middle member of the Stockton Formation consists of fine- to medium-grained arkosic sandstone interbedded with shale. Beds of shale and siltstone are common in the upper portion of the middle member, while coarser-grained units are more common in the lower portion of the member. These

rocks are weakly cemented and well sorted, accounting for a relatively high porosity compared to the upper and lower members of the formation (Rima et al., 1962). Underlying NAS Willow Grove, the middle member is approximately 4,200 feet thick, and typically weathers to a depth of 15 to 35 feet (EA, August 1991).

The upper member of the Stockton Formation is generally not present in the vicinity of NAS Willow Grove. This member consists of shale, siltstone and fine-grained arkosic sandstone. In general, grain size decreases upwards, with beds of fine-grained sandstone most common in the lower portion of this member.

In the fine- and medium-grained sandstones of the Stockton Formation, groundwater is transmitted through primary porosity (between grains), as well as along fractures and bedding planes. The shale and siltstone beds are commonly too fine-grained to transmit large amounts of groundwater through primary porosity. Fractures or joints (secondary porosity) are typically not well developed in the fine-grained beds. In general, fracture permeability is better developed in the sandstone layers compared to the shale and siltstone layers of this formation. Consequently, transmissivity and groundwater movement is greater parallel to sandstone layers than across them (Rima et al., 1962). Numerous sets of vertical joints were reported by EA Engineering (August 1991) and Earth Data, Inc., (1985) in the vicinity of NAS Willow Grove. The degree or development and vertical extent of these features is apparently unknown.

Bedding layers are broken by small displacement normal faults which parallel the strike of the Stockton Formation, trending northeast-southwest. The upthrown blocks of these faults are to the northwest (EA, August 1991). A nearly vertical diabase dike cuts the Stockton Formation just south of the NAS Willow Grove boundary. This dike is approximately 90 feet thick and trends northeast-southwest (Rima et al., 1962). The Stockton Formation dips at approximately 7 to 14 degrees to the north-northeast.

3.5 REGIONAL HYDROGEOLOGY

The major groundwater production aquifer in the vicinity of NAS Willow Grove consists of the fractured bedrock of the Stockton Formation. Groundwater beneath the activity occurs under both water table and confined conditions, with movement through the aquifer being through both primary and secondary porosity. A hydrogeology report for the activity (Earth Data, Inc., 1985) suggests that a large percentage of the water available to production wells is transmitted through zones of increased porosity and permeability developed due to extensive subsurface fracturing. The report further suggests that the

shallow aquifer zone consisting of weathered bedrock lying between the bedrock and soil horizons has a high porosity and is therefore responsible for large amounts of groundwater storage.

3.6 ECOLOGY

An ecological evaluation of the activity was completed during the Site Inspection phase of the NAS Willow Grove study. Biological features, including ecosystems and discussion of endangered and threatened species, was presented in the SI Report for this activity (EA, May 1990). It was determined during the SI investigation that endangered or threatened wildlife and plants included in either the U.S. Fish and Wildlife Service lists or the Commonwealth of Pennsylvania lists under Chapter 147, Title 58 have not been reported within the boundaries of NAS Willow Grove. One species, the peregrine falcon, which is included on the Federal Endangered and Threatened Species List, has been observed in the area, but is considered to be a rare seasonal transient.

4.0 PRIVET ROAD COMPOUND SITE - NAS SITE 1

4.1 SITE HISTORY AND DESCRIPTION

The Privet Road Compound consists of a fenced area approximately 1/2 acre in size located immediately east of and across Privet Road from NAS Willow Grove Building No. 6, as shown on Figure 1-2. The compound was constructed to serve as a transfer station for wastes after closure of the 9th Street Landfill (Site 3) in 1967. According to the Final SI Report (EA, May 1990), between 1967 and 1975 the compound was used as an open disposal area where appreciable quantities of wastes were burned and buried. The suspected waste handling area, as shown in the Plan of Action (EA, August 1991) extends outside the limits of the fenced compound, and covers more than 2 acres, including the present location of the bowling alley and parking area.

Results of RI sampling and analysis are consistent with the findings of the Site Inspection (SI) completed by EA Engineering, in terms of prevalent chemical compounds. Estimated quantities of materials disposed of at the compound during the time of operation are presented within that document. Analytical results for the Privet Road Compound soil, groundwater, surface water, and sediment samples are summarized in Section 4.5 of this report and are presented in tabular form in Appendix A.

4.2 SUMMARY OF PREVIOUS SITE INVESTIGATIONS

Previous investigation work related to the Privet Road Compound Site included a Preliminary Assessment (PA) and a Site Inspection study (SI). The PA indicated that the Privet Road Compound was a potential source of volatile organic compounds, polychlorinated biphenyls (PCBs), dieldrin, chromium, and lead. Based on these findings, an SI was recommended for the site.

In 1989, a Site Inspection was conducted (EA, 1990). Site investigation work included sampling and laboratory analysis of groundwater, subsurface soil, and drainage ditch sediment. Four 4-inch monitoring wells and two test borings were installed at the site. Groundwater, soil, and sediment samples were collected and analyzed for Target Compound List (TCL) volatile organics, semivolatile organics, and pesticides/PCBs; Target Analyte List (TAL) metals (both total and dissolved for groundwater samples), total organic carbon (TOC), total petroleum hydrocarbons (TPH), and cyanide. Three sediment samples collected from surface drainage ditches located along the north and east boundaries of the site were analyzed for TCL/TAL parameters, TOC, and TPH. Three rounds of groundwater sampling were completed during the study.

Volatile organic chemicals were detected in samples collected from the four shallow monitoring wells that surround the site. Several of these compounds were present at concentrations that exceeded Safe Drinking Water Act Maximum Contaminant Levels (MCLs) (tetrachloroethene and trichloroethene). In addition, Aroclor-1260, dieldrin, 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, and lead were also found in at least one sample at concentrations that presented a potential concern and prompted additional investigation.

Several soil samples were also collected during the course of the site inspection. No volatile organic chemicals were detected, however several polynuclear aromatic hydrocarbons were found at concentrations below the Contract Required Detection Limits (CRDLs). In addition, Aroclor-1260, dieldrin, and 4,4'-DDT were also detected. None of the soil samples were collected from inside the fenced area where actual waste handling occurred.

Some potential for offsite migration of contaminated media was also noted with the detection of Aroclor-1260 and dieldrin in the sediment samples collected from the drainage swales located outside the fenced area. Based on the findings of the SI, the site was recommended for an RI/FS.

4.3 PHASE I REMEDIAL INVESTIGATION

Previous investigations at the site have indicated that the Privet Road Compound may be a contributing source of volatile organic compounds, PCBs, dieldrin, chromium, and lead in groundwater. Therefore, soil borings were advanced to further characterize the suspected source area, and additional shallow and intermediate depth wells were installed and sampled to further delineate the vertical and horizontal extent of groundwater contamination. Surface water and sediment sampling was conducted to assess the potential for contaminants to migrate into adjacent drainage pathways. Two separate pumping tests and three periods of baseline data collection during normal pumping conditions were conducted to assess the impact of nearby production wells on the groundwater regime at the site. Of particular interest was the relative influence of pumping from existing Navy production wells on the water table aquifer and a deeper, semi-confined aquifer. All samples obtained from the Privet Road Compound Site were analyzed for TCL volatile organics, pesticides/PCBs, TAL metals (total and dissolved in groundwater), and cyanide.

4.3.1 Soil Investigation

A total of 16 soil borings were drilled as part of the field investigation. Boring locations are shown on Figure 4-1. Drilling was performed by a HALLIBURTON NUS subcontractor under the direction of

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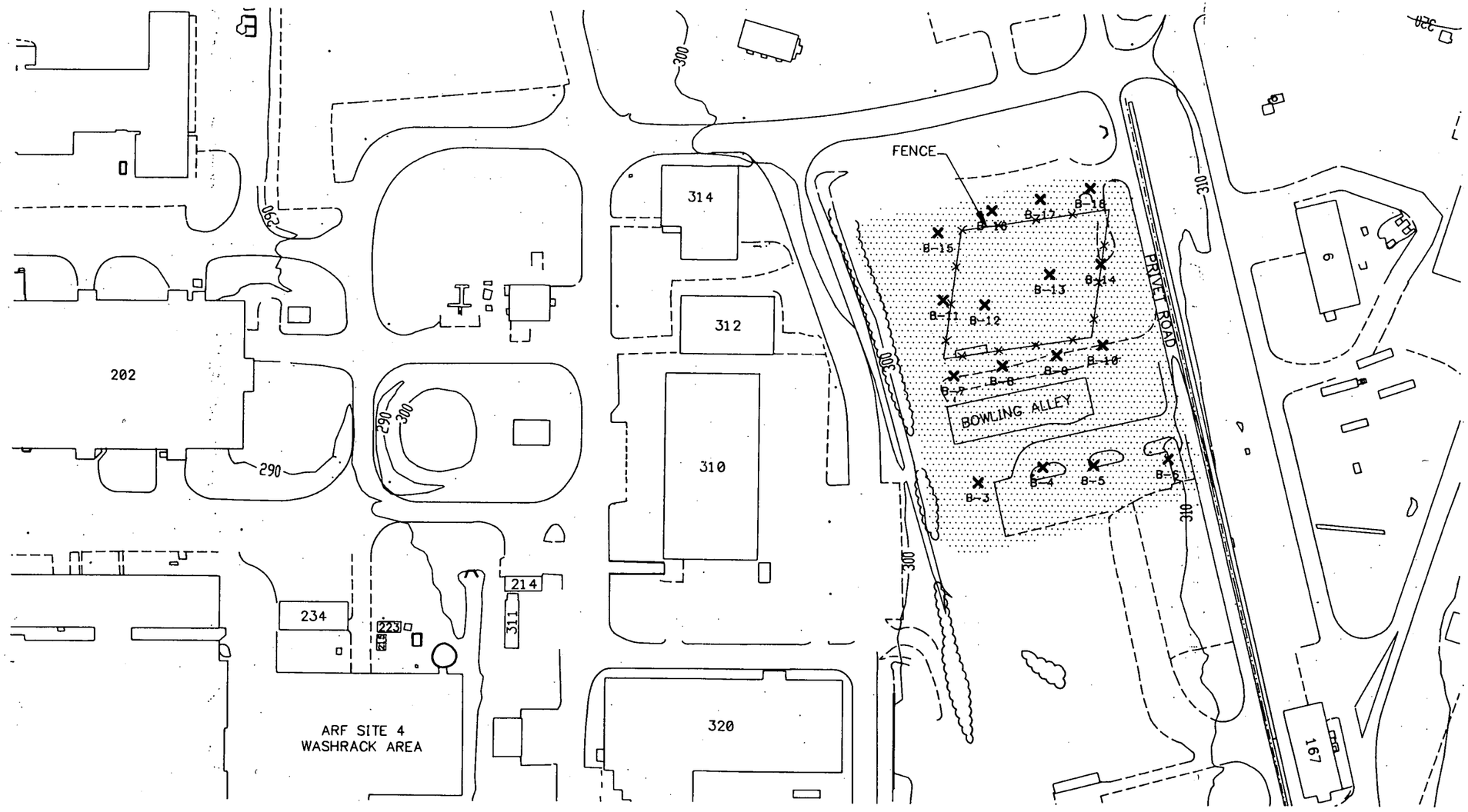

LEGEND

✕ SOIL BORING LOCATION

SUSPECTED WASTE AREA

SOIL BORING LOCATIONS
NAS SITE 1 – PRIVET ROAD
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

0 100 200
SCALE IN FEET

FIGURE 4–1

HALLIBURTON NUS
Environmental Corporation

HALLIBURTON NUS geologists. The boreholes were advanced using an Acker-82 drill rig equipped with a 140-pound hammer dropped a distance of 30 inches (ASTM D 1586-84 designation). Split-spoon samplers (2-inch-diameter by 2-foot-long) were driven continuously from the ground surface to the total depth of the boring. One soil sample was obtained from each 2-foot interval and submitted to the laboratory for the full range of analytical parameters specified by the Draft Plan of Action (EA, May 1991). A 6-inch inside-diameter (ID) hollow-stem auger was then used to advance the boring to the next sample interval. Borings were terminated upon refusal of the split-spoon sampler. When each borehole was completed, the borehole was backfilled with the drill cuttings. Up to five subsurface soil samples were collected per borehole for chemical analysis.

Soil densities, color, and lithologies were documented for each borehole. Borehole logs are included in Appendix B. A portable photoionization detector (PID) was used to screen each recovered interval as well as the general borehole vicinity and downhole conditions for volatile organics contamination. In boreholes where more than five subsurface soil samples were obtained, the three samples with the highest instrument readings, along with the shallowest and deepest sample obtained, were sent to the laboratory for chemical analysis. All downhole drilling equipment and the back end of the drill rig were decontaminated between borings.

4.3.2 Groundwater Investigation

4.3.2.1 Drilling, Installation, and Sampling of Monitoring Wells

Eight monitoring wells were installed as part of the RI field investigation at the Privet Road Compound. Three shallow wells and five intermediate wells were installed in addition to four existing shallow wells installed during SI activities. Intermediate wells were installed adjacent to existing shallow wells to facilitate monitoring of the separate aquifer zones. The locations of all wells installed during RI and SI activities at both the Privet Road Site and the adjacent Washrack Area Site (currently being investigated through Extended Site Inspections under separate contract) are shown on Figure 4-2. Wells were drilled and installed by a HALLIBURTON NUS subcontractor using two Mobil B-80 drill rigs and air percussion and hollow-stem auger methods.

One well location at each well cluster was logged by obtaining split-spoon samples of the unconsolidated overburden to the top of weathered bedrock. Soil from each sampling spoon was placed in glass sample jars. Within 1 to 2 hours, the headspace from each sample was screened with a field PID for organic vapors, and results were documented along with soil densities, color, and lithologies. When auger refusal occurred, the hole was reamed to an 8-inch nominal-diameter borehole

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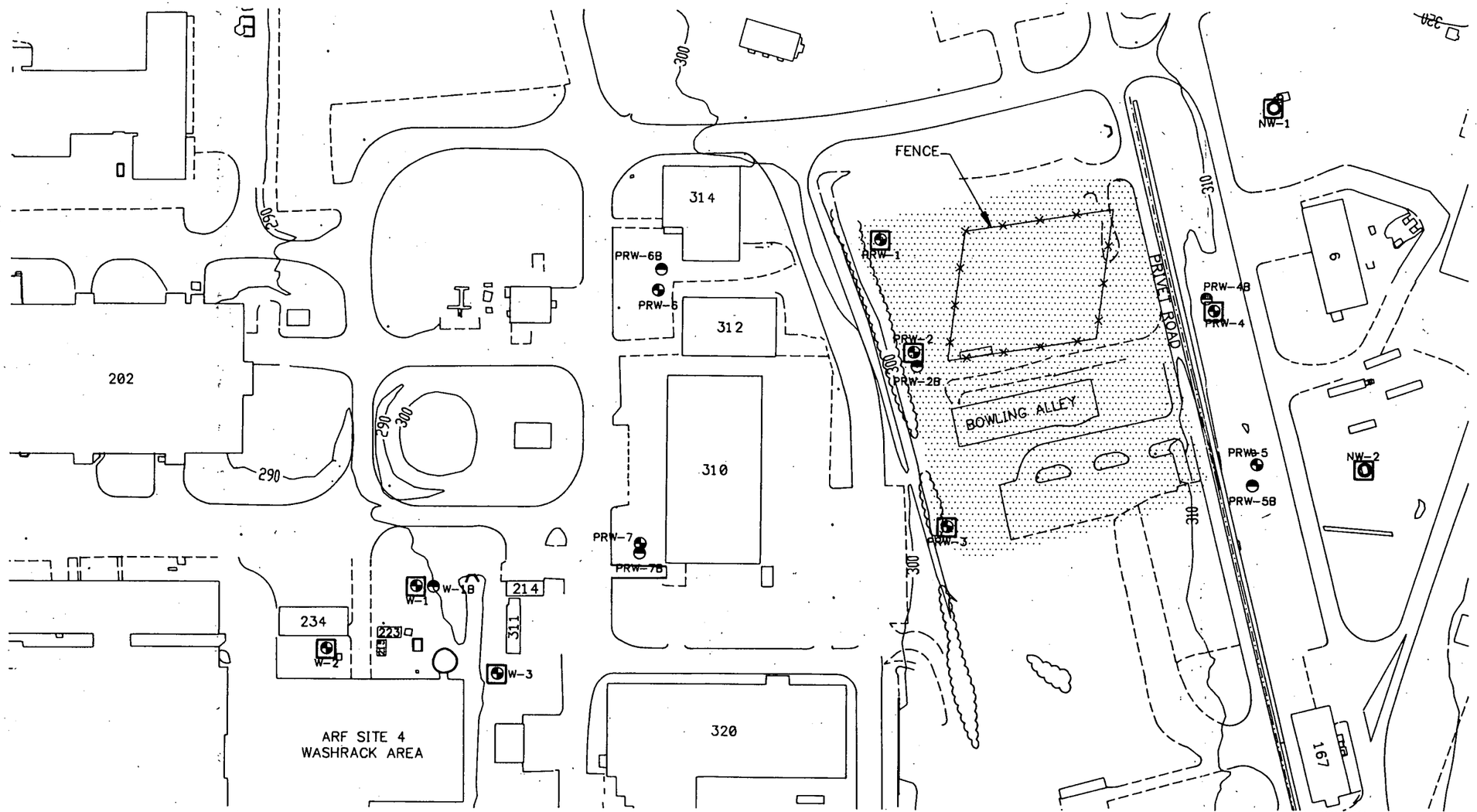

LEGEND

- SHALLOW WELL
- INTERMEDIATE WELL
- PRE-EXISTING WELL
- NAVY-PRODUCTION WELL
- SUSPECTED WASTE AREA

0 100 200
SCALE IN FEET

WELL LOCATIONS
NAS SITE 1 - PRIVET ROAD
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 4-2

HALLIBURTON NUS
Environmental Corporation

for shallow wells, or 10-inch nominal-diameter borehole for placement of permanent casing for intermediate depth wells.

The depth of the shallow wells was determined on the basis of water level encountered to ensure that the screened interval was set to intersect the top of the shallow aquifer.

Shallow wells ranged in depth from 28 to 39 feet and were constructed of 4-inch-ID Schedule 40, flush-jointed, threaded PVC casing and well screen. A 6-inch unslotted sediment trap was installed at the bottom of 20 feet of factory-slotted (0.01-inch) well screen. Wells were filter packed with No. 2 quartz sand from the total depth of the well to a minimum 2 feet above the top of the screen. A minimum 2-foot-thick bentonite pellet seal was then installed on top of the sand pack. All wells were continuously grouted via tremie pipe from the top of the bentonite seal to the ground surface with a 20:1 cement-bentonite mixture grout. Well construction details are provided in Table 4-1.

Intermediate wells were initially drilled with a 10-inch-diameter hammer bit to allow for the placement of 8-inch-diameter permanent steel casing. The steel casing was placed to a depth of 5 to 10 feet into competent bedrock and grouted via tremie pipe with the cement-bentonite grout mixture. Grout was allowed to hydrate for a minimum of 24 hours prior to drilling through the casing with a 7-7/8-inch drill bit to accommodate placement of 4-inch schedule 40 well screen and riser. Intermediate wells were to be drilled to a target depth of 80 to 100 feet in accordance with the Final Plan of Action (EA, August 1991). Actual depths ranged from 85 to 90 feet. Well construction was identical to shallow well construction with the exception that 10 feet of well screen was installed in intermediate wells and 20 feet of well screen was installed in shallow wells.

All wells were completed with 8-inch-diameter steel protective casing rising approximately 2 feet above the ground surface. Wells were secured with a locked cap, and the outside of the steel risers were painted bright yellow to increase visibility.

The monitoring wells were developed with a submersible pump. Specific conductance and pH were measured for each well volume removed. Development continued until three consecutive pH and conductivity readings did not vary by more than 10 percent, or for a maximum of 3 hours. Newly installed wells were not sampled until 2 weeks after development to assure that samples collected were representative of actual aquifer conditions.

Before all the new and existing monitoring wells were sampled, five well volumes were purged using a stainless-steel submersible pump, stainless-steel bailers, or Teflon bailers. The purging method (i.e., bailing or pumping) was selected on the basis of the calculated well volume, with deeper wells generally

TABLE 4-1

WELL COMPLETION DATA
PRIVET ROAD COMPOUND
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

HNUS Well Number	Total Depth(1)	Date Completed	Ground Elevation(2)	Elevation Top PVC(2)	Depth to Water(3)	Groundwater Elevation(2)	Screen(1)		Sand Pack(1)	
							From	To	From	To
PRW-2B	90	09/04/91	302.3	303.67	15.27	288.40	78	88	75	88.5
PRW-4B	92	09/03/91	311.2	313.27	25.71	287.56	80	90	78	90.5
PRW-5	40	08/29/91	311.1	212.61	23.81	288.80	18.5	38.5	16.5	40
PRW-5B	88	09/03/91	311.4	313.03	25.42	287.61	75	85	72	86
PRW-6	28	08/29/91	295.8	298.07	9.60	288.47	6	26	5	28
PRW-6B	85	08/30/91	296.5	297.85	9.89	287.96	74.5	84.5	71.5	85
PRW-7	29	09/03/91	296.3	298.30	9.76	288.54	6	26	5	29
PRW-7B	85	09/03/91	296.2	297.20	8.78	288.42	74	84	72	85

(1) Measurements in feet from surface.
(2) Measurements in feet above sea level.
(3) Measurements from top of PVC.

Note: Water levels measured 09/13/91.

being purged using pumping methods due to greater well volume. Decontaminated stainless steel or Teflon bailers were considered to be interchangeable. Calculations of well volumes required measurement of the water level elevations and well depths, which were measured to a surveyed mark on the casing with an electronic water level indicator. Well volume calculations included casing volume plus the saturated gravel pack, assuming 30 percent porosity. Wells that were purged dry were allowed to recover, and purged a second time. Samples were obtained within 24 hours of purging.

Samples were collected with dedicated Teflon or stainless-steel bailers and new lines. The first aliquot for sampling was used to fill the volatile organic analysis (VOA) containers. All sample bottleware was labeled, sealed, and shipped under approved United States Environmental Protection Agency (EPA) procedures for chain-of-custody and sample handling.

4.3.2.2 Aquifer Testing

The hydraulic characteristics of the groundwater system(s) were interpreted by performing a series of pumping tests. Tests were performed using two Navy wells which produce from the general level of the intermediate depth wells installed at the site. Actual depths of the production depth wells are 398 feet for Navy Well No. 1 and 352 feet for Navy Well No. 2. No means of measurement of precise pumping rates was available and production well plumbing configuration did not allow measurement of drawdown in pumping wells. Based on previous pumping data it is estimated that the production rates for Navy Wells No. 1 and 2 are approximately 240 to 250 gpm. The scope of work detailed in the Plan of Action was modified in the field in order to accommodate the capabilities of the base water supply system. The changes resulted in a 12-hour pumping test on Navy production Well No. 2 and a 24-hour pumping test on Navy production Well No. 1. Prior to starting the 12-hour pumping test, during the period between pumping tests, and after completion of the 24-hour pumping test, water level monitoring was performed to establish baseline conditions and to record the response of the aquifer during post pumping recovery. Two samples were collected during the pumping test in addition to those included in the Plan of Action. Each Navy production well was sampled for chemical analysis shortly after the start of pumping, and again at the end of the pumping period.

All 12 new and existing wells at the Privet Road Compound and four wells at an adjacent site (Washrack Area) were monitored with electronic water level data recorders during each pumping test. The locations of all monitored wells and pumping (production) wells are shown on Figure 4-2. All wells except Washrack well W-2 were monitored for 12 days before the pumping tests to record the effects of normal pumping schedules on water levels and groundwater underlying these sites (baseline conditions).

Before the start of the pumping test on Navy production Well No. 2, all pumping at water supply production wells (including Navy Well No. 1) was stopped for 12 hours to allow the aquifer to stabilize. During the pumping of production Well No. 2, the water levels in an adjacent observation test well (OTW) were monitored by hand every hour to assure that the production well would not be pumped to a level which could damage the pumping equipment. The OTW was located approximately 20 feet from the production well. After the 12-hour pumping test, the production well was shut down for 14 hours to allow the aquifer to recover.

The 24-hour pumping test was performed on Navy production Well No. 1. The pre-pumping stabilization period for this test was 19 hours during which both Navy production wells were shut off, and a 12-hour recovery period was attained after pumping was stopped. This production well was not equipped with an adjacent OTW.

The 12 wells at the site were also monitored during normal pumping of both production wells simultaneously. This monitoring provided information related to baseline aquifer response. Pumping from individual wells provided information pertaining to the heterogenous characteristics of the aquifer, as discussed in Section 4.4.4.

All water removed during the pumping tests was treated via the on-line air stripping system and stored for use as onsite potable water.

Each pump test required a initial and post-pumping test sample to be collected. The initial groundwater sample was collected 10 minutes after the start of the pumping test and was collected from a pre-treatment ball valve sample location on the side of each respective pump house. The post-pumping test sample was collected 10 minutes before the end of each pumping test, in the same manner as the initial sample.

A detailed discussion of the hydrogeology can be found in Section 4.4.4.

4.3.3 Surface Water and Sediment Investigation

Grab samples of surface water were collected in appropriate glass bottles. Corresponding sediment samples were taken at the same location with a stainless-steel trowel. All sampling occurred upstream of any disturbances caused by the sampler or sampling team. All five proposed sediment sample locations were collected during dry conditions, on the same day. All five surface water samples were collected after an overnight rain. All locations were adequately staked or pinned to allow the surface water sample to be collected at the same location at a later date. Downgradient samples were collected

first, and upgradient samples were collected last. All samples were labeled, sealed, and shipped according to established EPA chain-of-custody and sample-handling procedures. Surface water and sediment sample locations at the Privet Road Site are shown on Figure 4-3.

4.4 SITE CHARACTERISTICS

4.4.1 Surface Features

The Privet Road Compound lies within a relatively well developed section of the activity, occupying the area between Privet Road and the Air Reserve and Pennsylvania National Guard facilities. The activity bowling alley and associated parking area cover a significant portion of the ground surface south of the compound. The compound area is approximately 1/2 acre in size and contains many scattered piles of miscellaneous household and construction debris in various stages of sorting by material type. The ground surface is unvegetated and characterized by vehicle ruts and scattered debris mixed with near surface soils.

4.4.2 Geology

The near surface geology of the site has been characterized most recently through the completion of 16 boreholes and 8 monitoring wells. Observations made during this work were consistent with the findings of earlier drilling performed and reported during SI work. Borings advanced in the vicinity of the compound (Figure 4-1) consistently encountered weathered sandstone underlying sandy silt, silty sand, and silty clay material. The top of the weathered bedrock surface ranged from approximately 7 feet below the ground surface in the vicinity of the bowling alley parking area, and increased in depth to approximately 12 feet near the northeast side of the compound. Fill material, generally having a high gravel content, was encountered within the top 1 to 2 feet of each test boring but was not observed at well borings located outside the limits of the suspected waste area.

Bedrock encountered in monitoring well borings ranging from 29 to 92 feet in depth was generally logged as an alternating sequence of fine- to medium-grain sandstone and siltstone. Thin shale seams were encountered sporadically at borings located in the compound area and east of Privet Road. A red siltstone and shale was consistently logged at PRW-6 and PRW-7 locations, approximately 200 to 300 feet west of the compound. This red horizon graded to a red sandstone at the western side of the compound and was not logged at wells east of Privet Road. This observation is consistent with earlier reports of discontinuous, pinching, or gradational change laterally within the Stockton Formation.

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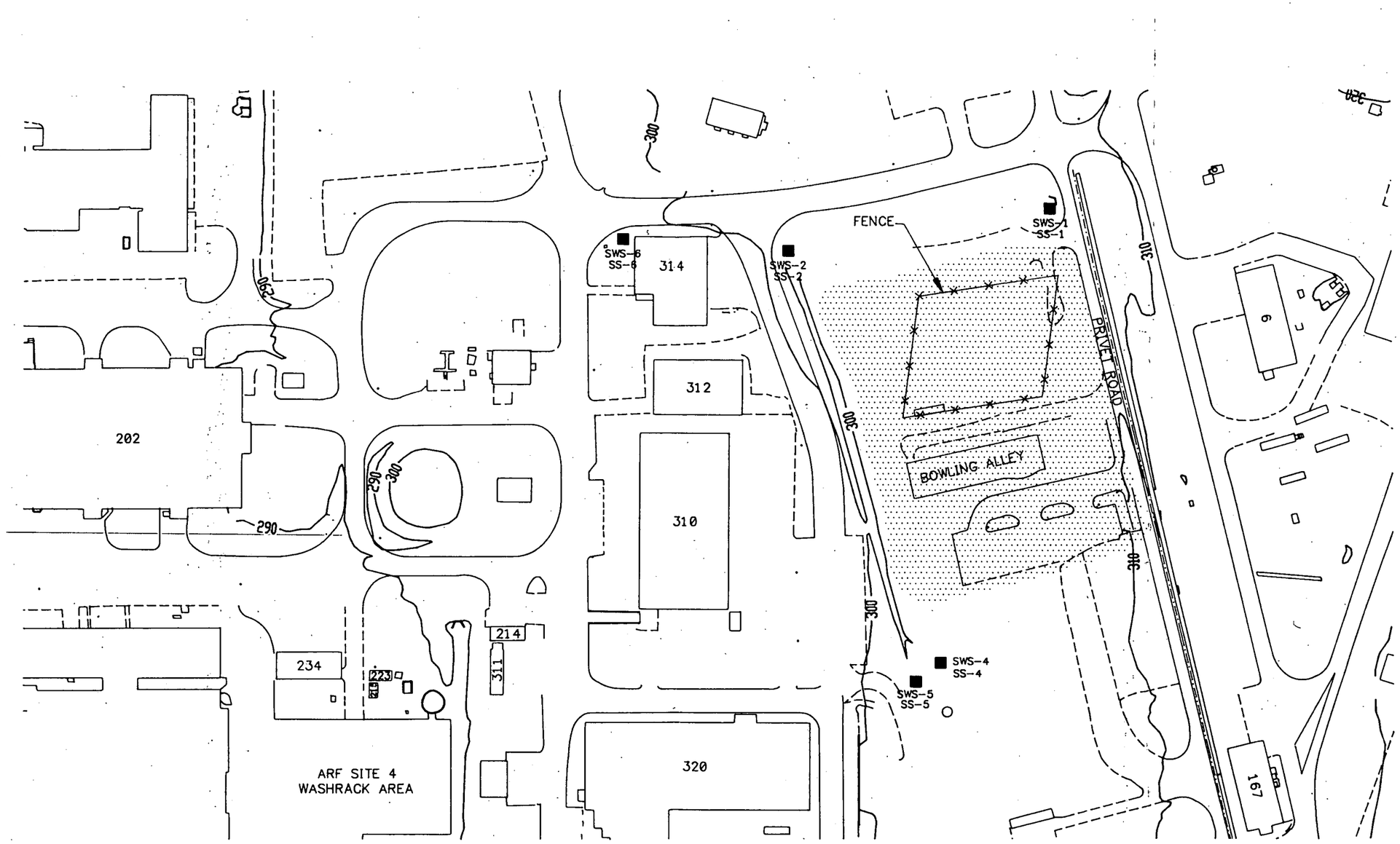

LEGEND

■ SURFACE WATER/SEDIMENT SAMPLE LOCATION

SUSPECTED WASTE AREA

0 100 200
SCALE IN FEET

FIGURE 4-3

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
NAS SITE 1 – PRIVET ROAD
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

HALLIBURTON NUS
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Alternating zones logged as "soft" or "more porous" and having higher water yield were characteristic of the well borings. Possible fracturing and an increase in water discharge associated with the air rotary drilling technique were logged at depths of 72 and 82 feet in wells PRW-6B and PRW-7B, respectively. Increase in drilling water yield was also commonly observed at various shallower depths, typically associated with lithologic variation of the formation. A detailed description of the rock associated with higher water yield was not possible due to the air percussion drilling method used. Cross section A-A' (Figure 4-4) shows the generalized lithologic characteristics through the site.

4.4.3 Hydrology

The ground surface in the vicinity of the Privet Road Compound Site slopes at a grade of approximately 2 percent toward the northwest. Although a significant portion of the ground surface in the area is covered by impermeable paving material, it is probable that the relatively gentle slope, intermittent vegetated areas, and rutted, uneven nature of the ground surface in the compound area result in infiltration of most precipitation during normal weather conditions.

Storm drainage swales parallel the northeast and southeast sides of the compound, intersecting at the northern corner of the site. Runoff entering the site from the south is precluded by grading and a storm drainage channel located along the south side of Privet Road. Runoff from the compound through the drainage swales outfalls to the Air Reserve Facility Detention Basin. Water flow from the detention basin follows an unnamed tributary to Park Creek and enters the Little Neshaminy Creek drainage basin.

4.4.4 Hydrogeology

The hydrogeology of the Privet Road site has been interpreted during previous investigations (Earth Data, Inc., 1985; EA, May 1990). The earlier report focused primarily on the aquifer characteristics related to production wells drawing from relatively deep sections of the aquifer. The SI studies (1990) were developed to obtain information related primarily to the water table aquifer and the occurrence of shallow groundwater contamination associated with waste disposal at the site.

Both studies indicated that the general direction of groundwater movement in the vicinity was toward the northwest. The earlier study used water level measurements obtained during non-pumping conditions from production wells as well as both deep and shallow monitoring wells. No deep wells were installed or measured during the SI phase. The 1985 study indicated that some interconnection existed between the deeper and shallow aquifer zones and limited data (one shallow well) suggested that a slightly

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higher head existed in the water table zone, which would result in downward migration of shallow groundwater.

The RI was designed to obtain information related to both shallow and deep aquifer characteristics, and the interaction between the two the aquifer zones. Data were obtained during baseline conditions and during separate pumping tests involving Navy Wells No. 1 and No. 2, located along the northeast side of Privet Road, as shown on Figure 4-5. The five intermediate wells and three shallow wells installed during the RI, as well as eight pre-existing wells, were monitored during both pumping and non-pumping conditions. Piezometric elevations are shown on Table 4-2.

Water levels recorded during normal pumping conditions indicate a significant difference in groundwater flow direction between the shallow and deeper sections of the aquifer. As indicated by the potentiometric surface maps (Figures 4-5 and 4-6), the direction of groundwater flow is approximately reversed between the two zones during normal pumping conditions. Contouring of water levels in the water table wells indicates that the general flow direction is toward the northwest, which is consistent with earlier observations. In contrast, water levels measured in the intermediate wells during the same period show a relatively steep gradient (0.001) toward the east-southeast, in the direction of the pumping wells.

These data suggest that the direction of groundwater flow in the water table zone is not influenced by pumping and that minimal if any recharge to the deeper portion of the aquifer from the water table zone exists. However, continuous measurement of the water level in shallow wells during pumping tests shows a subdued response in some wells to pumping from the deeper production wells, indicating that at least some restricted interconnection exists between the two zones. Further, a slightly higher head in shallow wells at some shallow/intermediate well groups indicates that vertical migration of groundwater and contaminants from the water table zone to the level of the pumping wells is probable.

During standard operating conditions, activity water requirements are met by simultaneously pumping from Navy Wells No. 1 and 2, as required to maintain a supply reservoir at desired levels. When the water level in the reservoir drops to a predetermined level, both pumps are engaged and pump continuously until the reservoir is filled to its upper level. Pumping cycles were observed to range from approximately 3 to 4 hours of pumping followed by 6 to 8 hours of aquifer recharge during storage reservoir depletion. Figure 4-7 is a typical plot of three drawdown and two recovery cycles recorded on a continuous data logger at intermediate depth monitoring well PRW-5B.

Sharp breaks, or reversals in the drawdown recovery curves at the beginning and end of each pumping cycle shown on Figure 4-7 indicate a relatively high transmissivity between the pumping well and the

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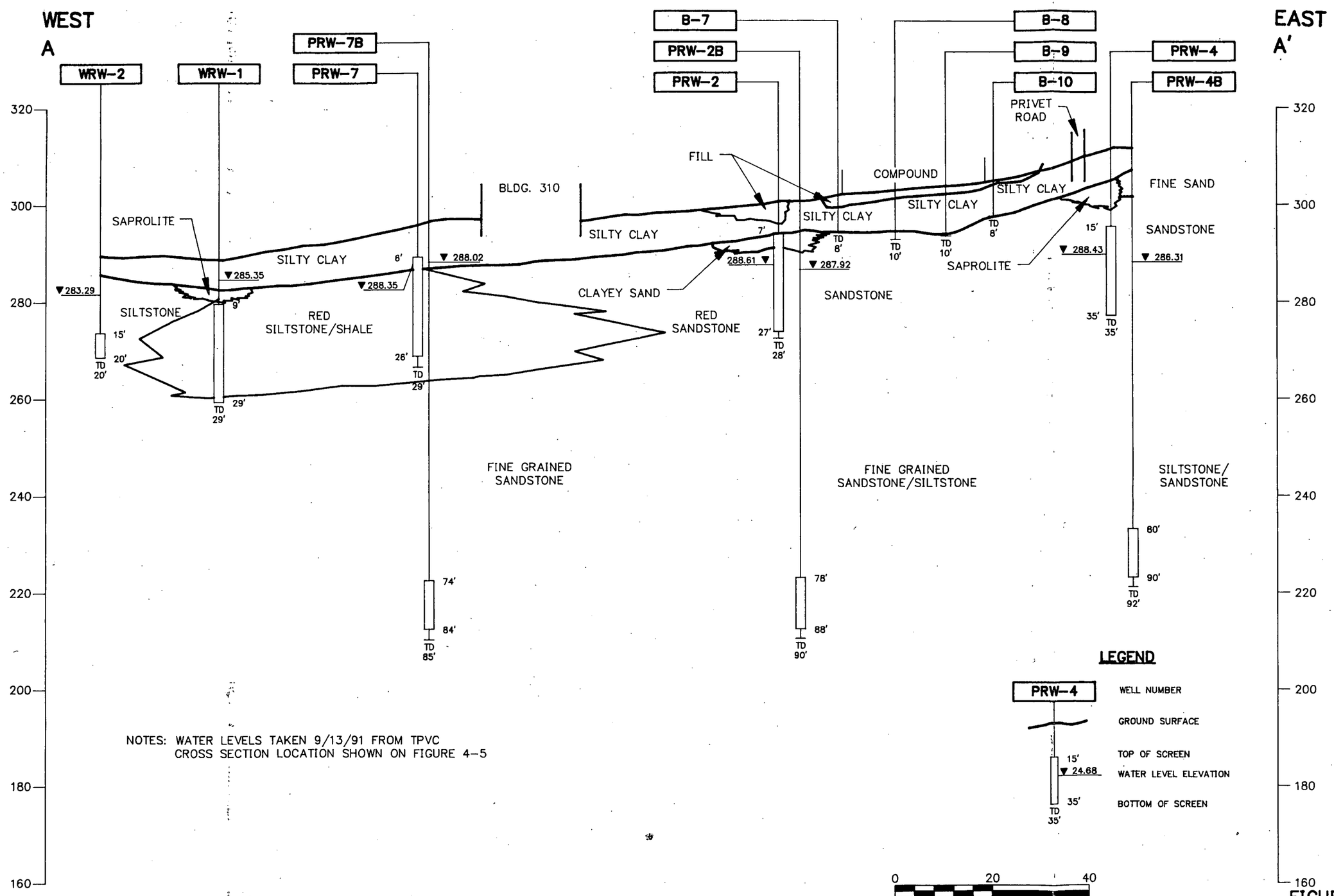

NOTES: WATER LEVELS TAKEN 9/13/91 FROM TPVC
CROSS SECTION LOCATION SHOWN ON FIGURE 4-5

CROSS SECTION A-A'
NAS SITE 1 - PRIVET ROAD
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 4-4

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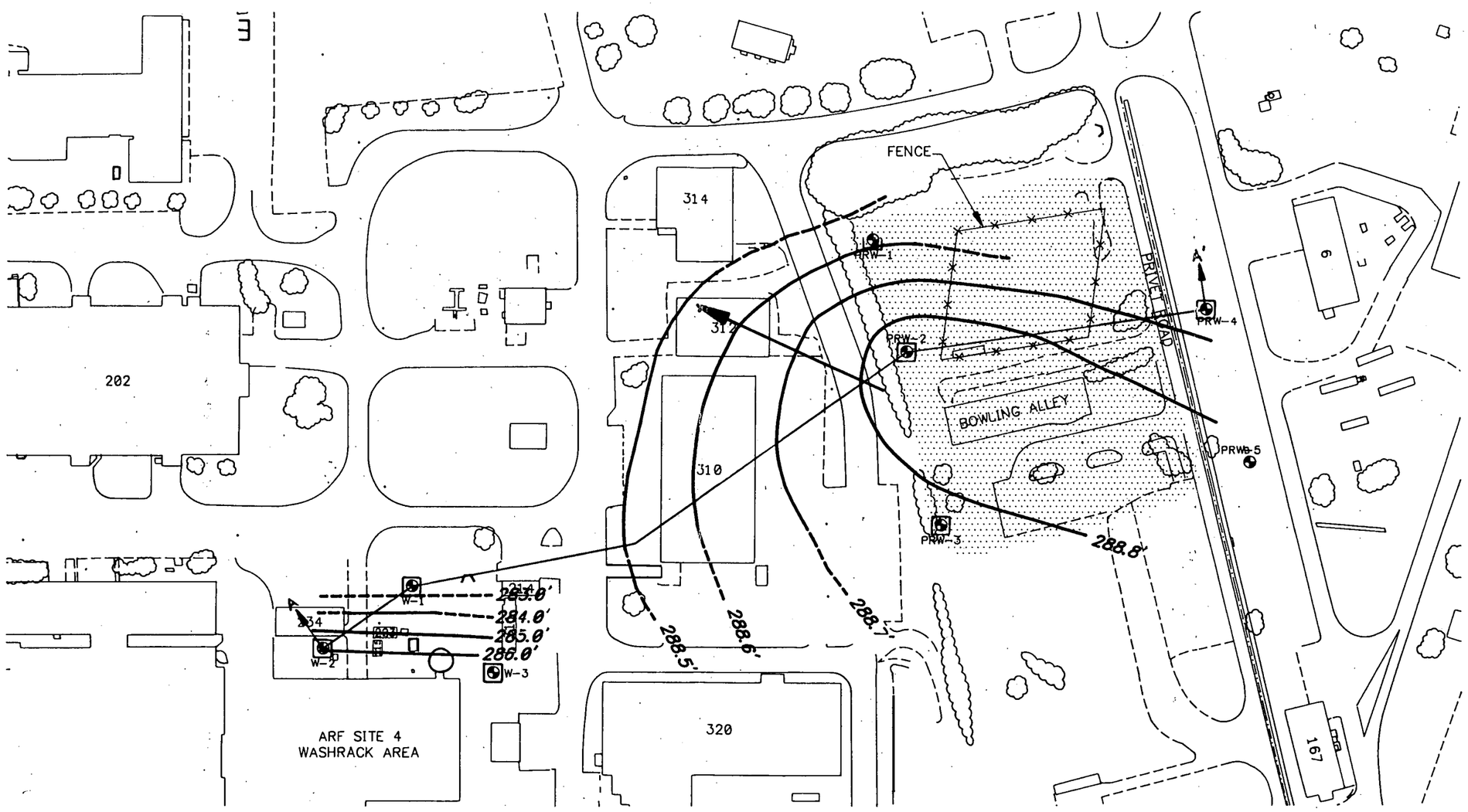

NOTE:

CONTOUR INTERVAL 1.0 FEET AND 0.1 FOOT
WATER LEVELS MEASURED ON 9/13/91
GROUND WATER CONTOURS MEASURED IN FEET ABOVE MSL.

"WATER LEVEL MEASUREMENTS OBTAINED DURING NORMAL (BASELINE) PUMPING CONDITIONS"

LEGEND

- SHALLOW WELL
- PRE-EXISTING WELL
- 5.0 — CALCULATED WATER TABLE CONTOUR (DASHED WHERE INFERRED) MEASURED IN FEET ABOVE MSL.
- SUSPECTED WASTE AREA
- A A' — CROSS SECTION LOCATION
- GENERAL DIRECTION OF GROUND WATER FLOW

0 100 200
SCALE IN FEET

POTENTIOMETRIC SURFACE MAP OF SHALLOW WELLS
NAS SITE 1 – PRIVET ROAD
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 4–5

HALLIBURTON NUS
Environmental Corporation

TABLE 4-2

WATER LEVEL DATA[1]
PRIVET ROAD/WASH RACK AREA
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Well Number	Top PVC Elevation	Ground Elevation	Water Level[2] (Normal Pumping)	Water Elevation (Normal Pumping)	Water Level[2] (Non-Pumping)	Water Elevation (Non-Pumping)
PRW-1	305.50	303.71	16.91	288.59	17.16	288.34
PRW-2	304.03	301.82	15.17	288.86	15.42	288.61
PRW-2B	303.67	302.30	15.27	288.40	15.75	287.92
PRW-3	303.52	302.09	14.73	288.79	15.00	288.52
PRW-4	313.35	311.24	24.68	288.67	24.92	288.43
PRW-4B	313.27	311.20	25.71	287.56	26.96	286.31
PRW-5	312.61	311.10	23.81	288.80	24.03	288.58
PRW-5B	313.03	311.40	25.42	287.61	29.91	283.12
PRW-6	298.07	295.80	9.60	288.47	9.80	288.27
PRW-6B	297.85	296.50	9.89	287.96	10.17	287.68
PRW-7	298.30	296.30	9.76	288.54	9.95	288.35
PRW-7B	297.20	296.30	8.78	288.42	9.18	288.02
WRW-1	291.24	289.32	8.44	282.8	5.89	285.35
WRW-1B	NM	NM	4.77	--	5.12	--
WRW-2	291.74	289.56	5.75	285.99	8.45	283.29
WRW-3	294.34	292.54	7.42	286.92	7.42	286.92

(1) Measurements in feet above MSL, except when noted.
(2) Measurements in feet below top of PVC.

Note: NM = Not Measured.
Normal Pumping: Measurements taken with NW-1 and NW-2 pumping as needed, 09/13/91.
Non-Pumping: Measurements taken during 12 hour recovery prior to pumping test, 09/16/91.

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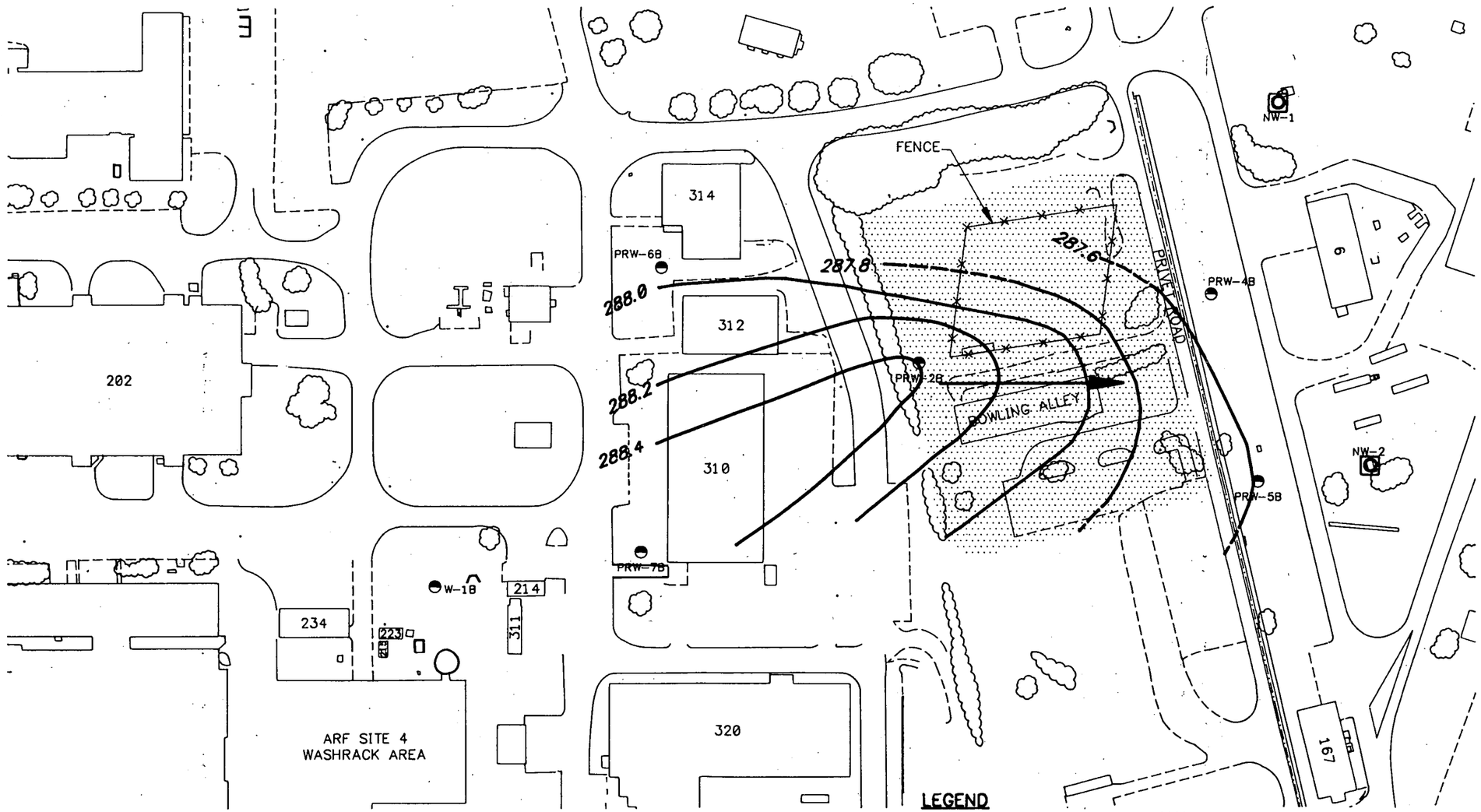


LEGEND

- INTERMEDIATE WELL
- NAVY PRODUCTION WELL
- PRE-EXISTING WELL
- 5.0 — CALCULATED WATER TABLE CONTOUR (DASHED WHERE INFERRED) MEASURED IN FEET ABOVE MSL.
- SUSPECTED WASTE AREA
- GENERAL DIRECTION OF GROUND WATER FLOW

NOTE: CONTOUR INTERVAL 0.2 FEET
WATER LEVELS MEASURED ON 9/16/91

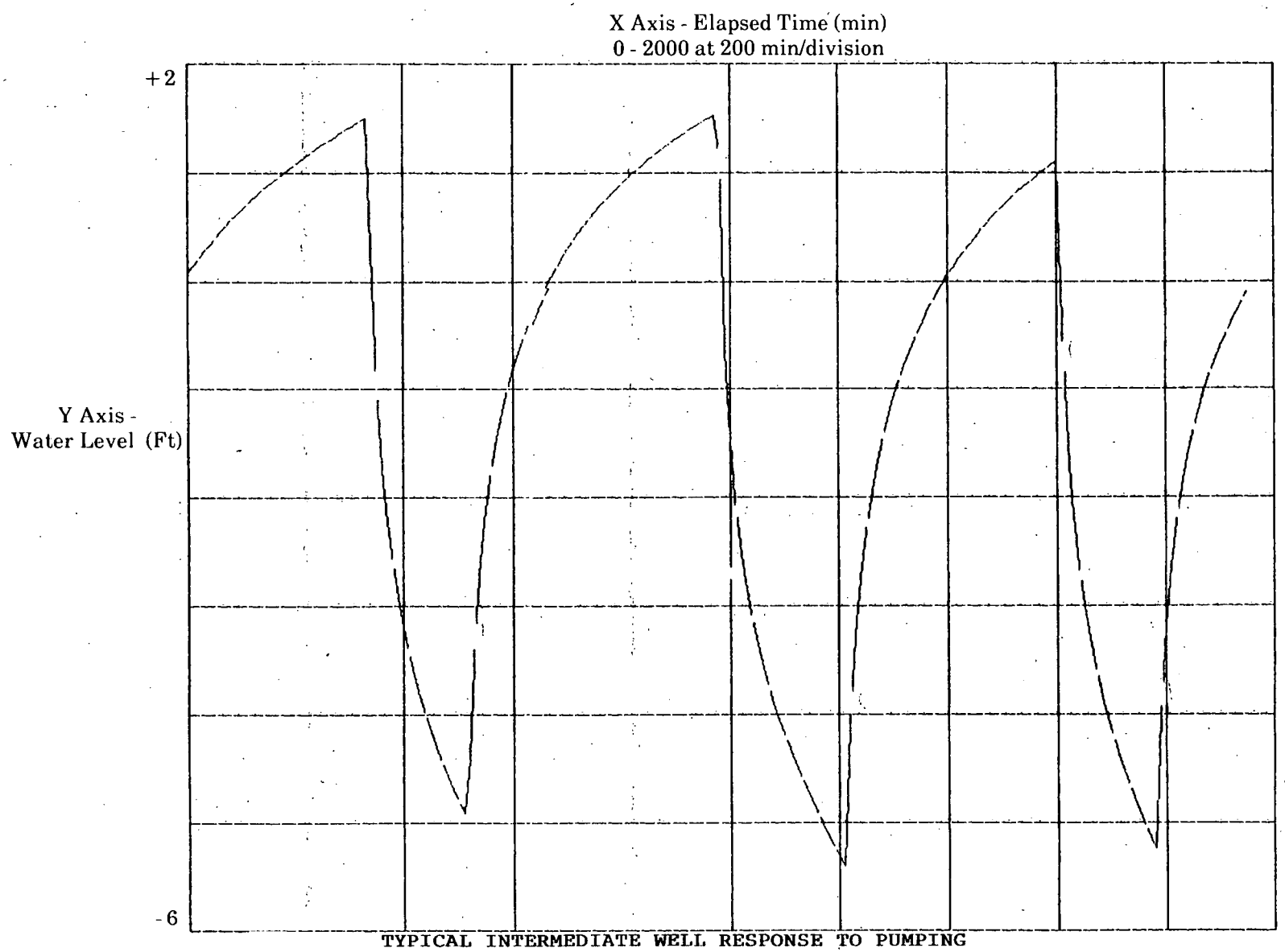
"WATER LEVEL MEASUREMENTS OBTAINED DURING NORMAL (BASELINE) PUMPING CONDITIONS"

0 100 200
SCALE IN FEET

FIGURE 4-6

POTENTIOMETRIC SURFACE MAP OF INTERMEDIATE MONITORING WELLS
NAS SITE 1 – PRIVET ROAD
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

HALLIBURTON NUS
Environmental Corporation



TYPICAL INTERMEDIATE WELL RESPONSE TO PUMPING
BASELINE CONDITIONS - PLOT OF PRW-5B

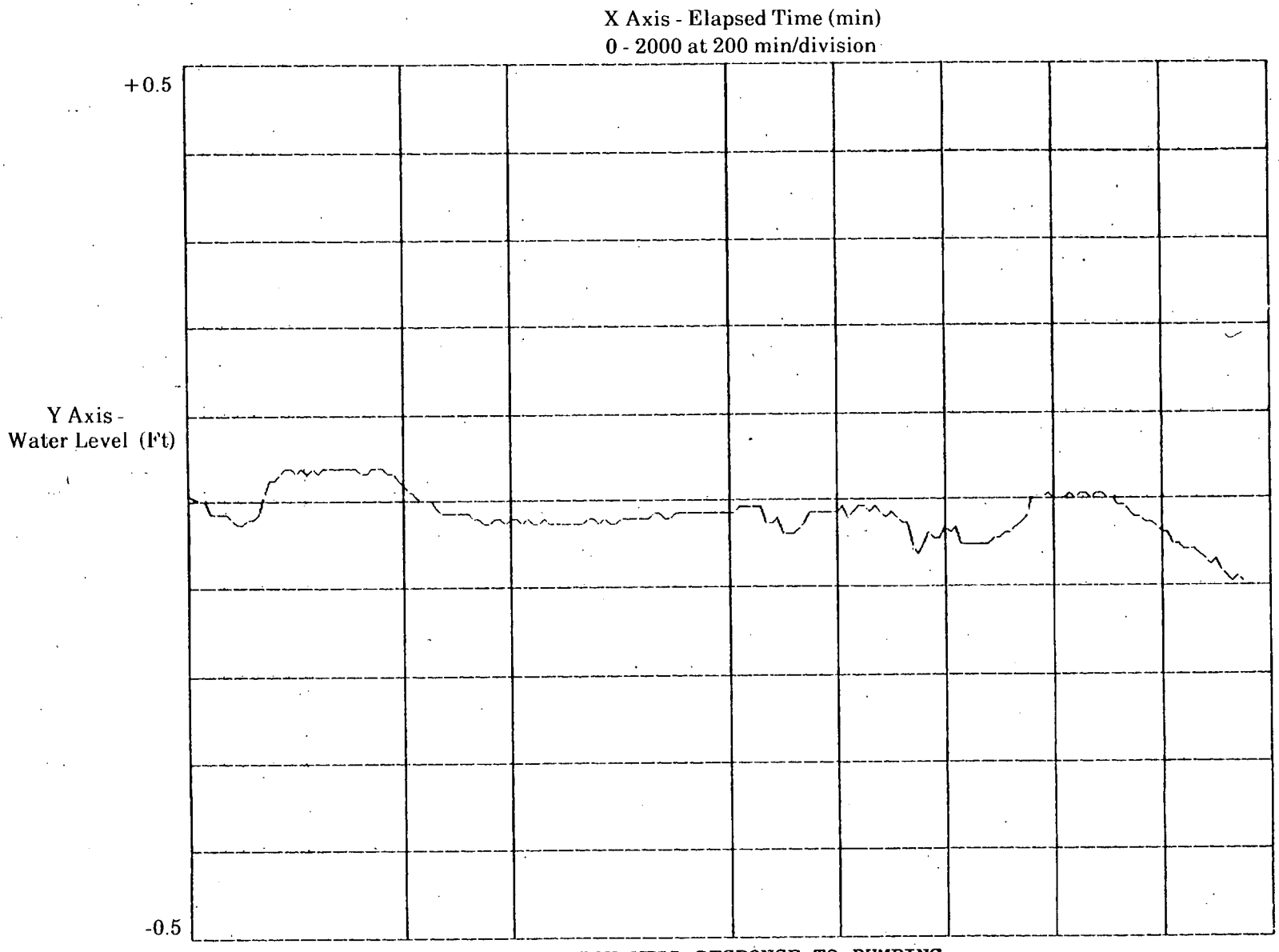
FIGURE 4-7

monitored well. This direct, and nearly instantaneous relationship between pumping and drawdown of the monitoring well installed in the deeper aquifer zone was not observed at the adjacent shallow monitoring well (PRW-5) during the same pumping period. Figure 4-8 is a plot of water level trend data at shallow well PRW-5 during the same pumping period as that recorded on Figure 4-7 at the adjacent intermediate depth well. Similar results were observed at all locations where a direct comparison of water level response to pumping in both intermediate and shallow wells was possible. Cyclical water level response to pumping was observable in drawdown-recovery plots for six intermediate level monitoring wells. The magnitude of the response in intermediate depth wells ranged from approximately 7 feet of drawdown at PRW-5B (Figure 4-7) located 140 feet from the nearest pumping well (Navy Well No. 2) to less than 0.2 feet at Washrack Site well WRW-1B located 1,010 feet from Navy Well No. 2. Minor fluctuations in water levels recorded in shallow wells during the same period did not show a clear correlation with pumping cycles.

After recording baseline conditions during normal pumping cycles, two pumping tests were performed to measure the aquifer response to prolonged pumping from each of the two Navy production wells independently. Two 48-hour pumping tests were specified by the Plan of Action (EA, August 1991) for RI work at the site. However, due to present water system design configurations and concern that inadequate fire protection capabilities which would result if damage to any pumping system components occurred as a result of excessive drawdown, overheating, etc., pumping tests were limited to 12 hours at Navy Well No. 2 and 24 hours at Navy Well No. 1.

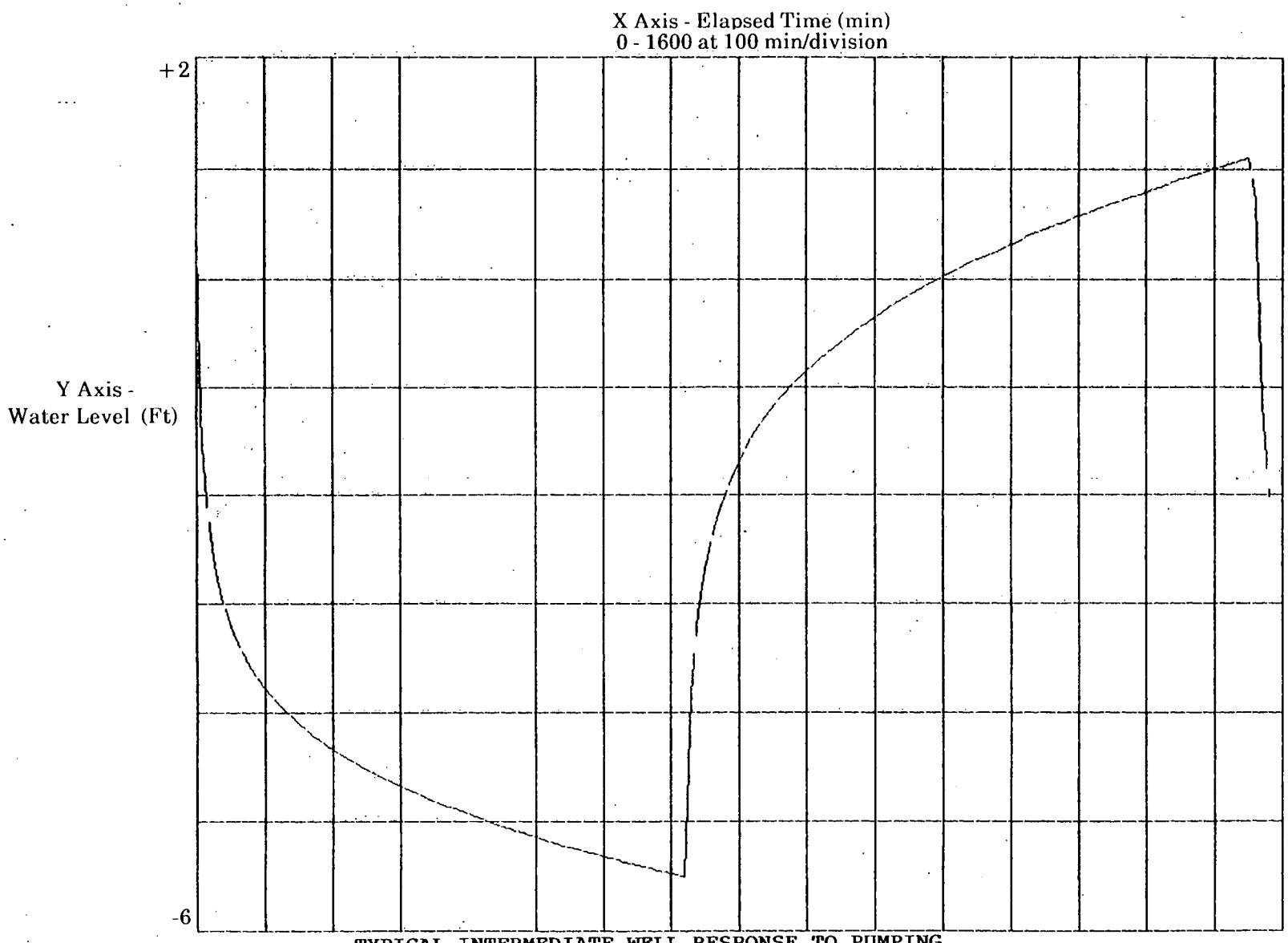
Shallow and intermediate depth well response to pumping from Navy Well No. 2 during the 12-hour test was similar to that observed during baseline pumping. Intermediate depth wells showed a strong response to pumping and a sharp break in the drawdown curve at the end of the pumping period. The maximum response to pumping was recorded in intermediate well PRW-5B, with a drawdown of approximately 5.6 feet, at a distance of 140 feet from the pumping well. No observable drawdown response occurred during the same pumping period at shallow well PRW-5, also 140 feet from the pumping well. Drawdown recovery data plots for wells PRW-5B and PRW-5 are presented in Figures 4-9 and 4-10, respectively.

After pumping from Navy Well No. 2 for approximately 12 hours, water levels were recorded during recovery for a period of 13 hours prior to resumption of normal pumping cycles. During this period an incomplete recovery of 6.7 feet was observed at intermediate well PRW-5B. Since this recovery period was insufficient to allow water levels to stabilize, the potential piezometric head has not been determined . No response to the pumping or recovery cycles at shallow well PRW-5 is observable (Figure 4-10).



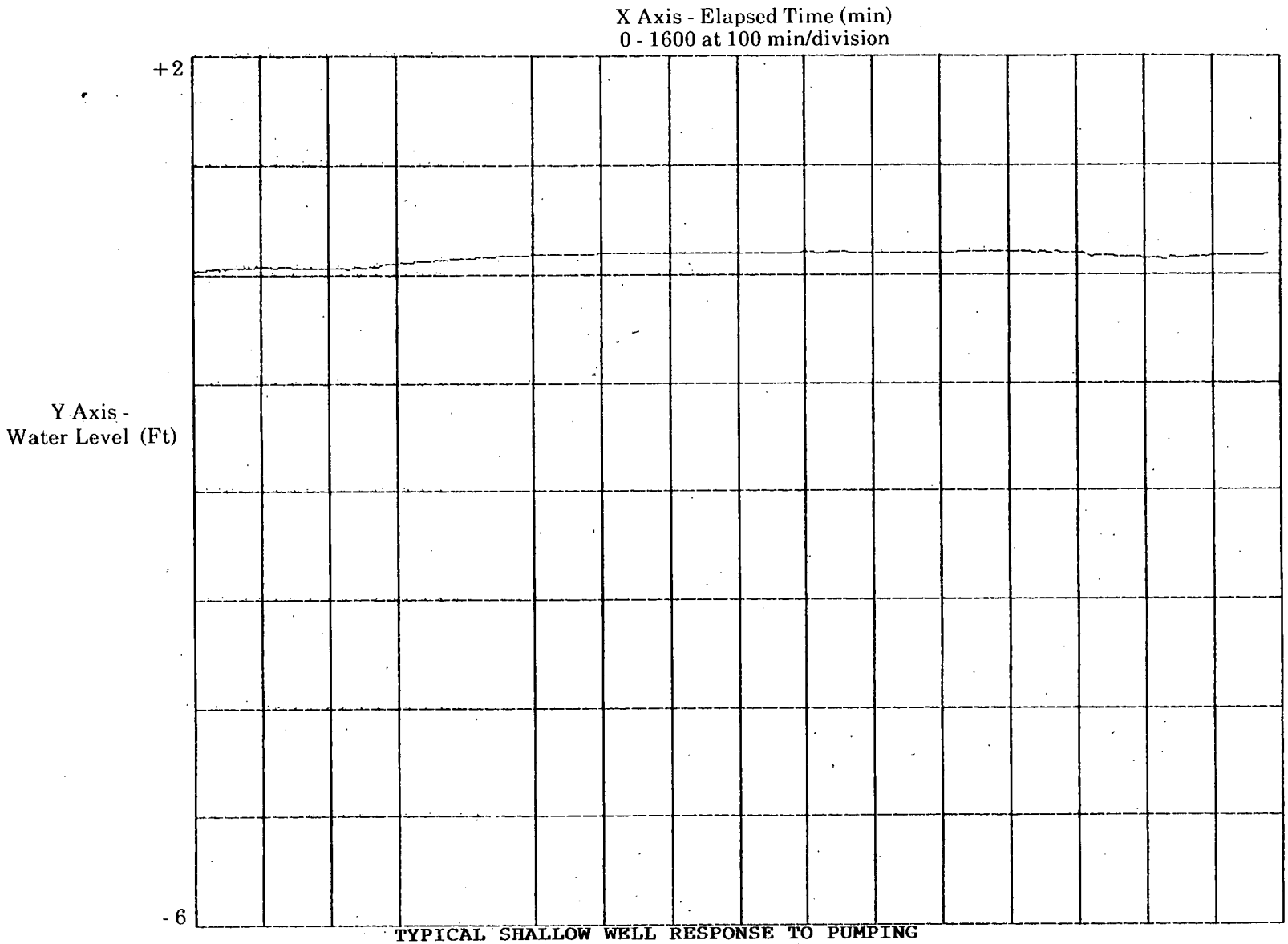
TYPICAL SHALLOW WELL RESPONSE TO PUMPING
BASELINE CONDITIONS - PLOT OF PRW-5

FIGURE 4-8



TYPICAL INTERMEDIATE WELL RESPONSE TO PUMPING
12 HOUR PUMPING OF NAVY WELL 2 - PLOT OF PRW-5B

FIGURE 4-9



TYPICAL SHALLOW WELL RESPONSE TO PUMPING
12 HOUR PUMPING OF NAVY WELL 2 - PLOT OF PRW-5

FIGURE 4-10

During a 24-hour pump test of Navy Well No. 1, all 16 monitoring wells in the Privet Road and Washrack Areas were again monitored to record drawdown and subsequent recovery. Although the well group PRW-4 and PRW-4B were located nearest to the pumping well (230 feet) the maximum response to pumping, approximately 6 feet of drawdown, was recorded at intermediate well PRW-5B, located 400 feet from the pumping well. Plots showing water level response at wells PRW-5B and PRW-5 during the 24-hour pumping test are provided in Figures 4-11 and 4-12 for comparison to baseline and 12-hour pump test data.

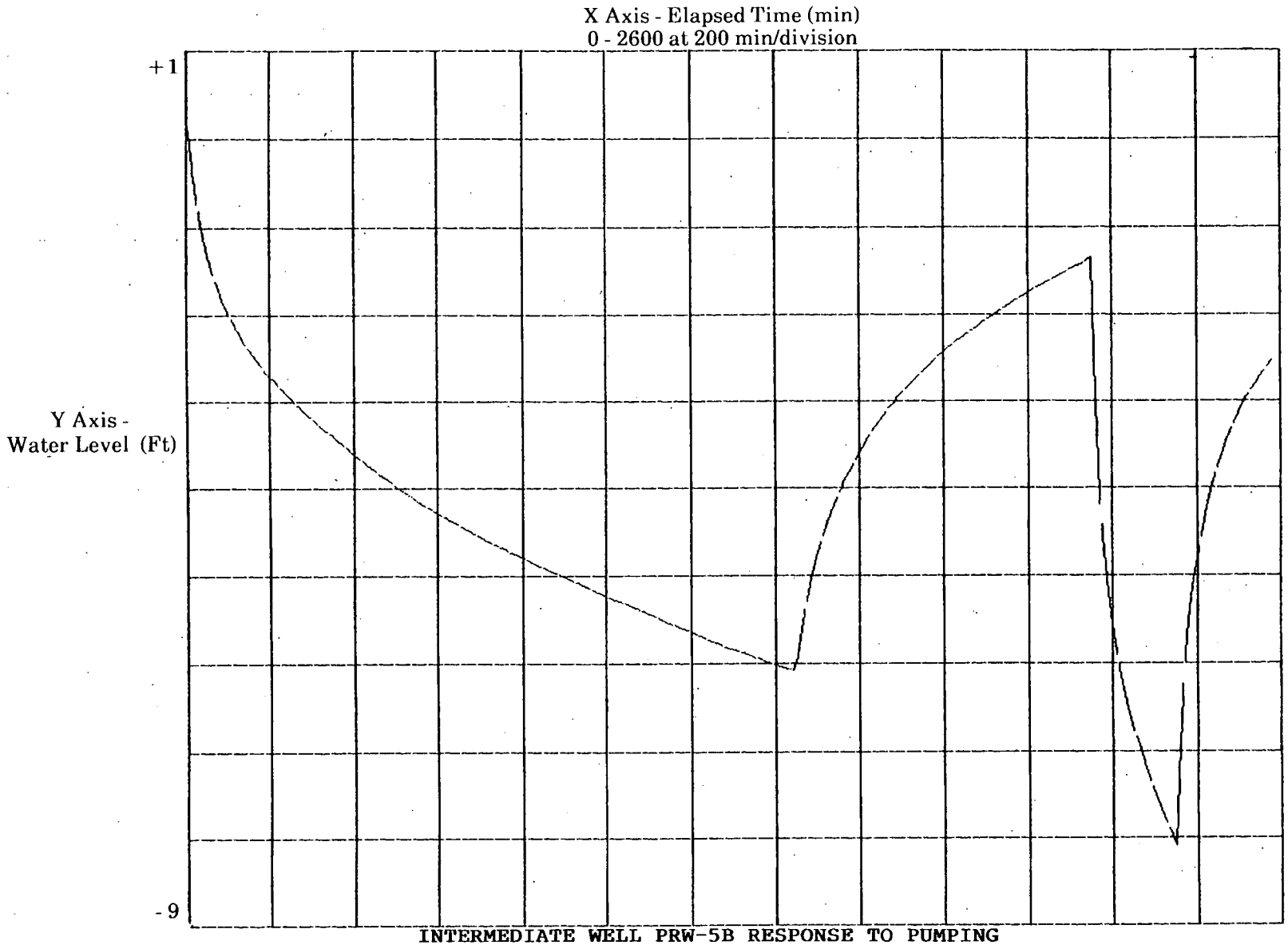
In contrast to the response to pumping observed in shallow wells during baseline conditions and during the 12-hour pumping test, a gradual, subdued response to pumping was generally observed in shallow wells during the 24-hour pumping test. This observation indicates that the lateral transmissivity and hydraulic conductivity of the aquifer is much higher than the vertical transmissivity and conductivity, thus some hydraulic connection exists between the shallow and deeper aquifer zones but that vertical migration from the shallow aquifer to the zone of pumping is restricted. One exception to this was observed in the response of shallow well PRW-4 to pumping from Navy Well No. 1 during the 24-hour pump test, and to a lesser degree during baseline conditions. Water levels in shallow well PRW-4 showed direct response to the drawdown and recovery phases of pumping cycles at Navy Well No. 1, indicating significant transmissivity between shallow and deeper aquifer zones. It should be noted that no correlation between pumping cycles and PRW-4 water levels were observed during the 12-hour pumping test at Navy Well No. 2, located the same distance (240 feet) from PRW-4 as Navy Well No. 1. This observation is likely to be indicative of fractures or other areas of higher permeability having a limited extent or specific orientation. Figures 4-13 and 4-14 show the water level response at PRW-4 and PRW-4B to pumping from Navy Well No. 1.

Time drawdown plots for all wells monitored during normal production pumping and both the 12- and 24-hour pumping tests are included in Appendix C.

4.5 NATURE AND EXTENT OF CONTAMINATION

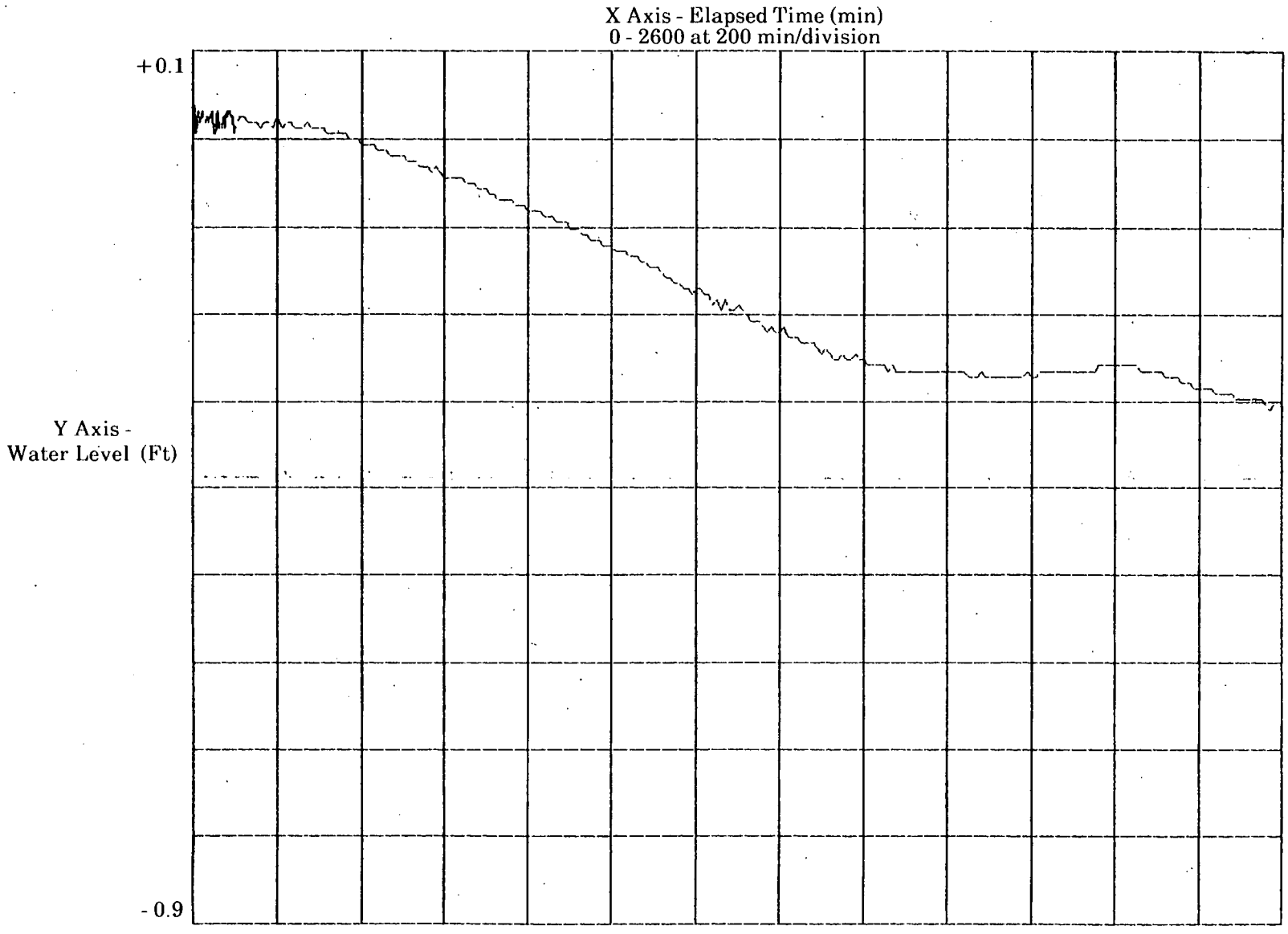
As noted previously, the investigation at the Privet Road Compound Site included the collection and analysis of soil, groundwater, surface water, and sediment samples. Analyses included TCL volatile organics and pesticides/PCBs, TAL metals, and cyanide (soils only).

Samples of groundwater obtained at the Privet Road Compound Site during the SI were found to contain trichloroethene and tetrachloroethene at maximum concentrations of 8 µg/L and 110 µg/L, respectively. Both these values exceed the MCLs for these chemicals. The maximum concentrations were detected in sample PRW-2 (June 1989). These and other volatile organics were also detected



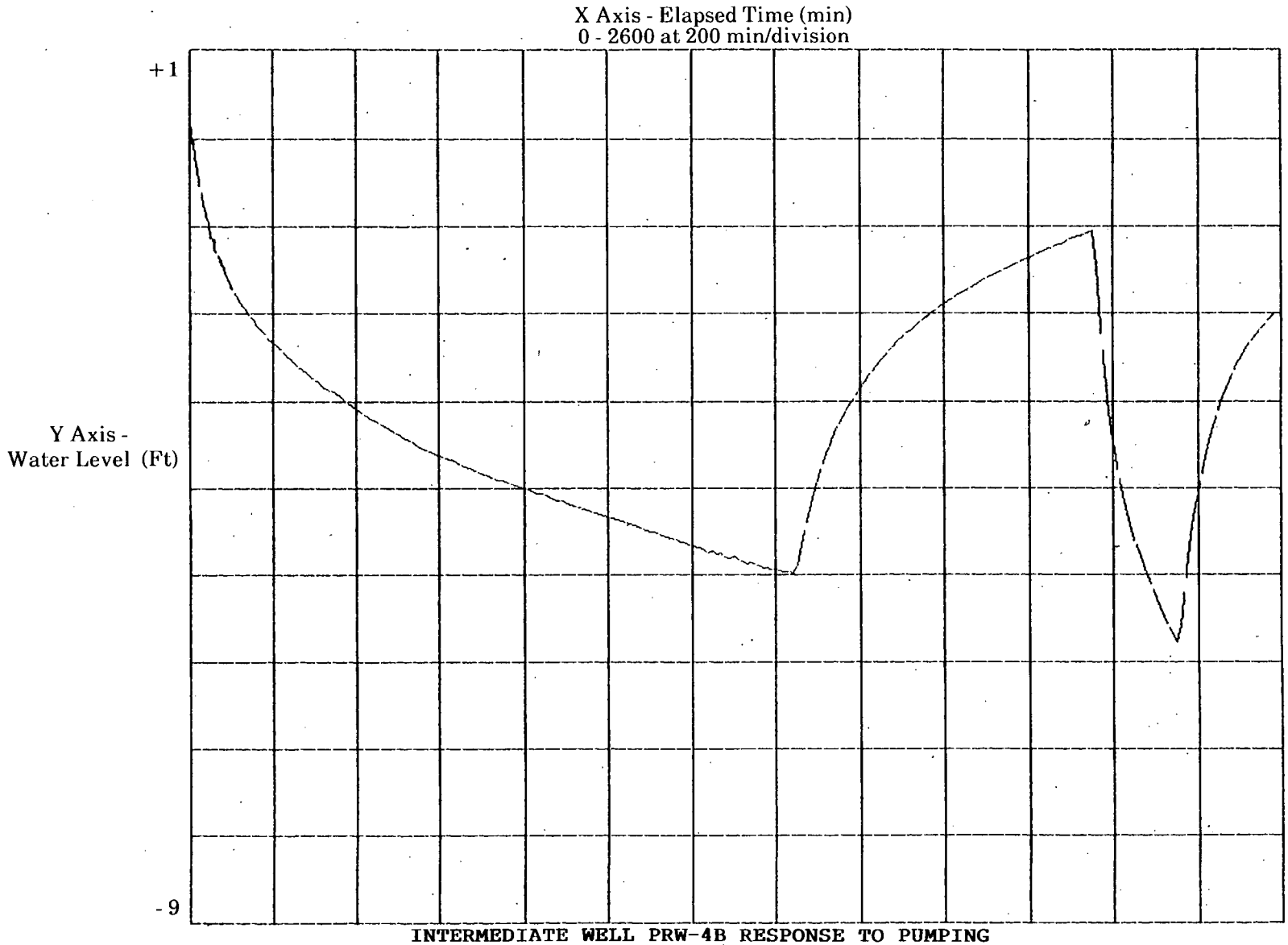
INTERMEDIATE WELL PRW-5B RESPONSE TO PUMPING
24 HOUR PUMPING OF NAVY WELL 1 - PLOT OF PRW-5B

FIGURE 4-11



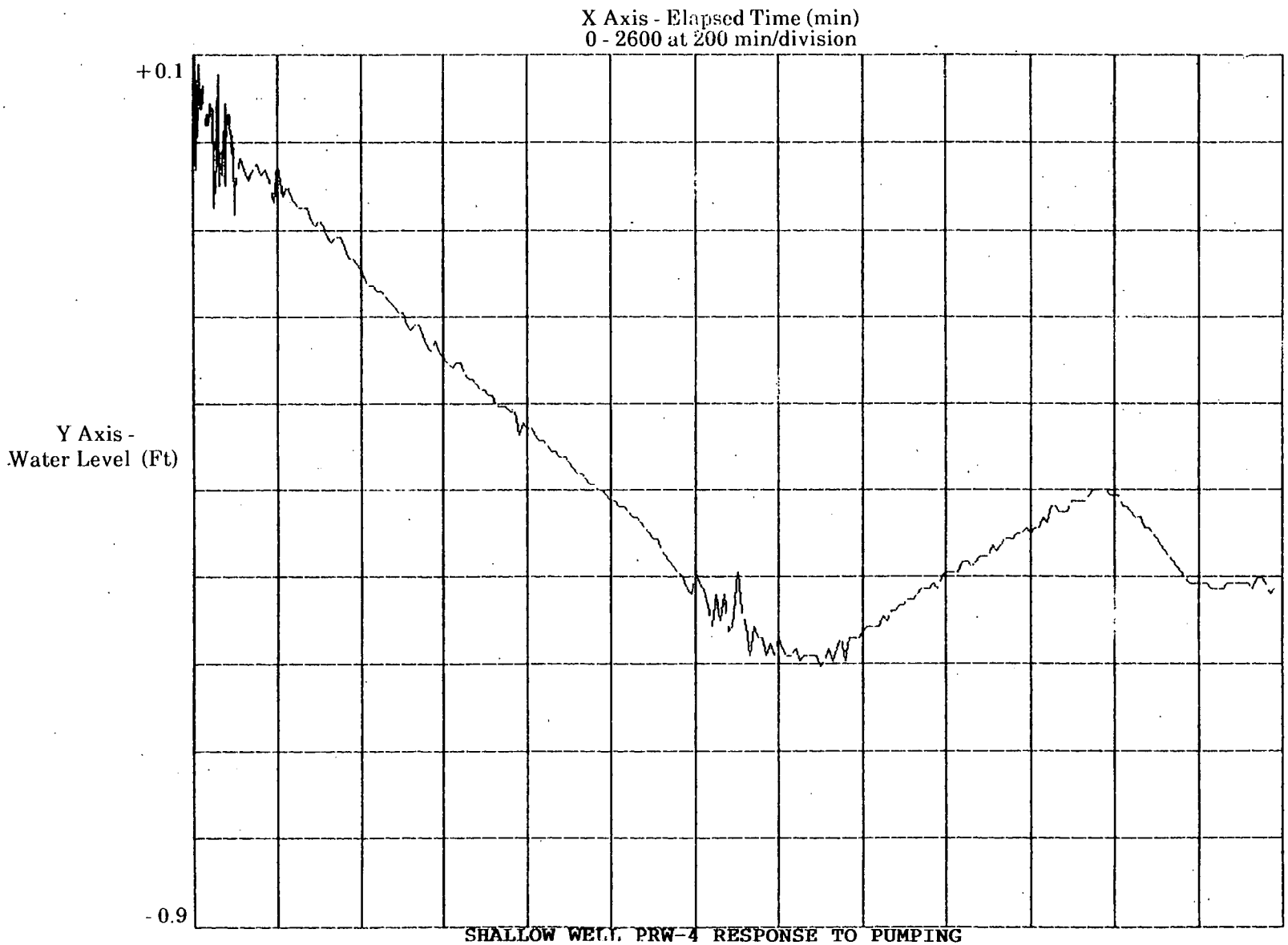
SHALL WELL PRW-5 RESPONSE TO PUMPING
24 HOUR PUMPING OF NAVY WELL 1 - PLOT OF PRW-5

FIGURE 4-12



INTERMEDIATE WELL PRW-4B RESPONSE TO PUMPING
24 HOUR PUMPING OF NAVY WELL 1 - PLOT OF PRW-4B

FIGURE 4-13



SHALLOW WELL PRW-4 RESPONSE TO PUMPING
24 HOUR PUMPING OF NAVY WELL 1 - PLOT OF PRW-4

FIGURE 4-14

(at lower concentrations) in sample PRW-1, as well as in the most upgradient well PRW-4. Both sampling rounds showed similar results (EA, May 1990).

Several soil samples were also collected during the course of the Site Inspection. No volatile organic chemicals were detected, however several polynuclear aromatic hydrocarbons (PAHs) were found at concentrations below the CRQLs. In addition, Aroclor-1260, dieldrin, and 4,4'-DDT were also detected. The maximum detected concentration of Aroclor-1260 was 7,500 µg/kg in one of a duplicate pair of samples. None of the soil samples were collected from inside the fenced area where actual waste handling occurred.

Some potential for offsite migration of contaminated media was also noted with the detection of Aroclor-1260 (41 to 500 µg/kg) and dieldrin (8.9 to 55 µg/kg) in the sediment samples collected from the drainage swales located outside the fenced area. These compounds were also detected in the soil samples.

All the analytical results were presented in the Site Inspection (SI) Report (EA, May 1990) and were used to develop the RI scope of work. The results for sampling and analysis conducted during the Remedial Investigation are discussed in the remainder of this section.

4.5.1 Surface and Subsurface Soil

Twelve soil borings were drilled in the former storage area in a rough grid system of approximately 65 feet between nodes, as shown in Figure 4-1. The grid spacing was determined primarily on the basis of site dimensions, however some adjustment to boring locations was necessary due to the presence of drilling obstacles. Soil samples were collected for chemical analysis from several depths at each location. Two foot sampling intervals were used, and samples were collected from depths of up to 14 feet. Each sample was analyzed for Target Compound List (TCL) volatile organics, pesticides, and polychlorinated biphenyls (PCBs); and Target Analyte List (TAL) metals. The results for each sample are presented in Appendix A, and are summarized in several tables in this section.

Each summary table for the soil samples contains a variety of information because sample-specific results are not presented as is done for other media due to the extensive number of soil samples collected. This type of information is presented for the other sites (in Sections 6.5 and 7.5). Contract-required quantitation limits (organic) or detection limits (inorganic) are presented for each detected analyte. These detection limits may vary for each sample because of percent moisture in the sample or dilution analyses necessitated by significant concentrations of sample constituents or matrix interferences. Therefore, another column presents the range of sample-specific quantitation limits.

Sample-specific CRQLs are only presented for analytes with less than 100 percent frequency of detection.

The frequency of detection for each analyte (i.e., the number of positive detections out of the total number of samples), as well as the data completeness are presented on these tables. In some cases, the total number of samples varies for particular analytical groups (e.g., volatile organics versus pesticides). In addition, the total number of samples reflect that portion of the data that was rejected during validation (see Section 2.3). If all samples were reported by the laboratory and no data points were rejected, the data are considered to be 100 percent complete. If, however, several samples are rejected, the percent completeness is proportionally reduced.

The summary tables also include the ranges of all positive detections, the upper 95 percent confidence limit (UCL) on the arithmetic/geometric mean, and the mean of all values. The means and the UCL were calculated for each sample set according to the following rules:

- Duplicate sample results were averaged and counted as one sample.
- One-half the detection limit was used when an analyte was not detected.

Table 4-3 summarizes the results for organic chemicals detected in the Privet Road Compound Site soils. A few volatile organic chemicals were detected in these soil samples at relatively low concentrations. Several data points for acetone and methylene chloride were rejected during the validation process because of blank contamination. Therefore, the data for these chemicals are not considered to be 100 percent complete. In addition, acetone and methylene chloride were also noted in various blank samples at maximum concentrations of 48 µg/L and 12 µg/kg, respectively. Acetone and carbon disulfide were found in 17 of 57 and 1 of 73 samples, respectively. The maximum detected sample concentration of acetone was 21 µg/kg, and carbon disulfide was detected in the samples at a maximum concentration of 1 µg/kg. Tetrachloroethene was detected once in a sample at a concentration of 2 µg/kg. Chloroform was also found in one sample at a concentration of 1 µg/kg. Methylene chloride was also detected in 1 of 43 samples. Most volatile organics were found only in samples from borings B07, B08, B11, and B12, which are located in the western corner of the fenced area. Low concentrations of acetone (6 and 9 µg/kg) were found as deep as the 8- to 10-foot depth interval in borings B08 and B12, respectively. Methylene chloride was found only in the 2- to 4-foot-deep sample in boring B03. These low concentrations of acetone and methylene chloride could not be discounted in the samples because these compounds were not identified in the associated blanks. Because these compounds are typical laboratory blank contaminants, it is likely that these compounds are not true sample constituents. However, since only a portion of the sample data were validated, it is difficult to identify soundly the trend of potential blank contaminant affects.

TABLE 4-3

ORGANIC DATA SUMMARY TABLE - SOIL
PRIVET ROAD COMPOUND SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	CRQL[1] (µg/kg)	Frequency of Detection	Data Completeness (%)	Range of Sample Quantitation Limits (µg/kg)	Range of Detected Concentrations (µg/kg)	95% UCL[2] (µg/kg)	Mean of All Values (µg/kg)
Acetone	10	17/57	78.1	6-12	4J[3]-21	7.7	6.8
Carbon Disulfide	10	1/73	100	5-6	1J	1[4]	2.9
Chloroform	10	1/73	100	5-6	1J	1[4]	2.9
Methylene Chloride	10	1/44	58.9	5-6	2J	2[4]	2.9
Aroclor-1260	0.05	13/71	100	170-250	220-230,000	10,000	3,760
Tetrachloroethene	10	1/73	100	5-6	2J	2[4]	2.9
Dieldrin	0.05	1/71	100	17-380	77J	7	19.6

(1) Contract required quantitation limit.
(2) Upper 95% confidence limit on arithmetic average.
(3) J - estimated value.
(4) UCL exceeds maximum detected, therefore maximum reported.

The low concentrations of methylene chloride found in the single sample could reflect blank contamination as it was found at a concentration below those found in the QA/QC samples. However, the sample containing the maximum concentration of acetone was validated, and therefore that detection of acetone is considered to be real based on the blanks associated with that sample. However, some of the lower concentrations found in unvalidated samples are questionable. An attempt was made to determine whether some of the acetone may be due to acetone in blank samples. However, as stated previously, these acetone results could not be definitively discounted since a clear trend of blank contaminant occurrences could not be identified because not all data were validated. Neither chloroform nor carbon disulfide were detected in any blank samples, and tetrachloroethene was found in one water method blank at a concentration of 2 µg/L.

No volatile organic chemicals were detected in the soil samples collected from outside the fence during the SI. The low concentrations detected during the RI do not indicate that the site soils, to depths of up to 14 feet, are a significant source of volatile organics.

Each soil sample was also analyzed for pesticides and PCBs. Only one pesticide (dieldrin) was detected in the soil samples (in 1 of 71 samples). Dieldrin was found at a concentration of 77 µg/kg in the surface (0 to 2 feet) sample from boring B10 (PRB-10-0002), located off the southern corner of the fenced area. Dieldrin was detected in two of six soil samples collected during the SI at a maximum concentration of 22 µg/kg. The background soil samples (Table 2-2) contained up to 400 µg/kg dieldrin.

Aroclor-1260 was detected in three of six offsite soil sampling locations during the SI, at a maximum concentration of 5,000 to 7,500 µg/kg in duplicate samples. During the RI, the sampling locations were more widespread and were also located on site, and PCBs were, with the exception of acetone, the most frequently detected organic chemical in soil.

Aroclor-1260, a PCB, was found in 8 of 13 surface (0 to 2 feet) samples at concentrations ranging from 920 µg/kg to 230,000 µg/kg. The maximum concentration in these surface samples was found in boring B03 (PRB-3-0002), which is located in an unpaved area on the western corner of the sampling grid. The presence of PCBs in the surface soil appears to be confined to the western portion of the soil sampling area. At the 2- to 4-foot depth, Aroclor-1260 was also detected in several (4) samples at concentrations ranging from an average of 245 µg/kg (in duplicate samples from boring B14) to 5,200 µg/kg in boring B11 (PRB-11-0204). Aside from these fairly shallow detections of PCBs, Aroclor-1260 was found in only one other sample collected from a depth of 6 to 7.5 feet in

boring B07 (PRB-7-06075). The reported concentration of PCB (Aroclor-1260) in this sample was 220 µg/kg. Figure 4-15 presents the PCB data spatially.

The chemical analytical results for inorganics in the soil samples are summarized in Table 4-4. With the exception of selenium and thallium, all data sets were 100 percent complete. Results for thallium were rejected as false positives in several samples during data validation as a result of its detection in blanks at similar concentrations. Results for selenium were rejected in several samples due to extremely low matrix spike recoveries. Two metals (cobalt and selenium) were found at concentrations that exceeded the background analytical results discussed in Section 2.4 of this report. Cobalt was detected in all 72 samples, and the maximum concentration (30.2 mg/kg) was found in the 10- to 12-foot-deep sample from boring B16 (PRB-16-1012). The mean cobalt concentration in the site soils was found to be 10.9 mg/kg, and the geometric mean was calculated as 10.3 mg/kg. Selenium was detected in only 1 of 41 samples at a concentration of 1.2 mg/kg in a sample that was one of a duplicate pair (PRB-5-0204D). Both the mean and the upper 95 percent confidence limit on the mean concentrations for both these metals exceeded the reported background values.

The concentrations of cobalt in offsite soil samples collected during the SI ranged from 9.4 to 14.6 mg/kg, which is within the range found during the RI. Selenium, however, was not detected during the SI.

Several other metals (chromium, copper, manganese, thallium, and vanadium) were found at average concentrations that were somewhat greater than those reported in the background samples. However, when the upper 95 percent confidence limits were determined for the arithmetic average concentration, all of the values were less than (or within 3 percent of) the background values.

In addition, all soil samples were analyzed for cyanide. However, cyanide was detected in only one subsurface soil sample (PRB-13-1214) at a concentration of 3.2 mg/kg during the RI, and was not detected during the SI. Contact with soils at this depth (12 to 14 feet) is considered to be highly unlikely under even conservative construction scenarios that involve excavation (typically limited to depths of 10 to 12 feet).

In conclusion, it can be stated that the soil at the Privet Road Compound Site contains little organic contamination with the exception of PCBs (Aroclor-1260) found in the soil at depths of 4 feet or less. Aroclor-1260 was also noted in several SI soil samples, which were collected from outside the fenced area. The volatile organic chemicals and dieldrin that were detected in the soil samples were found at low concentrations that do not represent a notable source of contamination, although dieldrin was found in soil samples collected from outside the fenced area. Dieldrin, however, is also found in soil

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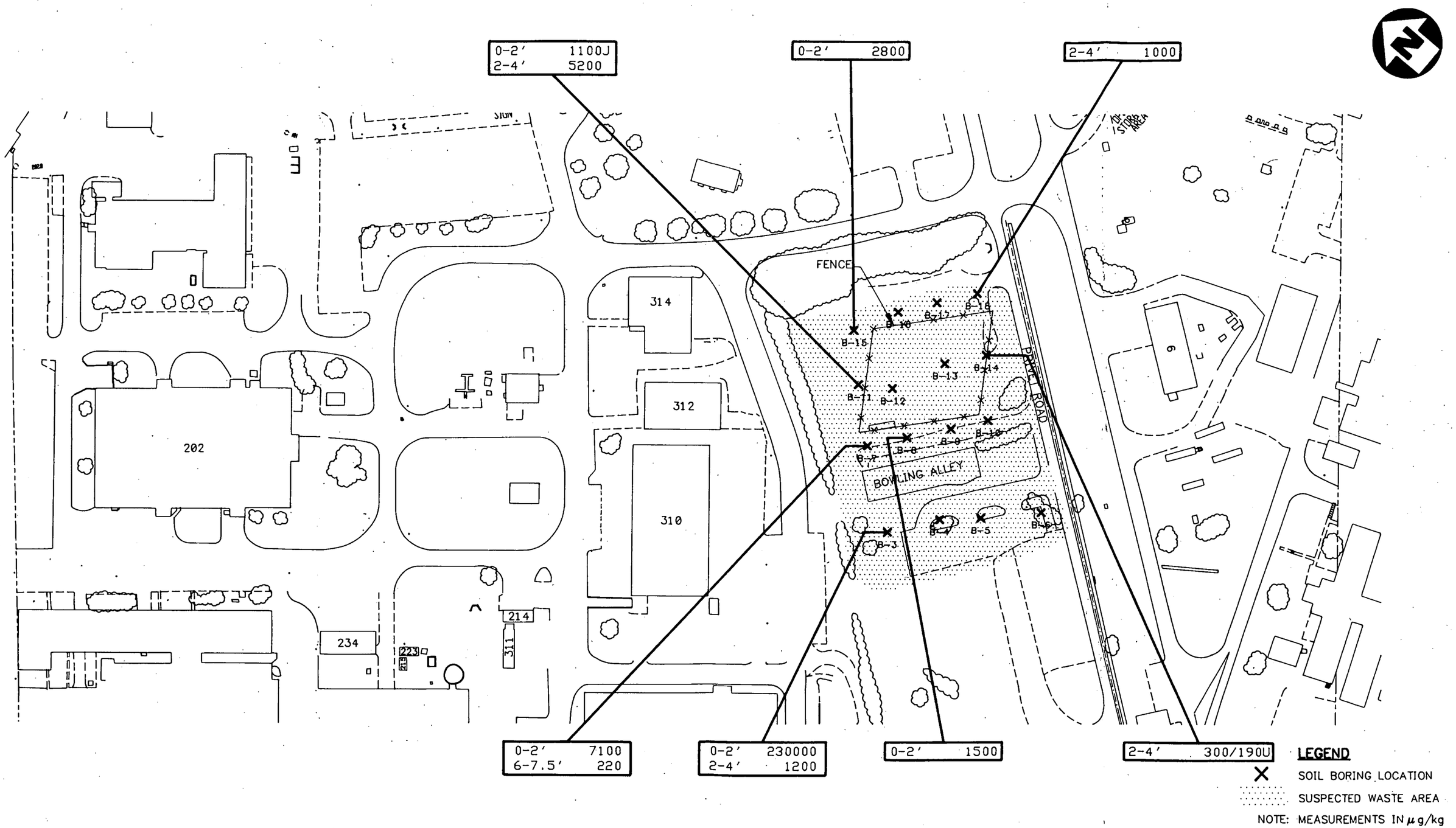

CONCENTRATIONS OF AROCLOR-1260 IN SOIL
NAS SITE 1 - PRIVET ROAD
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 4-15

HALLIBURTON NUS
Environmental Corporation

TABLE 4-4
INORGANIC DATA SUMMARY TABLE - SOIL
PRIVET ROAD COMPOUND SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	CRDL (mg/kg)[1]	Frequency of Detection	Data Completeness (%)	Range of Sample Quantitation Limits (mg/kg)	Range of Detected Concentrations (mg/kg)	95% UCL[2] (mg/kg)	Mean of All Values (mg/kg)	Background Samples		
								Range of Detected Concentrations (mg/kg)	95% UCL (mg/kg)	Mean of All Values (mg/kg)
Aluminum	40	72/72	100	NA[4]	5,910-24,500	16,100	15,200	18,200-26,500	22,700	21,000
Arsenic	2	58/72	100	0.64-0.92	0.90-16.2	4.0	3.3	2.3-5.9	5.0	4.1
Barium	40	72/72	100	NA	45.6-422	114	98.0	80.2-217	156	111
Cadmium	1	31/72	100	0.77[5]-0.99	0.79-5.8	1.3	1.0	4.3-6.0	5.1	4.7
Calcium	1000	71/72	100	1,130	154-13,700	2,810	2,060	828-2,340	1,790	1,420
Chromium	2	72/72	100	NA	10.4-37.2	26.1	25.0	18.8-27.9	26.2	24.1
Cobalt	10	72/72	100	NA	5.9-30.2	11.8	10.9	6.3-9.7	8.9	8.2
Copper	5	71/72	100	3.4	4.1-44.0	19.8	17.6	11.5-27.5	19.7	15.5
Cyanide	2	1/72	100	1.4-2.75[5]	3.2	1.2	1.1	(3)	(3)	(3)
Iron	20	72/72	100	NA	12,900-35,400	25,600	24,400	18,900-25,700	23,500	21,700
Lead	0.6	72/72	100	NA	1.9-164	25.0	18.0	16.2-199	105	58.8
Magnesium	1000	72/72	100	NA	261-10,600	2,750	2,310	1,580-2,460	2,260	3,070
Manganese	3	72/72	100	NA	70.3-2,310	713	612	256-1,360	843	519
Mercury	0.1	7/72	100	0.09-0.15	0.11-0.36	0.08	0.07	0.12-0.19	0.10	0.06
Nickel	8	70/72	100	5.9-16.2	5.9-38.2	14.9	13.8	13.5-19.2	16.9	15.8

TABLE 4-4
INORGANIC DATA SUMMARY TABLE - SOIL
PRIVET ROAD COMPOUND SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA
PAGE 2

Chemical	CRDL (mg/kg)[1]	Frequency of Detection	Data Completeness (%)	Range of Sample Quantitation Limits (mg/kg)	Range of Detected Concentrations (mg/kg)	95% UCL[2] (mg/kg)	Mean of All Values (mg/kg)	Background Samples		
								Range of Detected Concentrations (mg/kg)	95% UCL (mg/kg)	Mean of All Values (mg/kg)
Potassium	1000	72/72	100	NA	184-2,840	1,140	1,010	731-1,390	1,080	928
Selenium	1	1/41	56.9	0.77-9.4	1.2	0.83	0.62	0.08-0.40	0.29	0.22
Silver	2	1/72	100	1.35[5]-1.7	3.0	0.85	0.79	0.81-1.4	1.1	0.96
Sodium	100	72/72	100	NA	387-1,250	777	741	29.5-79.6	59.8	49.1
Thallium	2	36/63	57.1	0.15-0.24	0.18-0.45	0.20	0.18	0.03-0.35	0.25	0.18
Vanadium	10	72/72	100	NA	19.5-48.8	36.1	34.5	27.5-40.6	35.2	32.5
Zinc	4	72/72	100	NA	10.7-237	54.2	44.8	40.1-170	97.6	63.1

(1) Contract required detection limit.
(2) Upper 95% confidence limit.
(3) Chemical not analyzed in background samples.
(4) NA - Only positive results reported for this chemical.
(5) Value reported is the average of duplicate sample results.

throughout NAS Willow Grove at similar concentrations, as well as in offsite samples. The source of the volatile organics in groundwater (observed during the SI as well as in the RI) does not appear to be the soil within the waste-handling area. In addition, two metals (cobalt and selenium) are present at the site in elevated concentrations and are therefore considered to be potential chemicals of concern.

4.5.2 Groundwater

As previously discussed, there are two groundwater flow systems at this site. Groundwater in the shallow aquifer flows toward the north, east, and west (Figure 4-5), while groundwater in the intermediate aquifer flows toward the south, southeast, and east (Figure 4-6). These variable flow directions are apparent on the potentiometric surface maps of the site. A restricted downward vertical gradient exists at this site due, at least partially, to the effects of pumping from two Navy production wells. Each of these systems will be discussed in this section. All well locations were shown in Figure 4-2.

4.5.2.1 Monitoring Wells

Seven shallow wells and five intermediate depth monitoring wells were each sampled once during this investigation. In addition, two Navy wells were sampled before and after a pumping test to determine whether they might be drawing in contamination from the Privet Road Compound area during pumping. All samples were analyzed for TCL volatile organics, pesticides and PCBs, and both total and dissolved TAL metals. The groundwater analytical data (chemicals with positive detections only) are presented in Tables 4-5 (shallow groundwater) and 4-6 (deep groundwater). The complete analytical data base is contained in Appendix A.

Tetrachloroethene was not found in any of the onsite wells during 1991, however, trichloroethene was found in several intermediate and shallow RI groundwater samples at concentrations ranging from 1 to 120 µg/L (a sample from well PRW-7B, an intermediate well, contained the highest concentration). Samples from the shallow wells were generally less contaminated than those from the deeper wells. For example, the data presented for well clusters 4/4B, 5/5B, 6/6B, and 7/7B in Tables 4-5 and 4-6 indicated that no volatile organics were present in the shallow aquifer, yet several compounds were detected in the intermediate aquifer, such as toluene (1 to 6 µg/L), trichloroethene (1 to 120 µg/L), carbon tetrachloride (2 to 7 µg/L), and 1,1,1-trichloroethane (3 µg/L). The maximum detected contaminant concentrations were found in the intermediate well 7B (PRW-7B), which is located upgradient of the site. Trichloroethene was the only organic chemical detected during the RI in the monitoring wells at this site that exceeded its MCL (5 µg/L). Volatile organic chemicals were not

TABLE 4-5

CHEMICALS DETECTED IN SHALLOW GROUNDWATER SAMPLES (µg/L)[1]
PRIVET ROAD COMPOUND SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	PRW-1		PRW-2[2]		PRW-3		PRW-4		PRW-5		PRW-6[2]		PRW-7	
	(276.5'-296.5')[3]		(277.0'-297.0')		(277.0'-297.0')		(278.4'-298.4')		(272.6'-292.6')		(269.8'-289.8')		(270.3'-290.3')	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Trichloroethene	3J(1)	-	3J(1)/3J(1)	-	18	-	5U	-	5U	-	5U/5U	-	5U	-
1,1,1-Trichloroethane	1J(1)		5U/5U	-	5U	-	5U	-	5U	-	5U/5U	-	5U	-
1,1-Dichloroethane	5U		5U/5U	-	2J(1)	-	5U	-	5U	-	5U/5U	-	5U	-
Aluminum	3870	85	2930/2870	72U/72U	72U	72U	27800J(2)	593	20000J(2)	3430	4290/4410	72U/72U	166	72U
Arsenic	2UJ(1)	2	2UJ(1)/2	2U/2U	2U	2U	8.8J(3)	2UJ(2)	4.6J(3)	2UJ(2)	2U/2U	2U/2U	2U	2U
Barium	130	19	68/65	15/17	18	21	1160	20B	524	22B	149/176	65/64	58	38
Beryllium	5B	3.0	5B/5B	3/3	4B	3	10B	5B	10B	9B	4B/4B	4/4	4B	4
Calcium	29200	31600	28100/29600	29900/30700	13900	13900	36400	40600	31100	27300	12100/14200	12300/12400	26000	23600
Chromium	12B	10	12B/12B	11B/7UJ(1)	7U	7B	32	7U	12B	7U	12B/15B	9U/8U	7U	8B
Cobalt	10	10U	10U/11	10U/10U	10U	10U	54	10	52.0	17	10U/11	10U/10U	10U	10U
Copper	13B	18	18B/13B	19B/19B	7B	13B	120	18B	115	37	7B/6B	10B/10B	6B	10B
Iron	5120J(2)	40B	4050J(2)/ 3730J(2)	45B/42B	167B	34B	46400	43B	22900	47U	6320J(2)/ 6110J(2)	50B/40B	353J(2)	46B
Lead	8.8	1U	10.4/9.6	1U/1.3	1.1	1U	22.2	1U	10.5	1	3.6/3.6	1U/1U	1.8	1U
Magnesium	12400	11900	11300/12100	10900/11000	6220	6060	15400	14500	10600	10700	5170/5850	3810/3780	9070	7940
Manganese	242	16	260/221	44/45	55	44	4040	668	4590	981	337/348	31/32	218	167
Mercury	0.2U	0.2U	0.2U/0.2UL(1)	0.2UL(2)/0.2U	0.2U	0.2U	0.2	0.2U	0.2U	0.2U	0.2U/0.2U	0.2UL(2)/ 0.2UL(2)	0.2U	0.2UL(2)
Nickel	21B	13B	20B/17B	21B/19B	15B	12B	76B	26	71B	26B	16B/18B	14B/12U	22B	17B
Potassium	3340	2400	3080/3080	2390/2630	2180	2140	5710	2140	3420	2140U	3160/3020	2140/2140	2970	2260
Sodium	16600	16400	15500/16300	15300/15400	11000	10500	23100	19500	14800	14200	31000/33600	27900/28500	16600	15000
Vanadium	10B	4U	6B/7B	5B/5B	4U	5B	43	4U	24	4U	8B/10B	5B/4U	4U	4B
Zinc	38B	33B	34B/32B	29B/30B	25U	16B	143	55.0	115	65	35B/55	26B/24B	32B	47B

(1) Complete analytical data base in Appendix A.
(2) Field duplicate sample results for both samples reported.
(3) Screened interval elevation (NGVD 1929).

Qualifiers defined as follows:
U - Not detected at detection limit shown.
B - Value is considered to be a false positive due to blank contamination.
J(1) - Value is estimated because result is reported at a concentration less than the CRQL.
J(2) - Value is estimated due to laboratory duplicate RPD outside QC limits.
J(3) - Value is estimated due to GFAA calibration correlation coefficient <0.995.
UL(1) - Nondetect is biased low because of low MS %R and/or low GFAA PDS % R.
UL (2) - Nondetect is biased low because of holding time exceedance.
UL (1) - Nondetect is estimated due to laboratory duplicate RPD >20%.
UJ (2) - Nondetect is estimated due to GFAA calibration coefficient <0.995.

TABLE 4-6

CHEMICALS DETECTED IN INTERMEDIATE GROUNDWATER SAMPLES (µg/L)[1]
PRIVET ROAD COMPOUND SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	PRW-2B		PRW-4B		PRW-5B		PRW-6B		PRW-7B	
	(214.3'-224.3')[2]		(221.2'-231.2')		(226.4'-236.4')		(212.0'-222.0')		(212.2'-222.2')	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Toluene	2J(3)	-	6	-	4J(1)	-	1J(1)	-	2J(1)	-
Carbon tetrachloride	2J(4)	-	5U	-	5U	-	2J(4)	-	7J(4)	-
Trichloroethene	6J(2)	-	1J(1)	-	1J(1)	-	10	-	120	-
1,1,1-Trichloroethane	5U	-	5U	-	5U	-	3J(1)	-	5U	-
Aluminum	95	72U	72U	119B	442B	72U	1260	72U	297	72U
Antimony	45U	45U	45U	45U	45U	45U	45U	45U	45	45U
Arsenic	2U	2U	2U	2J(5,6)	2.4J(6)	2UJ(1)	2U	2U	2U	2U
Barium	65	59	130	181	159	155B	82	61	236	213
Beryllium	4B	4	3B	5B	3B	4B	4B	4	4B	4
Calcium	43500	41800	40000	53200	23000	23200	30200	30700	26100	26000
Chromium	11B	11B	10B	18	20B	18	11B	10B	8B	7UJ(2)
Iron	576J(5)	43B	19B	117B	709	43B	1310J(5)	46B	388J(5)	48B
Lead	7	1.4	18	17	39.8	4.5	5.8	1.2	3.5	1U
Magnesium	11800	11600	12200	16400	9450	10200	7240	7390	6980	6850
Manganese	232	213	243	350	65	6.0	79	6.0	62	43
Potassium	11500	11000	19700	22000	41600	38700	5980	2650	2600	2460
Sodium	19600	18900	21100	24600	22400	21600	17300	15200	14900	14700
Zinc	40B	37B	33	51	26	5	18B	14B	9B	9B

[1] Complete data base in Appendix A.
[2] Screened interval elevation (NGVD 1929).

Qualifiers defined as follows:
U - Not detected at detection limit shown.
B - Value is considered to be a false positive due to blank contamination.
J(1) - Value is estimated because result is reported at a concentration less than the CRQL.
J(2) - Value is estimated due to MS/MSD RPDs outside QC limits.
J(3) - Value is estimated due to MSD %R outside QC limits.
J(4) - Value is estimated because initial calibration % RSD >30.
J(5) - Value is estimated due to laboratory duplicate RPD >20.
J(6) - Value is estimated due to GFAA calibration correlation coefficient <0.995.
UJ(1) - Nondetect is estimated due to GFAA calibration correlation coefficient <0.995.
UJ(2) - Nondetect is estimated due to laboratory duplicate RPD >20.

frequently detected in the soil samples collected from the fenced area and beyond, so it appears unlikely that the site soils as they currently exist are the source of volatiles observed.

No intermediate depth wells existed at the time of SI, nor did any wells exist at locations 5, 6, or 7. The SI wells are shown in Figure 4-2 as pre-existing wells. Tetrachloroethene was the volatile organic chemical found at the maximum concentration (120 µg/L in well PRW-2), as compared to its MCL of 5 µg/L. Trichloroethene was found most often in the shallow wells during the RI, and tetrachloroethene was not detected at all during the RI. In general the types of contaminants found in the shallow well samples during the SI (halogenated aliphatics) were the same as were found in the shallow well samples during the RI, albeit at generally lower concentrations.

Groundwater samples from all wells were also analyzed for both total and dissolved metals in unfiltered and filtered samples, respectively, during the RI. The concentrations of most toxic metals were lower in the filtered samples than in the unfiltered samples, but none of the toxic metals found in the unfiltered samples were found at concentrations that exceeded drinking water standards. However, there is one notable exception to this generality, and that is that beryllium was frequently detected (at concentrations of 4 µg/L or less) in the filtered samples, and was not detected at all in the unfiltered samples.

The detection of metals in unfiltered groundwater samples is often related to the presence of suspended sediment in the sample, and the sample preparation techniques digest the sediment thereby releasing metals to the sample. The concentrations of most metals in the unfiltered samples are greater than those reported for the filtered samples, with the exception of some of the highly soluble metals such as calcium, magnesium, and sodium. Therefore, the presence of metals in the unfiltered samples may not be indicative of a source of metals contamination associated with the site. When the results for the filtered samples are examined, there is little indication of the presence of soluble (and therefore mobile) metals in the groundwater at this site.

Several metals were detected in the unfiltered groundwater samples at notable concentrations. These metals include one detection of antimony in a sample from well PRW-7B (45 µg/L) and two detections of vanadium in samples from well PRW-4 (43 µg/L) and PRW-5 (24 µg/L). The maximum observed concentration of lead was also found in an unfiltered sample from well PRW-5B (39.8 µg/L). The MCL for antimony is 5 to 10 µg/L, and the action level for lead is 15 µg/L.

Beryllium was detected only in the filtered samples (in 8 of 12 samples) at concentrations of 3 to 4 µg/L. As shown in Table 4-6, the analytical results for all unfiltered groundwater samples and 2 of 5 filtered samples were considered false positives, because of blank contamination. Although the remaining results could not be considered false positives based on available analytical data for field QC

samples or laboratory method blanks, the concentrations detected are similar to those in the other samples. It is considered likely that these results may also be laboratory artifacts. The proposed MCL for beryllium is 1 µg/L. The complete analytical results are presented in Tables 4-5 and 4-6.

The detections of metals in the filtered and unfiltered groundwater samples collected during the SI generally followed the same pattern (i.e., higher in the unfiltered samples). Because the total metals results reflect the presence of suspended sediment in the sample, little comparison can be made between the SI and the RI, with the exception of the following observations:

- Antimony was not detected during the SI, and the concentrations of vanadium reported in the shallow wells at that time were lower than the RI maximum (43 µg/L) .

- Lead was found in unfiltered samples at slightly higher concentrations during the SI (2.6 to 70.7 µg/L) than during the RI (1.1 to 39.8 µg/L). Lead was found at higher concentrations in the filtered samples from the RI (1.2 to 18 µg/L) than the SI (1.3 to 1.6 µg/L).

- During the SI, beryllium was also more frequently detected in the unfiltered samples.

4.5.2.2 Navy Supply Wells

Samples from the two Navy supply wells (NW-1 and NW-2) contained several volatile organic chemicals. The original sample collected from well NW-1 prior to the pump test (PRW-NW-1A) contained 53 µg/L tetrachloroethene and 13 µg/L trichloroethene (average results from duplicate samples), and the second sample collected after the pump test (PRW-NW-1B) contained 37 and 10 µg/L, respectively. Tetrachloroethene was not observed in samples from any of the seven onsite monitoring well clusters, and trichloroethene was found at a higher concentration in a monitoring well (PRW-7B). The concentration of these compounds in both samples exceed the MCLs.

The other Navy supply well (NW-2) was found to contain tetrachloroethene and trichloroethene at somewhat lower concentrations, as shown in Table 4-7. Tetrachloroethene was found at a concentration of 4 µg/L in both samples (before and after the pump test), and trichloroethene was found at a concentration of 6 µg/L in the pre-test sample and at 5 µg/L in the post-test sample (PRW-NW-2A and PRW-NW-2B, respectively). The MCLs for both these compounds are 5 µg/L.

Both of the Navy wells are located southeast of the Privet Road Compound Site and affect groundwater flow direction in the intermediate aquifer when they are pumping. Both wells currently have air strippers installed to reduce the concentrations of volatile organics. It is possible, because of the immediate

TABLE 4-7

CHEMICALS DETECTED IN PRODUCTION WELL SAMPLES (μg/L)(1)
PRIVET ROAD COMPOUND SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	PRW-NW-1A(2)		PRW-NW-1B		PRW-NW-2A		PRW-NW-2B	
	Before Pump Test		After Pump Test		Before Pump Test		After Pump Test	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Tetrachloroethene	53/52	-	37	-	4J(1)	-	4J(1)	-
Trichloroethene	13/12	-	10	-	6L(1)	-	5	-
Arsenic	2.8/3.7	4/3.6	2.4	4.2	3.2B	2.2	2.4B	2.9
Barium	232/225	233/237	114	200	241	280	287	299
Calcium	42900/42800	45400/44400	21600	34800	37400	43000	41400	43900
Iron	56BB/46BB	156BB/177B	40BB	62BB	247	83BB	76B	73BB
Lead	1U/1.1	3/1.8	1U	1.2U	2.8K(1)	1U	3.1	1U
Magnesium	26600/25300	27300/27500	12900	20400	14700	16600	16900	17600
Potassium	2140U/2140U	2140U/2140U	2140U	2140U	2140U	2140U	2140U	2140U
Sodium	12000/12000	12700/12400	6530	9840	10700	12100	12000	12000

(1) Complete analytical data base in Appendix A.
(2) Field duplicate sample results for both samples reported.

Qualifiers defined as follows:
U - Not detected at detection limit shown.
B, BB - Value is considered to be a false positive due to blank contamination.
J(1) - Value is estimated because result is reported at a concentration less than the CRQL.
L(1) - Value is baised low due to MS/MSD %R outside QC limits.
K(1) - Value is biased high due to high GFAA PDS %R.

response to pumping observed in the intermediate monitoring wells, that the source of at least some of the volatile organic contamination noted in the supply wells could be the onsite groundwater, however, no significant soil source areas have been identified.

In summary, the groundwater at this site contains several volatile organic chemicals at concentrations that exceed drinking water standards. Results were fairly consistent between the SI and the RI. This fact indicates that the groundwater at the site is unsuitable for potable use in its current state and that all source areas may not be fully characterized (i.e., the source of volatile organics has not been identified). While metals are not a major concern for this medium, several metals were detected in the unfiltered samples at concentrations that exceeded drinking water standards, which could be considered potential chemicals of concern.

4.5.3 Surface Water and Sediment

Five surface water and sediment samples were collected from a drainage system at the Privet Road Compound Site at the locations shown in Figure 4-3. Each sample was analyzed for TCL volatile organics, pesticides/PCBs, and metals, and the results are summarized in several tables in this section. The results are presented in their entirety in Appendix A..

4.5.3.1 Surface Water

Organic chemicals were occasionally detected at low concentrations in the surface water samples, but no PCBs or pesticides were found, as shown in Table 4-8. One surface water sample collected from a stream immediately north of the fenced area (PR-SWS-2) contained 92 µg/L 4-methyl-2-pentanone and 170 µg/L carbon disulfide. While another ketone (acetone) was detected in the onsite soil, no 4-methyl-2-pentanone was detected. Carbon disulfide was detected in one soil sample at a concentration of 1 µg/kg. Therefore, the surface water data do not appear to indicate that the onsite soil is a source of contaminated runoff from the site. In addition, neither of these chemicals was found in the shallow groundwater which discharges to this stream.

Acetone (1,300 µg/L) and 4-methyl-2-pentanone (220 µg/L) were also detected in an upstream surface water sample collected from the area west of the fenced area (PR-SWS-5), as shown on Figure 4-3. This sample location is farthest from the known source area, as well as upstream, and therefore it is unlikely that this observed contamination originated on site. Based on the concentrations reported in the blank samples, the presence of these chemicals may not be related to blank contamination, although it is possible because these chemicals are common laboratory contaminants.

TABLE 4-8

CHEMICALS DETECTED IN SURFACE WATER SAMPLES (μg/L)[1]
PRIVET ROAD COMPOUND SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	PR-SWS-1	PR-SWS-2	PR-SWS-4	PR-SWS-5	PRW-SWS-6
4-Methyl-2-pentanone	10U	92	10U	220	10U
Acetone	10U	170	10U	1300E	10U
Aluminum	590BB	1400	887BB	1260	415BB
Antimony	45U	45U	45U	45U	47
Barium	3U	5	5	37	3U
Calcium	8520	10600	16400	42000	7420
Chromium	7U	7U	7	10	7U
Iron	709	1660	1100	1290	571
Lead	3.8	5.2	3.4	3.2	1.5
Magnesium	1950	2600	4020	9040	2430
Manganese	16BB	41	21	32	12BB
Potassium	2140U	2380U	4740	5160	3230
Sodium	4450U	4450U	4450U	16700	4450U
Zinc	45	18BB	21BB	9BB	194

(1) Complete analytical data base in Appendix A.
Qualifiers defined as follows:
U - Not detected at detection limit shown.
BB - Value is considered to be a false positive due to blank contamination.
E - Value exceeds linear calibration range.

Only a few metals were detected in the surface water samples collected at this site. These include lead (maximum concentration of 5.2 µg/L), manganese (maximum concentration of 41 µg/L), chromium (maximum concentration of 10 µg/L), and zinc (maximum concentration of 194 µg/L). All of these samples were unfiltered, and therefore these values represent worst-case concentrations at the time of sampling.

No distinct patterns of surface water contamination could be discerned from the analytical data discussed above. The only two samples to contain volatile organics were located upstream of the site (PR-SWS-5) and at the confluence of two drainage ditches near the former storage area (PR-SWS-2). However, the contaminants found in the surface water samples were present at higher concentrations than in any other media samples (soil and groundwater), and in one case (that of 4-methyl-2-pentanone) were not detected at all in other media. In addition, the concentrations of metals in the surface water were not elevated in the vicinity of the site. The data appear to indicate that surface waters have not been adversely affected by onsite activities.

4.5.3.2 Sediment

The chemical analytical results for sediment samples collected at this site are presented in Table 4-9. Sediment samples were found to be free of volatile organic and pesticide contamination, with the exception of one detection of dieldrin in an upstream sample (PR-SS-1). The widespread occurrence of dieldrin on the air station property and the fact that this is an upstream sample appear to indicate that the 210 µg/kg dieldrin found in this sample is not related to waste storage or disposal activities at the Privet Road Compound. In fact, this value is only 5 percent greater than the reported upper confidence limit on the mean background concentration of dieldrin (200 µg/kg) and below the maximum reported background concentration (400 µg/kg).

Several metals were found at the greatest concentrations in the sediment sample collected from the confluence area (PR-SS-2), including cadmium, cobalt, copper, manganese, and nickel. Other metals were found at their maxima at other locations. For instance, the maximum concentration of lead found at this site (88.6 mg/kg) was found in an upstream sample (PR-SS-1), and the maximum concentrations of arsenic, vanadium, and zinc (7.8 mg/kg, 41.7 mg/kg and 124 mg/kg, respectively) were found in another upstream sample (PR-SS-5). The concentrations of other metals were lowest in sample PR-SS-6, which is farthest from the site. This fact appears to indicate that the offsite extent of sediment contamination is limited.

While it is not truly appropriate to compare concentrations of inorganic contaminants in sediment concentrations to those in soil (primarily because the matrices differ in grain size and other

TABLE 4-9

CHEMICALS DETECTED IN SEDIMENT SAMPLES (mg/kg)[1]
PRIVET ROAD COMPOUND - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	PR-SS-1	PR-SS-2	PR-SS-4	PR-SS-5	PR-SS-6
Dieldrin	0.210	0.041U	0.038U	0.059U	0.033U
Aluminum	13,300	10,300	18,300	18,700	8,060
Arsenic	7.1	6.2	6.2	7.8	3.6
Barium	85.0	167	87.3	97.7	39.7
Beryllium	1.1	1.4	0.95BB	1.3BB	0.69BB
Cadmium	2.2	4.7	2.1	1.9	0.87
Calcium	9,220	3,990	2,380	2,360	2,510
Chromium	26.8	24.9	27.0	31.8	14.7
Cobalt	9.3	17.1	9.0	9.9	5.2
Copper	21.6	36.1	21.5	22.9	8.8
Iron	21,900	33,500	24,400	24,400	12,800
Lead	88.6	29.7	41.6	44.5	23.4
Magnesium	5,400	3,970	2,610	2,820	1,910
Manganese	545	1,280	463	571	243
Nickel	13.8	22.3	14.0	16.9	7.6
Potassium	1,390	1,550	1,080	1,160	692
Vanadium	36.1	34.5	41.4	41.7	21.0
Zinc	102	84.3	101	124	67.5

(1) Complete analytical data base in Appendix A.
Qualifiers defined as follows:
U - Not detected at detection limit shown.
BB - Value is considered to be a false positive due to blank contamination.

characteristics), a simple comparison may highlight metals of potential concern. For instance, arsenic, cobalt, copper, manganese, and zinc were found at average concentrations in the sediment samples that exceed the reported background averages. These metals were also found at the lowest concentrations in the sample that was collected farthest from the site (PR-SS-6).

Dieldrin, which is commonly found in soil and sediment samples collected from the Air Station as a result of past pesticide application, was detected in only one sediment sample (which was located upstream of the site) during the RI. The greatest concentrations of metals observed in these samples were found in the sample collected from the confluence of the two boundary drainageways. No distinct patterns of sediment contamination were noted in the other samples collected.

4.6 CONTAMINANT FATE AND TRANSPORT

There are two primary contaminant migration routes acting at this site -- the migration of soluble chemicals through the subsurface soil with eventual downgradient transport via groundwater advection and the erosion of contaminated surficial material with downstream transport during storm events.

The types of chemicals that are more amenable to the first transport mechanism are the volatile organics such as those that were found in the groundwater. These types of chemicals generally have high solubilities and low organic carbon partition coefficients, which act in concert to make them fairly mobile in groundwater. In addition, their high vapor pressures and Henry's Law constants make them more likely to volatilize from surface spills, and therefore their concentrations in unsaturated soil tend to be fairly low. There was little soil contamination observed in the soil borings installed throughout the fenced area. These data appear to indicate that there is not a significant source of organic contamination at the Privet Road Compound Site that would continue to degrade groundwater quality, although previous activities at the site may have resulted in at least some of the observed groundwater contamination.

Chemicals with low solubilities and high organic carbon partition coefficients such as pesticides and PCBs generally adhere to the soil matrix, where they are transported via bulk movement processes such as erosion. These chemicals do not generally move in solution. PCBs and pesticides were detected in the shallow subsurface soils, as well as in sediment during the SI.

Fugitive dust emissions from this site would be expected to be minimal in light of the fact that the site is well vegetated and much of the site is paved or covered with structures. In addition, volatile emissions would also be minimal given the low concentrations of volatile organic chemicals in the soil (maximum detected concentration was 21 µg/kg of acetone).

4.7 POTENTIAL HUMAN RECEPTORS

Because of the limited amount of contamination observed at this site and the fact that most contamination was in the subsurface media, there is little public health risk associated with exposures at this site. While the groundwater contains several volatile organic chemicals, it is not used for potable purposes in this area prior to air stripping. Therefore, any potential exposures are purely hypothetical since they could occur at some unspecified time in the future should a potable supply well (without an air stripper) be installed in this area. The potential receptors for such a scenario include both adult and child residents.

Persons using the bowling alley or other facilities in the immediate area could come in contact with surface soil, however, these exposures would be limited in duration and magnitude. One surface soil sample collected from an unpaved area contained 230 mg/kg Aroclor-1260. The average concentration of Aroclor-1260 throughout this site was estimated at 3.76 mg/kg. Receptors could include both adults and children who use the facilities. On the other hand, should construction activity occur in this area, these adult workers could be exposed to subsurface soil that is excavated for foundation construction. These exposures, while more intensive in magnitude, would most likely occur over a very limited period of time such as that allotted for construction projects (perhaps less than 6 months once in a lifetime for any receptor).

It is also possible that persons could also be exposed to sediment and surface water in the drainage swales. The most likely receptors for contaminants in this medium are youths who play in the area. Currently, the drainage areas are not secured by a fence, and therefore trespassers could possibly come in direct contact with the sediments or surface water. These exposures would not be continual in nature, primarily because there is a limited number of family housing units on base. In addition, the receptors would be limited to youths rather than adults, because adults are not likely to purposely wade in these areas.

There are no identified environmental receptors for contamination that originates on site. The drainage ditches are not permanent streams that support aquatic life.

4.8 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

4.8.1 Field Activities

Sixteen soil test borings were completed and eight monitoring wells were installed in the vicinity of the former waste disposal area. Monitoring wells installed during the RI included three shallow (water table) wells and five intermediate depth wells. Up to five soil samples were collected from each test boring location and groundwater samples were obtained from a total of 12 monitoring wells and 2 production wells. Five surface water and sediment samples were collected from surface drainage locations near the site. Samples were analyzed for TCL volatiles and pesticides/PCBs, TAL metals, and cyanide.

Pumping tests were performed to characterize the shallow and intermediate depth monitoring well response to pumping from Navy Well Nos. 1 and 2. Tests were completed under baseline (normal pumping) conditions and separately for Navy Well Nos. 1 and 2 for 24- and 12-hour durations, respectively.

4.8.2 Physical Characteristics

Overburden, consisting of sandy silt to silty clay material overlies bedrock to depths ranging from approximately 7 to 12 feet below the ground surface. Bedrock consists of an alternating sequence of fine- to medium-grained sandstone and siltstone with shale seams. Zones of varying resistance to drilling penetration, and corresponding variation in water yield, were encountered during monitoring well drilling.

Groundwater level measurements and pumping test data indicates that distinctly different groundwater flow directions exist between the shallow (water table) aquifer zone and a deeper zone roughly corresponding to the level of the Navy production wells. This variability in flow direction results from pumping of the production wells. Restricted communication between the two aquifer zones was observed during pumping tests, indicating that the production well output is derived almost entirely from the deeper zone. However, infrequent correlation between production well pumping and water table well piezometric level indicates that migration of contaminants from the water table level to the zone of groundwater production in Navy Well Nos. 1 and 2 is probable.

4.8.3 Site Contamination

In 1989, groundwater samples collected at the Privet Road Compound Site were found to contain several volatile organic chemicals (such as tetrachloroethene and trichloroethene) at concentrations that

exceeded drinking water standards (i.e., Maximum Contaminant Levels). These shallow groundwater samples were located on the northwestern side (downgradient) of the site (PRW-1 and PRW-2). However, none of the soil samples collected at that time were found to contain volatile organics. Instead, the primary soil contaminants observed at this site were polychlorinated biphenyls (PCBs) and dieldrin. The presence of these chemicals, particularly the fact that PCBs were detected in drainage ditches outside the waste handling area, led to the conclusion that contaminants could be migrating off site.

In 1991, various media at the site were again sampled to more precisely define the nature and extent of contamination at this site.

Soil samples were collected from a rough grid in the waste handling area and beyond. As during the 1989 SI investigation, volatile organics were infrequently detected at generally low concentrations (ranging from 1 to 21 µg/kg). It does not appear, therefore, that the soil in this area is the source of the volatile organic chemicals detected in the groundwater. Aroclor-1260 (a PCB) was found in 13 of 72 samples, at concentrations ranging from 220 to 230,000 µg/kg. The PCBs were found primarily in soil samples collected from depths of 4 feet or less, with one detection at greater depth (6 to 7.5 feet). Dieldrin was detected only once, unlike during the SI. Two metals, cobalt and selenium, were found at concentrations that were greater than those found in the background samples.

One complete round of groundwater samples was collected from the wells at this site. Volatile organics were the major types of groundwater contaminants detected at the site, as in 1989, however, their presence was limited in areal extent. The maximum concentrations were generally found in the sample collected from the intermediate depth well 7B (PRW-7B). This particular well is located upgradient of the site when the Navy supply wells are pumping, which is the normal (baseline) condition. Trichloroethene was detected in this sample at a concentration of 120 µg/L and tetrachloroethene was detected at a concentration of 7 µg/L, both of which exceed the MCLs. Groundwater flow direction in the intermediate portion of the aquifer is controlled by two Navy supply wells, which may serve to draw contamination to these wells from upgradient source area(s) such as the Washrack or from the shallow aquifer.

No distinct patterns of surface water and sediment contamination were observed during evaluation of the RI data. Minor differences were noted in the samples collected from the confluence of the two drainage ditches north of the site (PR-SS-2 and PR-SWS-2). Both the sediment and the surface water sample from this location contained slightly elevated levels of metals. However, it should be noted that some metals were found at their maximum concentrations in sediment in samples collected from upstream of the site (e.g., lead). No PCBs were detected in the 1991 sediment samples. Therefore,

the data do not appear to indicate that the site is currently a significant source of either runoff or discharge of contaminated groundwater.

4.8.4 Recommendations

Because the source of groundwater contamination has not been identified at this site, additional investigation may be warranted. Volatile organic chemicals were detected in samples collected from several wells, including an upgradient intermediate well during the RI and shallow onsite wells during the SI and RI. Volatile organic chemicals were found sporadically in the soil samples collected from the onsite grid, and the concentrations were too low (i.e., less than 25 µg/kg) to act as a source of groundwater contamination. It is possible, therefore, that additional source areas lie upgradient of the Privet Road Compound Site (such as the Washrack) that could contribute to the observed volatile organic contamination in groundwater. The Washrack is upgradient of the intermediate aquifer at Privet Road under normal pumping conditions. Another possibility is that the source was onsite and has been washed out.

Therefore, it is recommended that groundwater samples be collected or that existing data obtained by another site contractor during ESI work at the Washrack be evaluated to better define the lateral extent of groundwater contamination. In addition, a deeper well is recommended for the area around well PRW-7/7B, because the maximum observed concentrations of volatile organics in 1991 were found in the sample from well PRW-7B.

No soil source areas have been identified either at the Privet Road Compound or at the Washrack. No additional soil samples are recommended, and future investigation will focus on groundwater contamination.

Analyses of groundwater samples should focus on Target Compound List volatile organics. Neither semivolatiles, pesticides, or PCBs were considered to be major groundwater contaminants upon completion of the SI. In fact, the major concerns after the SI were pesticides and PCBs, neither of which were detected in the groundwater during the RI.

The approximate extent of PCB contamination in the soil grid area has been defined, with the exception of the single "hot spot" noted in the vicinity of boring 3 (PRB-3), where the surface sample contained 230,000 µg/kg Aroclor-1260. Because the vertical extent of PCB contamination in the grid area appears to be limited to depths of less than 8 feet, additional soil sampling should focus only on the shallower depths in this immediate area. It is possible that this sample location is from within a previously used drainage way through which transformer oil drained to the ditch. PCBs are not highly

soluble and therefore it would not be necessary to sample to the water table and/or collect additional groundwater samples for PCB analysis. PCBs were not detected in the ditches during the latest round of sampling, and therefore additional sediment sampling is not recommended.

Following receipt of these data points, the nature and extent of contamination will be reevaluated, and a quantitative risk assessment will be performed. Preliminary remediation goals will be developed, and the site can then be moved to the feasibility study stage.

5.0 ANTENNA FIELD LANDFILL - NAS SITE 2

5.1 SITE HISTORY AND DESCRIPTION

The Antenna Field Landfill was used between 1948 and 1960 as the exclusive disposal area for solid waste generated by the NAS Willow Grove Activity. The site is located near the south end of the Air Station, southwest of Runway 10/28 (Figure 1-2). Landfilling activities consisted of trench excavation and subsequent burning and burial of waste material disposed of within the trenches. The landfill area was estimated by EA Engineering (August 1991) to be approximately 9 acres in size, with the northern extent of the landfill being unknown. Previous work concluded that the site is a probable source of dieldrin found in surface water.

5.2 SUMMARY OF PREVIOUS SITE INVESTIGATIONS

Previous investigations at the Antenna Field Landfill Site included both a PA and an SI. The PA determined that a variety of hazardous materials were suspected to have been disposed of within the landfill. Wastes containing volatile and semivolatile organics, pesticides/PCBs, metals, cyanide, and petroleum hydrocarbons were reported to have been deposited, burned, then buried at the site. Based on these findings an SI study was recommended for the site.

The site investigation included sampling and laboratory analysis of groundwater, surface water, and sediment samples. Three shallow 4-inch monitoring wells were installed for collection of groundwater samples and investigation of subsurface geological and hydrogeological conditions. No subsurface soil samples were collected for laboratory analysis. Samples collected during the investigation were analyzed for Target Compound List (TCL) volatiles, semivolatiles, and pesticides/PCBs; Target Analyte List (TAL) metals (both total and dissolved for groundwater); total organic carbon (TOC); total petroleum hydrocarbons (TPH); and cyanide. Three complete rounds of sample collection and analysis were performed for all media.

Low concentrations of volatile organic chemicals were detected in an upgradient well (ALW-2), including monocyclic aromatics (such as benzene and toluene) and trichloroethene. However, all volatiles were found at concentrations below the Contract Required Detection Limits for these chemicals. The downgradient wells on the east (ALW-3) and south (AWW-1) sides of the landfill were found to contain dieldrin, and ALW-1 also contained a few phthalate esters at low concentrations. Metals such as lead, arsenic, mercury, and zinc were noted in the unfiltered groundwater samples.

No volatile organic chemicals were detected in either the surface water or sediment samples collected from the drainage swale, however a number of polynuclear aromatic hydrocarbons were found in the sediment samples. In addition, dieldrin was also detected in the sediment samples.

5.3 PHASE I REMEDIAL INVESTIGATION

Previous investigations at the Antenna Field Landfill indicate that it may be a source of dieldrin and other pesticides that have been detected in nearby surface waters and sediments. Surface water and sediment sampling was performed to determine whether the landfill is the actual source of the pesticide. Leachate samples, which were planned as part of the field investigation, were not obtained after numerous inspections of the landfill indicated that no leachate sources existed. Extremely dry weather conditions throughout the summer may have resulted in discontinued flow from previously existing areas of leachate seepage to the ground surface. All samples obtained from the Antenna Field Landfill Site were analyzed for TCL volatiles, semivolatiles, and pesticides/PCBs, and TAL metals.

5.3.1 Soil Investigation

No soil investigation activities were completed at the Antenna Field Landfill during the remedial investigation phase, in accordance with the Draft Plan of Action for the subject work (EA, May 1991).

5.3.2 Groundwater Investigation

Three existing shallow monitoring wells, located as shown on Figure 5-1, were measured (water level), purged, and sampled during the RI field activities. Purging and sampling procedures were identical to those described in Section 2.1.4. No additional wells were installed at the site.

5.3.3 Surface Water and Sediment Investigation

Eight on base and three off base surface water and sediment sample locations were originally planned as part of the field investigation. Upon further consideration, two additional locations were selected. Two locations are in an ephemeral stream located on the southeastern edge of the landfill (AL-SWS/SS-1, -2 and -4), and two are located in a drainage swale on top of the former landfill area (AL-SS-3 and -5). Two samples were selected from the drainage swale farther northwest (upstream) of the surface of the landfill (AL-SS-6 and AL-SWS/SS-13). Four sample locations were selected in the unnamed creek that flows along Horsham Road (AL-SWS/SS-7, -8, -9, and -10), and two were in Pennypack Creek upstream (AL-SWS/SS-11) and downstream (AL-SWS/SS-12) of the base drainage.

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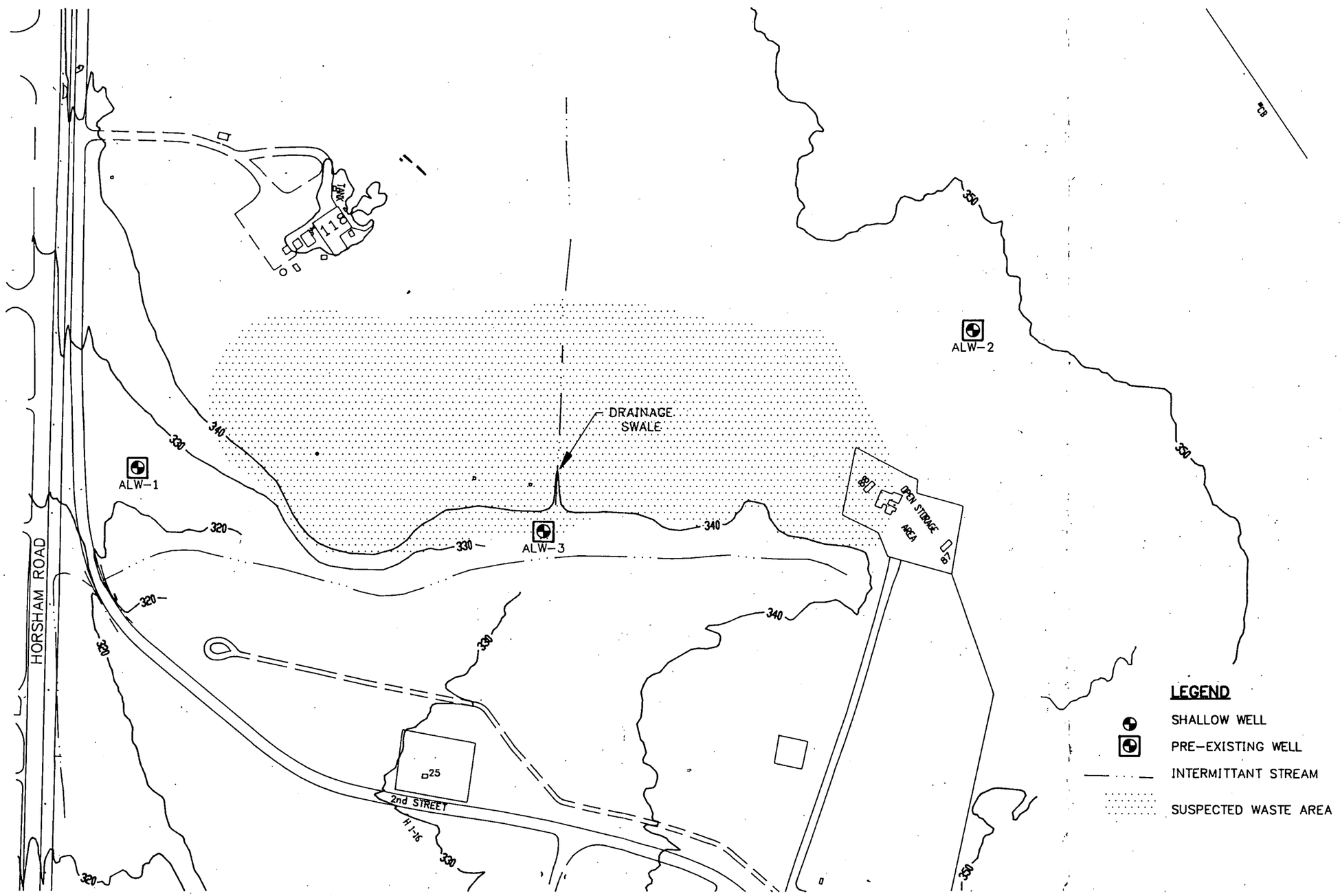

WELL LOCATIONS
NAS SITE 2 – ANTENNA FIELD LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 5-1

HALLIBURTON NUS
Environmental Corporation

The locations of surface water and sediment samples collected within the site are shown on Figure 5-2. Offsite sample locations are shown on Figure 5-3.

As a result of the unseasonably low precipitation there was no flow in the ephemeral stream, therefore, the sediment samples were collected on a separate (initial) date. All the sediment samples except one from an upstream location (AL-SS-13) location were collected on the same date, in sequence from the most downstream location to the most upstream location.

All locations were adequately staked or pinned to allow the surface water sample to be collected at the same location at a later date. All surface water samples were collected in the same order during the late morning after an overnight rainfall that provided adequate flow throughout the length of the stream to Pennypack Creek. No aqueous fraction could be collected from the drainage swale that extended across the landfill.

5.4 SITE CHARACTERISTICS

5.4.1 Surface Features

The Antenna Field Landfill is located in a relatively undeveloped section of NAS Willow Grove near the southern boundary of the activity northeast of 2nd Street and northwest of Horsham Road. The entire site is covered by vegetation, including grass, brush, and trees.

5.4.2 Geology

No monitoring wells, test borings, or other subsurface investigation activities were performed at the Antenna Field Landfill during the RI phase work. Previous work performed by EA Engineering (May 1990) included installation of three monitoring well borings. The top of bedrock, described as a tan, red-brown, or yellow-brown sandstone, ranged in depth from approximately 9 to 15 feet below ground surface. Overburden was generally described as silty clay to silty sand at the boring locations. Monitoring wells were located in the perimeter of the site and no borings were advanced through the waste disposal area. Cross section B-B' was developed on the basis of information provided in the SI Report (EA, May 1990) and is included as Figure 5-4.

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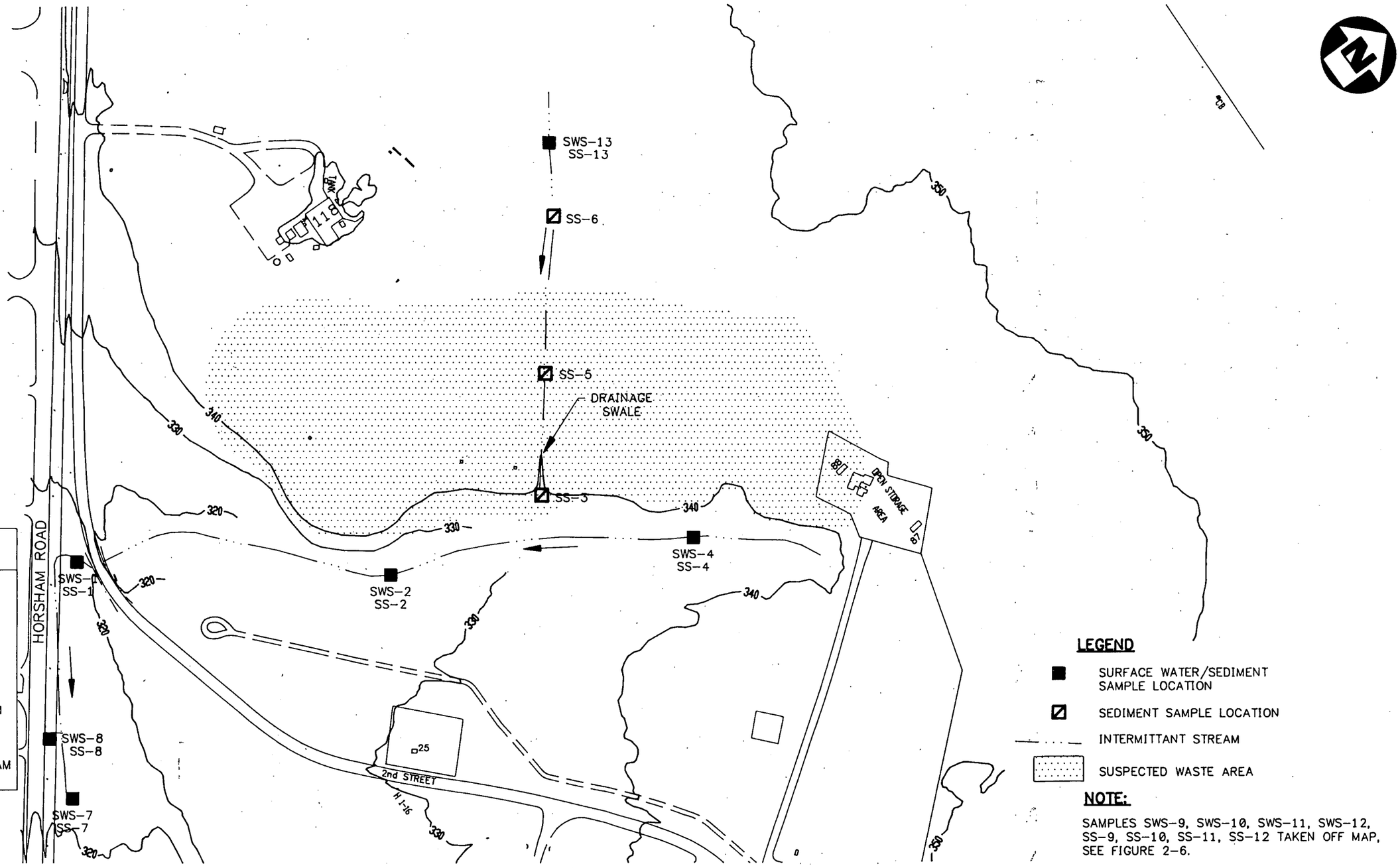

OFF BASE DOWNSTREAM SAMPLES

SWS-9 AND SS-9
300' DOWNSTREAM

SWS-10 AND SS-10
30' UPSTREAM FROM CONFLUENCE WITH PENNEYPACK CREEK

SWS-11 AND SS-11
PENNEYPACK CREEK UPSTREAM FROM BASE DRAINAGE

SWS-12 AND SS-12
PENNEYPACK CREEK DOWNSTREAM FROM BASE DRAINAGE

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
NAS SITE 2 - ANTENNA FIELD LANDFILL - ONSITE LOCATIONS
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

0 150 300
SCALE IN FEET

FIGURE 5-2

HALLIBURTON NUS
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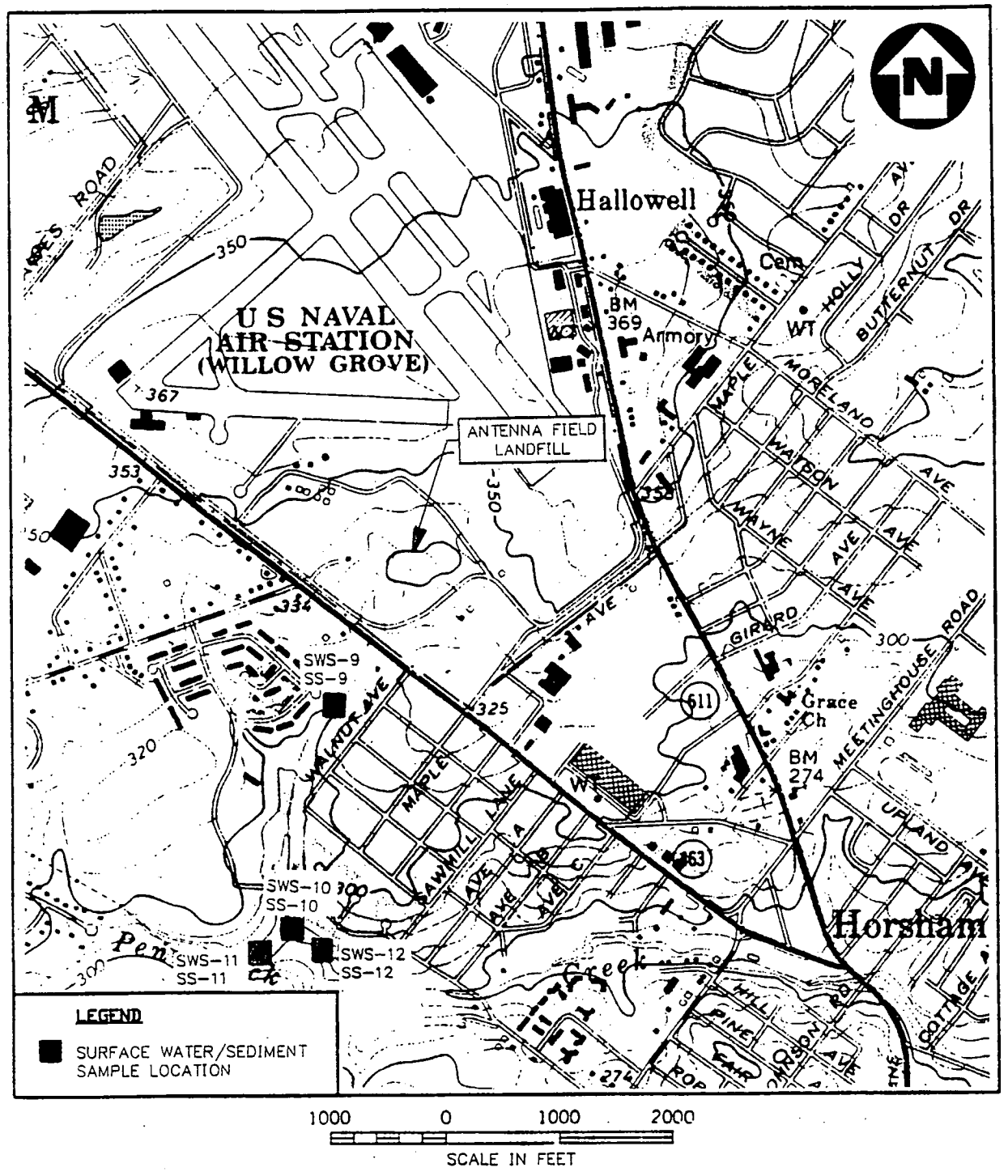

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS FIGURE 5-3
NAS SITE 2 - ANTENNA FIELD LANDFILL
OFF SITE LOCATIONS
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

HALLIBURTON NUS
Environmental Corporation

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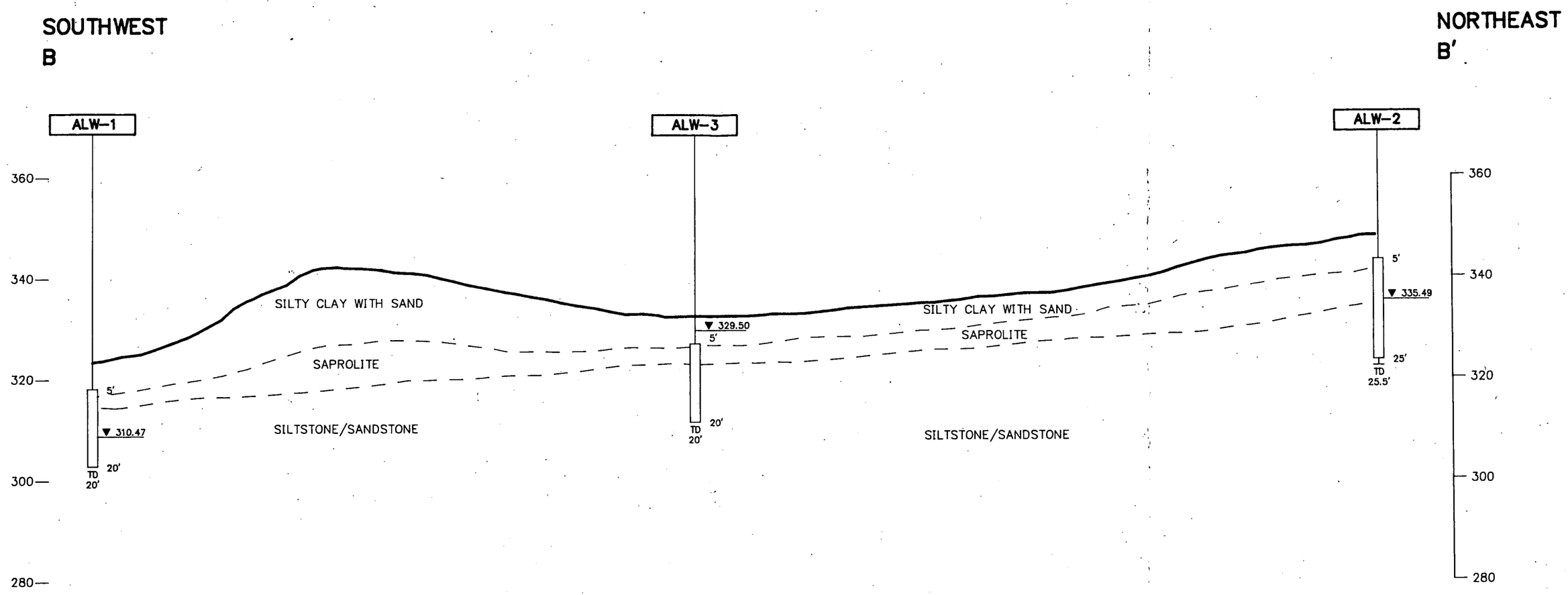
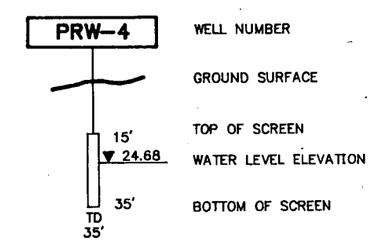


NOTES: WATER LEVEL DATA COLLECTED FROM 9/16–18/91
CROSS SECTION LOCATION SHOWN ON FIGURE 5–5

LEGEND



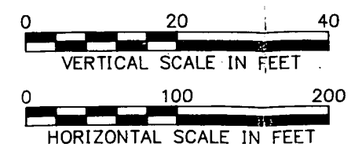


FIGURE 5–4

CROSS SECTION B–B'
NAS SITE 2 – ANTENNA FIELD LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

HALLIBURTON NUS
Environmental Corporation

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5.4.3 Hydrology

The ground surface at the Antenna Field Landfill Site generally slopes toward the southwest at a grade of less than 2 percent. The ground surface is covered throughout most of the area with grassy or woody vegetation, resulting in the probable infiltration of most precipitation falling in the vicinity.

A small ephemeral drainage swale traverses the area immediately southwest of the landfill area. The ephemeral drainage flows into an unnamed creek, which then flows off base approximately 300 feet from the landfill area and enters Pennypack Creek approximately 3,000 feet from the base boundary.

5.4.4 Hydrogeology

The SI Report (EA, May 1990) indicates that a perched water table rising to within 2.5 feet of the ground surface, potentially saturating waste material and resulting in percolation of contaminants to an underlying aquifer and into the nearby drainage swale, may be present at the site. A water level of approximately 4.5 feet below the ground surface was measured at one monitoring well. However, well construction at this location (screened from 5 to 20 feet below the ground surface) does not allow a determination to be made regarding the relationship of this water level to perched or water table conditions.

No evidence of seepage to the ground surface or drainage swale was observed during the RI. However, this may be the result of unseasonably dry conditions prevalent prior to and during the period of field investigation.

Groundwater levels at existing wells were measured during the RI and are shown in Table 5-1. Contouring of the potentiometric surface (Figure 5-5) based on these measurements suggests an westerly flow direction in the water table aquifer. A deeper, artesian aquifer is reported at the site, but has not been investigated. Several wells have been constructed approximately 1/2 mile north of the site in the vicinity of the 9th Street Landfill to monitor this aquifer.

5.5 NATURE AND EXTENT OF CONTAMINATION

This section presents a summary discussion of the nature and extent of groundwater, surface water, and sediment contamination associated with the Antenna Field Landfill Site. The complete analytical results are presented in Appendix A. Positive detections of chemicals are summarized in a series of tables in this section.

TABLE 5-1

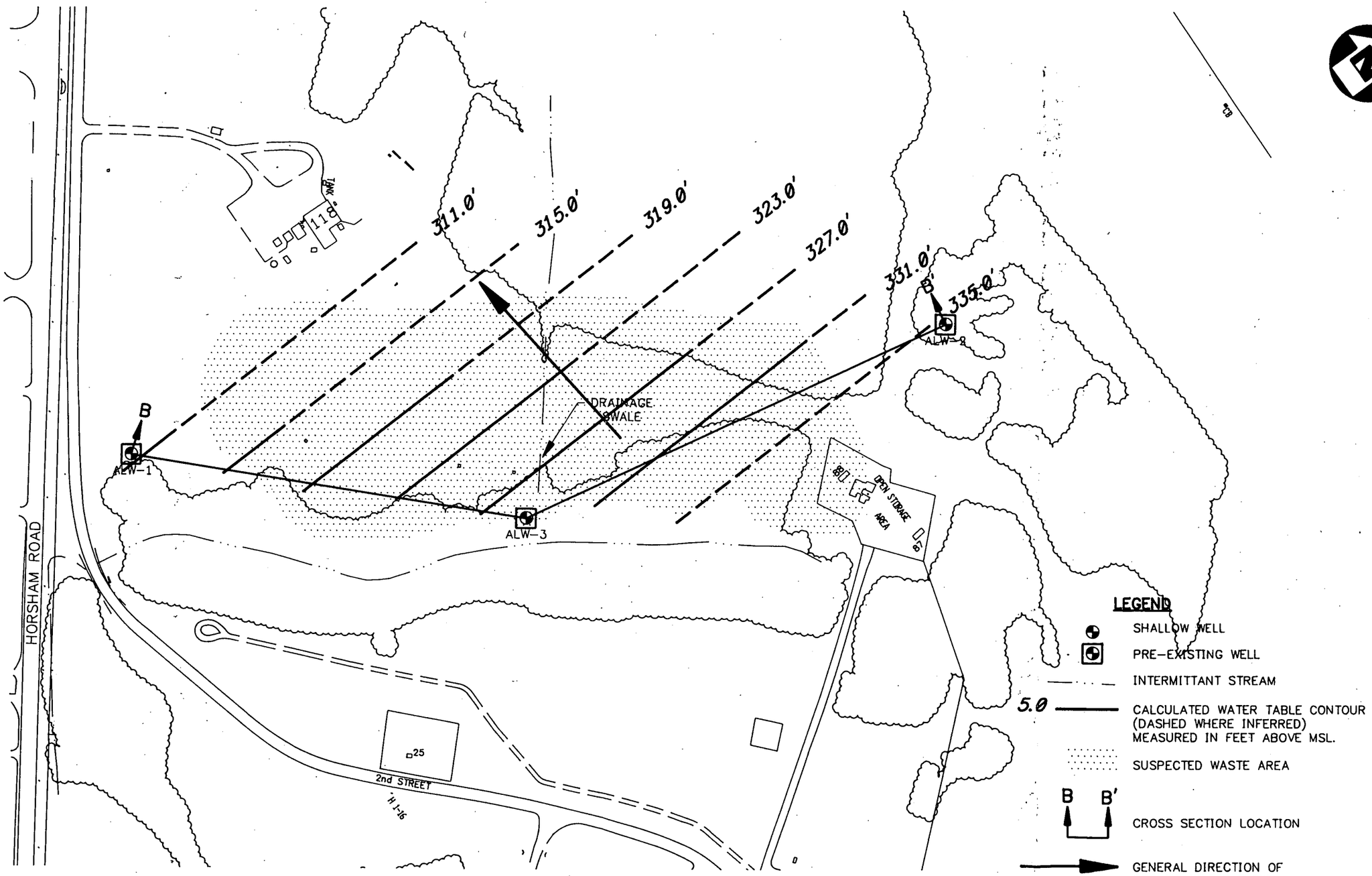
WATER LEVEL DATA[1]
ANTENNA FIELD LANDFILL
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Well Number	Top PVC Elevation	Ground Elevation	Water Level[2]	Water Elevation
ALW-1	326.57	324.46	16.10	310.47
ALW-2	350.29	348.35	14.80	335.49
ALW-3	[illegible]3.90	332.05	4.40	329.50

(1) Measurements in feet above MSL, except when noted.
(2) Measurements in feet below top of PVC.

Note: Measurement[illegible]en 09/16/91 and 09/18/91.

ACAD: 3552\NAS2.DWG LIMITS 6/2/92 MJJ (07/17/92)



NOTES:

CONTOUR INTERVAL 4.0 FEET

WATER TABLE CONTOURS IN FEET ABOVE MSL.
WATER LEVELS MEASURED ON 9/16 AND 9/18/91

POTENTIOMETRIC SURFACE MAP OF SHALLOW MONITORING WELLS
NAS SITE 2 – ANTENNA FIELD LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 5-5

HALLIBURTON NUS
Environmental Corporation

During the Site Inspection performed for this site, groundwater, surface water, and sediment were sampled. All the analytical results were presented in the Site Inspection Report (EA, May 1990) and were used to develop the scope of work for the current investigation.

Low concentrations of volatile organic chemicals were detected in the upgradient well (ALW-2), including monocyclic aromatics (such as benzene and toluene) and trichloroethene. However, all volatiles were found at concentrations of 3 µg/L, which is below the Contract Required Detection Limits for these chemicals. These chemicals were also detected only during the first sampling round. The wells on the east (ALW-3) and south (ALW-1) sides of the landfill were found to contain dieldrin (maximum concentration of 0.04 µg/L), and the southernmost well also contained a few phthalate esters at low concentrations (up to 4 µg/L). Several metals were noted in the unfiltered groundwater samples such as lead, arsenic, mercury, and zinc. However, with the exception of lead, which was found at concentrations that exceeded the current action level of 15 µg/L, none exceeded drinking water standards.

No volatile organic chemicals were detected in the sediment samples collected from the drainage ditch, however a number of polynuclear aromatic hydrocarbons were found. The PAH that was found at the maximum concentration in Round 1 was fluoranthene (2,000 µg/kg in sample AL-SS-3). The concentrations of other PAHs in sediment samples ranged from 65 µg/kg (fluorene) to 1,700 µg/kg (pyrene). In general, the highest concentrations were found in sample AL-SS-3.

In the second round of sampling, PAHs were found at the maximum concentrations in sample AL-SS-4. Pyrene (122,650 µg/kg) was found at the greatest concentration in this sample. In the second round, sample AL-SS-3 had the lowest concentrations of PAHs. In addition, dieldrin was also detected in the sediment samples. It was found at the greatest concentrations during both sampling rounds in sample AL-SS-3 (510 µg/kg and 200 µg/kg).

Three rounds of surface water samples were collected during the SI. Only two individual samples during Round 3 contained volatile organics (methylene chloride at 5.1 µg/L and 2-hexanone at 157.96 µg/L). No semivolatile organic chemicals were detected, with the exception of periodic low concentrations of phthalate esters at up to 4 µg/L. Dieldrin was also detected in several surface water samples. The maximum concentration of dieldrin in the surface water was found in sample AL-SWS-3 (0.30 µg/L) in Round 1. Dieldrin was not detected at all in Round 3.

The results of the Remedial Investigation sampling and analysis are discussed in the remainder of this section.

5.5.1 Groundwater

Three existing monitoring wells at the Antenna Field Landfill were sampled in 1991, and the samples were analyzed for Target Compound/Analyte List volatile and semivolatile organics, pesticides/PCBs, and total metals. The analytical results are summarized in Table 5-2, and the complete data base is contained in Appendix A.

Well ALW-2 is considered to be the upgradient well, and wells ALW-1 and ALW-3 are somewhat downgradient of the landfill, as shown in Figure 5-1. No organic chemicals were detected in any of the wells, although low concentrations of several compounds were noted in all wells during at least one round of the SI. Table 5-2 presents a summary of the inorganic analytical results (positive detections only).

Arsenic, cadmium, and chromium were each detected only once. Arsenic was detected at a concentration of 2.5 µg/L, which is similar to the levels reported during the SI (1.4 to 4 µg/L) Barium and magnesium were detected in all three wells, with the lowest concentrations found in the upgradient well (ALW-2). The maximum concentration of barium at this site was found to be 271 µg/L, and the maximum concentration of manganese was 4,730 µg/L. Again, these are similar to the ranges reported during the SI. The concentrations of the more soluble metals (aluminum, calcium, iron, magnesium, and sodium) also varied between samples; however, because these metals are also major components of natural soils their presence at elevated levels in downgradient samples may be related to the presence of suspended sediment in the water rather than be indicative of a source of metals contamination. Lead was detected during the SI at a concentration that exceeded the action level of 15 µg/L, however, the maximum concentration of lead noted during the RI was 2 µg/L.

In summary, although several organic chemicals were detected at low concentrations in groundwater samples during the SI, none were detected during the RI. The concentrations of metals in the unfiltered samples in 1991 were low, as in 1989. However, in 1991, no metal was found at a concentration that exceeded drinking water standards.

5.5.2 Surface Water and Sediment

Surface water and sediment samples were collected from the locations shown in Figures 5-2 and 5-3. The first six samples were collected from a drainage swale and an ephemeral drainage that flow through and beside the former landfill (AL-SWS/SS-1 through -6). One additional sample was collected upstream of the landfill in the swale (AL-SWS/SS-13). Four samples were collected from the unnamed stream which flows off base. (AL-SWS/SS-7, -8, -9 and -10), and the last two were collected from

TABLE 5-2

CHEMICALS DETECTED IN GROUNDWATER SAMPLES ($\mu g/L$)[1]
ANTENNA FIELD LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	ALW-1	ALW-2 (Upgradient)	ALW-3
	(304.46'-319.46')[2]	(323.35'-343.35')	(312.05'-327.05')
Aluminum	931	295BB	876
Arsenic	2U	2U	2.5
Barium	103	102	271
Cadmium	4U	4U	4
Calcium	15600	10600	24700
Chromium	7	7U	7BB
Iron	1280	558	11700
Lead	1	1	2.2
Magnesium	5900	3320	9900
Manganese	19	12BB	4730
Sodium	8560	8920	8750

(1) Complete analytical data base in Appendix A.
(2) Screened interval elevation (NGVD 1929).
Qualifiers defined as follows:
U - Not detected at detection limit shown.
BB - Value is considered to be a false positive.

Pennypack Creek upstream and downstream of the confluence with the unnamed creek (AL-SWS/SS-11 and -12, respectively).

5.5.2.1 Surface Water

Each of the 10 surface water samples was analyzed for Target Compound/Analyte List volatile organics, semivolatile organics, pesticides/PCBs, and metals (total or unfiltered). The surface water analytical results are summarized in Table 5-3, and are presented in their entirety in Appendix A.

No pesticides or PCBs were detected in the surface water samples that were collected from the drainage ditches or Pennypack Creek. However, there were a few detections of semivolatile organic chemicals in the surface waters. Two phthalate esters were detected in sample AL-SWS-4 collected from the ephemeral drainage adjacent to the landfill. Bis(2-ethylhexyl)phthalate was found in one of two duplicate samples at a concentration of 10 µg/L, which is the detection limit for this chemical in water. Di-n-butylphthalate was also found in one of the duplicate samples collected from this location, at a concentration of 30 µg/L (detection limit of 10 µg/L, also). Neither of these chemicals were found in any other surface water samples, and were infrequently detected in the sediment samples (as discussed in Section 5.5.2.2).

Both these compounds were identified sporadically (at concentrations ranging from 1 to 4 µg/L) during the SI. These chemicals are not generally soluble in water, and this fact in combination with the presence of di-n-butylphthalate in nonassociated laboratory method blanks indicates that their presence in these unvalidated surface water samples could be related to blank contamination.

The occurrence and distribution of metals in the surface water samples is also summarized in Table 5-3. The highest concentrations of many metals were in the samples collected from Pennypack Creek (AL-SWS-11 and -12), the most downstream sample from the unnamed creek (AL-SWS-10), and the most upstream sample (AL-SWS-13) in the swale. The metals that follow this particular distribution pattern are aluminum, iron, lead, potassium, and zinc. Other metals were found at similar concentrations in all samples (e.g., barium, manganese, and potassium). However, none of the observed concentrations or distribution appear to be indicative of a major source area of metals related to the Antenna Field Landfill since the maximum concentrations of many metals were found some distance downstream of the site.

When the SI and RI surface water sample inorganic analytical results are compared, some differences are noted. This comparison can only be made for samples AL-SWS-1 through -4. Primarily, the concentrations of total metals measured during the RI were lower than those measured during the SI.

TABLE 5-3

CHEMICALS DETECTED IN SURFACE WATER SAMPLES (µg/L)[1]
ANTENNA FIELD LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	AL-SWS-1[2] Ephemeral Drainage	AL-SWS-2 Ephemeral Drainage	AL-SWS4[2] Ephemeral Drainage	AL-SWS-7 Unnamed Creek	AL-SWS-8 Unnamed Creek	AL-SWS-9 Unnamed Creek	AL-SWS-10 Unnamed Creek	AL-SWS-11 Upstream Pennypack Creek	AL-SWS-12 Downstream Pennypack Creek	AL-SWS-13 Upstream Drainage Swale
Bis(2-ethylhexyl)phthalate	10U/10U	10U	10U/10J(1)	10U	10U	10U	10U	4BB	10U	10U
Di-n-butylphthalate	10U/10U	10U	10U/30J(1)	10U	10U	10U	10U	10U	10U	10U
Aluminum	128BB/121BB	126BB	190BB/144B	259BB	149BB	179BB	600BB	1500	1290	666BB
Barium	10/8	9	8/64	188	17	35	28	32	32	9
Beryllium	4BB/4BB	4BB	4BB/4	4BB	4BB	4BB	4BB	4BB	4BB	4BB
Calcium	10300/10500	11800	15800/32100	19500	10500	10800	8270	8460	8680	6710
Chromium	7U/7U	7U	7U/7	7U	7U	7U	7U	7U	7U	7U
Copper	12BB/10BB	11BB	9BB/30B	9BB	10BB	6BB	7BB	8BB	9BB	11BB
Iron	169BB/181BB	167BB	287BB/475	518	224BB	307BB	709	1520	1420	1010
Lead	1.6/1.4	1U	2/2.9	1.2	1U	1.2	2.2	3.3	3.4	4
Magnesium	2920/2870	3200	4070/13100	5960	3120	3170	2550	2850	2820	2200
Manganese	40/38	65	63/497	67	49	48	49	57	61	54
Potassium	2560/2480	2710	3290/186000	2140U	2660	2370	2440	3810	3580	5780
Sodium	4450U/4450U	4450U	4450U/53400	7500	4450U	4450U	4450U	4450U	4450U	4450U
Zinc	9BB/8BB	10BB	9BB/27	9BB	9BB	8BB	13BB	27	15BB	25BB

(1) Complete analytical data base in Appendix A.
(2) Field duplicate sample results for both samples reported.
(3) Screened interval elevation (NGVD 1929).

Qualifiers defined as follows:
U - Not detected at detection limit shown.
BB - Value is considered to be a false positive due to blank contamination.
J(1) - Value is estimated because result is reported at a concentration less than the CRQL.

In several cases, where metals were detected during the SI (e.g., arsenic, cobalt, nickel, thallium, and vanadium), they were not detected during the RI. This fact, however, may not be significant because the concentrations of metals in surface water are dependent to some extent on the amount of suspended sediment in the sample, which can vary over time with flow conditions.

In summary, the presence of organic chemicals in surface water was not widespread, either during the SI or the RI. It is possible that those volatile and semivolatile chemicals observed could be related to blank contamination. While dieldrin was detected during the SI, it was not detected in any of the RI samples. There is also a slight difference noted in the metals results, in that the concentrations measured during the SI generally somewhat higher than the RI results.

5.5.2.2 Sediment

The nature and extent of sediment contamination at the Antenna Field Landfill is discussed in this section. Table 5-4 presents a summary of all chemicals that were detected in the samples, and the complete data base, including all those analytes that were not detected, is contained in Appendix A. Sediment samples were collected from each of the same locations from which surface water samples were collected, as shown in Figures 5-2 and 5-3. All samples were analyzed for TCL volatile and semivolatile organics, pesticides, and PCBs, as well as TAL metals.

Polynuclear aromatic hydrocarbons (PAHs) were by far the most frequently detected compounds in the sediment samples. These compounds were also the most widespread and occurred at the highest concentrations. Many of the PAHs were found at the greatest concentrations in sample AL-SS-4, which is located immediately adjacent to the landfill. Because wastes were known to have been burned at this site, runoff during that time period could have contained PAHs, which are common combustion products. Other than in this notable sample, the concentrations of PAHs were fairly similar in the other samples, with occasional higher concentrations in some of the samples collected from the reach of stream along Horsham Road. This sort of pattern is not unusual where runoff from paved surfaces enters surface water bodies. The overall occurrence is also somewhat random, in that while the maxima are most frequently found in sample AL-SS-4, the next samples downstream (AL-SS-2 and -1) are somewhat lower, with the concentrations increasing in samples AL-SS-7 and -8, and finally are lowest in samples AL-SS-10 and the two collected from Pennypack Creek. In addition, the concentrations of PAHs were low in the two samples collected in the drainage swale in the upper portion of the landfill, and no PAHs were detected in the most upstream sediment sample (AL-SS-13). Figure 5-6 shows the distribution of PAHs in sediment.

TABLE 5-4

CHEMICALS DETECTED IN SEDIMENTS (mg/kg)[1]
ANTENNA FIELD LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	AL-SS-1 Ephemeral Drainage	AL-SS-2 Ephemeral Drainage	AL-SS-3 Drainage Swale	AL-SS-4[2] Ephemeral Drainage	AL-SS-5 Drainage Swale	AL-SS-6 Drainage Swale	AL-SS-7 Unnamed Creek	AL-SS-8 Unnamed Creek	AL-SS-9 Unnamed Creek	AL-SS-10[2] Unnamed Creek	AL-SS-11 Upstream Pennypack Creek	AL-SS-12 Downstream Pennypack Creek	AL-SS-13 Upstream Drainage Swale	UCL Mean Soil Concentration
Tetrachloroethene	0.005U	0.005U	0.005U	0.005U/0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U/0.005U	0.005U	0.005U	0.013	NA(3)
Bis(2-ethylhexyl)phthalate	0.12J(1)	0.32J(1)	0.39U	2.6/0.43J(1)	0.037J(1)	0.09J(1)	0.48U	0.28J	0.28J	0.066J/0.44UJ	0.40U	0.43U	0.82U	NA(3)
Butylbenzylphthalate	0.38U	0.39U	0.39U	2.5U/1.3U	0.36U	0.38U	0.48U	0.50U	0.053J	0.43U/0.44U	0.40U	0.43U	0.82U	NA(3)
Dibenzofuran	0.12J(1)	0.044J(1)	0.39U	1.6J(1)/0.76J(1)	0.36U	0.38U	0.48U	0.50U	0.41U	0.43U/0.44U	0.40U	0.43U	0.82U	NA(3)
2,4-Dinitrotoluene	0.38U	1.1	0.39U	2.5U/1.3U	0.36U	0.38U	0.48U	0.50U	0.41U	0.43U/0.44U	0.40U	0.43U	0.82U	NA(3)
2,6-Dinitrotoluene	0.38U	0.079J(1)	0.39U	2.5/1.3U	0.36U	0.38U	0.48U	0.50U	0.41U	0.43U/0.44U	0.40U	0.43U	0.82U	NA(3)
N-Nitrosodiphenylamine	0.38U	0.62	0.39U	2.5/1.3	0.36U	0.38U	0.48U	0.50U	0.41U	0.43U/0.44U	0.40U	0.43U	0.82U	NA(3)
Acenaphthene	0.045J(1)	0.39U	0.39U	2.3J(1)/0.81J(1)	0.36U	0.038J(1)	0.48U	0.50U	0.41U	0.43U/0.44U	0.041J(1)	0.43U	0.82U	NA(3)
Acenaphthylene	0.38U	0.39U	0.39U	2.5U/1.3U	0.36U	0.38U	0.17J(1)	0.50U	0.41U	0.43U/0.44U	0.40U	0.43U	0.82U	NA(3)
Anthracene	0.12J(1)	0.10J(1)	0.056J(1)	6.1/2.3	0.088J(1)	0.21J(1)	0.47J(1)	0.09J(1)	0.11J(1)	0.069J(1)/0.045J(1)	0.11J(1)	0.43U	0.82U	NA(3)
Benzo(a)anthracene	0.44	0.44	0.31J(1)	12/6.1	0.34J(1)	0.93	1.4	0.38J(1)	0.54	0.29J(1)/0.22J(1)	0.18J(1)	0.43U	0.82U	NA(3)
Benzo(a)pyrene	0.84	0.56	0.37J(1)	12/6.6	0.37	1.0	1.6	0.61	0.76	0.33J(1)/0.29J(1)	0.16J(1)	0.43U	0.82U	NA(3)
Benzo(b)fluoranthene	1.2	0.71	0.34J(1)	15/7.9	0.39	1.1	1.5	0.80	0.86	0.33J(1)/0.28J(1)	0.14J(1)	0.43U	0.82U	NA(3)
Benzo(k)fluoranthene	0.73J(2)	0.53J(2)	0.35J(1)	9.5J(2)/6.4J(2)	0.37J(2)	1.0J(2)	1.5J(2)	0.76J(2)	0.65J(2)	0.36J(2)/0.28J(2)	0.19J(2)	0.43U	0.82U	NA(3)
Benzo(g,h,i)perylene	0.43	0.25J(1)	0.17J(1)	2.5U/2.3	0.12J(1)	0.42	0.56	0.26J(1)	0.32J(1)	0.43UJ(1)/0.12J(1)	0.075J(1)	0.43U	0.82U	NA(3)
Chrysene	1.0	0.70	0.37J(1)	14/7.8	0.39	1.1	1.5	0.66	0.70	0.30J(1)/0.26J(1)	0.20J(1)	0.43U	0.82U	NA(3)
Dibenzo(a,h)anthracene	0.073J(1)	0.089(1)J	0.39U	0.5J(1)/0.89J(1)	0.043J(1)	0.083J(1)	0.16J(1)	0.056J(1)	0.10J(1)	0.43U/0.44U	0.40U	0.46U	0.82U	NA(3)
Fluoranthene	2.2	1.5	0.74	28/16	0.85	2.1	3.3	1.4	1.2	0.69/0.51	0.52	0.43U	0.82U	NA(3)
Fluorene	0.097J(1)	0.062J(1)	0.39U	3.6/1.5	0.36U	0.057J(1)	0.077J(1)	0.50U	0.049J(1)	0.43U/0.44U	0.053J(1)	0.43U	0.82U	NA(3)
Indeno(1,2,3-cd)pyrene	0.57	0.35J(1)	0.21J(1)	6.3/3.3	0.17J(1)	0.60	0.75	0.35J(1)	0.42	0.14J(1)/0.14J(1)	0.087J(1)	0.43U	0.82U	NA(3)
2-Methylnaphthalene	0.38U	0.39U	0.39U	2.5U/0.17J(1)	0.36U	0.38U	0.48U	0.50U	0.41U	0.43U/0.44U	0.40U	0.43U	0.82U	NA(3)

TABLE 5-4
CHEMICALS DETECTED IN SEDIMENTS (mg/kg)[1]
ANTENNA FIELD LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA
PAGE 2

Chemical	AL-SS-1 Ephemeral Drainage	AL-SS-2 Ephemeral Drainage	AL-SS-3 Drainage Swale	AL-SS-4[2] Ephemeral Drainage	AL-SS-5 Drainage Swale	AL-SS-6 Drainage Swale	AL-SS-7 Unnamed Creek	AL-SS-8 Unnamed Creek	AL-SS-9 Unnamed Creek	AL-SS-10[2] Unnamed Creek	AL-SS-11 Upstream Pennypack Creek	AL-SS-12 Downstream Pennypack Creek	AL-SS-13 Upstream Drainage Swale	UCL Mean Soil Concentration
Naphthalene	0.38U	0.39U	0.39U	2.5U/0.25J(1)	0.36U	0.38U	0.48U	0.35U	0.41U	0.43U/0.44U	0.40U	0.43U	0.82U	NA(3)
Phenanthrene	1.9	1.0	0.32J(1)	27/13J(1)	0.47	1.0	1.8	0.88	0.68	0.35J/0.27J	0.46	0.43U	0.82U	NA(3)
Pyrene	1.7	1.1	0.59	24/12	0.64	1.7	2.8	1.1	1.1	0.51/0.44	0.36J	0.43U	0.82U	NA(3)
Aldrin	0.019	0.0095U	0.0094U	0.049U/0.060U	0.0087U	0.0091U	0.011U	0.12U	0.0098U	0.010U/0.011U	0.0098U	0.010U	0.020U	ND(4)
Dieldrin	0.11	0.019U	0.16	0.098U/0.12U	0.49	0.25	0.023	0.12	0.020U	0.021U/0.021U	0.020U	0.020U	0.040U	0.200
Endosulfan I	0.012	0.0095U	0.0094U	0.049U/0.060U	0.087U	0.0091U	0.011U	0.012U	0.0098U	0.010U/0.011U	0.0098U	0.010U	0.020U	ND(4)
Aluminum	4330	4370	12100	9740/8750	10800	14700	4740	6060	4980	5890/5300	4710	4350	19400	22700
Antimony	8.9UL(1)	9.9UL(1)	11.5L(1)	11.1UL(1)/10.3UL(1)	8.0UL(1)	10.0UL(1)	13.6UL(1)	13.1UL(1)	10.4UL(1)	10.9UL(1)/10.8UL(1)	10.5UL(1)	10.7UL(1)	13.3U	3.5
Arsenic	2.8J(4)	2.4J(4)	3.5J(4)	3.0J(4)/2.1J(4)	2.6J(4)	3.3J(4)	1.7J(4)	4.4J(4)	6.1J(4)	3.1J(4)/2.0J(4)	3.2J(4)	3.8J(4)	4.2	5.0
Barium	64.4	55.2	87.7	704K(1)/255K(1)	72.0	92.7	154	238	105K(1)	128/72.8	90.5	57.2	93.8	156
Beryllium	0.59B	0.66B	0.98B	7.7K(1)/10.5K(1)	0.71B	1.1B	0.91B	0.87B	0.92B	0.97B/0.96B	0.93B	0.95B	1.28B	1.2
Cadmium	0.79U	0.88U	0.98U	1.7L(2)/1.6L(2)	0.71U	0.89U	1.2U	1.2U	2.3L(2)	0.97U/0.96U	0.93U	0.95U	2.48B	5.1
Calcium	1350	749	2780	22300/49500	2290	3170	1490	1880	3960	2350/2080	1490	1190	1270	1790
Chromium	11.3	17.2	20.8	98.8/145	20.3	24.1	10.9B	17.2	26.6	20.1/15.3	12.1	11.9	24.2	26.2
Cobalt	6.3	9.5	7.3	58.7/98.1	7.3	6.0	3.6	10.8	8.8	6.1/6.0	7.0	5.2	7.4	8.9
Copper	9.5	11.5	14.9	825K(1)/980K(1)	25.2	16.7	8.5B	13.7	61.7K(1)	11.9/14.9	7.2B	6.9B	15.6	19.7
Iron	9860J(6)	11700J(6)	19000J(6)	52800J(6)/43400J(6)	17200J(6)	18100J(6)	7670J(6)	15900J(6)	75600	17300J(6)/16700J(6)	12500J(6)	13200J(6)	19900	23500
Lead	63.6J(6,7)	75.3J(6,7)	23.1J(6,7)	306J(6,7)/687J(6,7)	25.4J(6,7)	141J(6,7)	60.2J(6,7)	107J(6,7)	205J(6,7)	44.5J(6,7)/44.0J(6,7)	6.6J(6,7)	9.3J(6,7)	52.3	105
Magnesium	1130	744	1970	11000/27400	1640	1940	618	1390	3110	2590/2120	1340	1070	1980	2260
Manganese	513J(6)	143J(6)	394J(6)	1240J(3,6)/733J(3,6)	448J(6)	125J(6)	185J(6)	2120J(6)	629J(3,6)	604J(6)/415J(6)	1010J(6)	342J(6)	136	519
Mercury	0.10U	0.11U	0.12U	0.12U/0.10U	0.09U	0.12	0.16U	0.13U	0.12U	0.11U/0.11U	0.11U	0.11U	0.14U	0.1

TABLE 5-4
CHEMICALS DETECTED IN SEDIMENTS (mg/kg)[1]
ANTENNA FIELD LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA
PAGE 3

Chemical	AL-SS-1 Ephemeral Drainage	AL-SS-2 Ephemeral Drainage	AL-SS-3 Drainage Swale	AL-SS-4[2] Ephemeral Drainage	AL-SS-5 Drainage Swale	AL-SS-6 Drainage Swale	AL-SS-7 Unnamed Creek	AL-SS-8 Unnamed Creek	AL-SS-9 Unnamed Creek	AL-SS-10[2] Unnamed Creek	AL-SS-11 Upstream Pennypack Creek	AL-SS-12 Downstream Pennypack Creek	AL-SS-13 Upstream Drainage Swale	UCL Mean Soil Concentration
Nickel	8.1	9.5	12.9	274K(1)/379K(1)	10.8	13.8	5.7	9.3	30.5K(1)	12.4/9.3	9.6	7.4	15.9BB	16.9
Potassium	423U	472U	828	1260/1190	943	940	647U	650	1030	1020/854	499U	508U	951	1080
Selenium	0.91U	0.88U	0.77U	0.93U/2.1J(4,5)	0.78U	0.89U	1.3U	1.1U	0.80U	0.96U/10U	0.95U	1.0U	1.1U	0.29
Sodium	879U	982U	1090U	1890K(1)/1880K(1)	791U	992U	1350U	1290U	1620K(1)	1080U/1070U	1040U	1060U	1310U	59.8
Thallium	0.45UJ(1)	0.44UJ(1)	0.38UJ(1)	0.46UJ(1)/0.39UJ(1,8)	0.39UJ(1)	0.45J(4)	0.65UJ(1)	0.53UJ(1)	0.40UJ(1)	0.48UJ(1)/0.50UJ(1)	0.47UJ(1)	0.50UJ(1)	0.57U	0.25
Vanadium	17.0	17.2	29.1	20.8K(1)/19.8K(1)	27.0	31.6	11.8	20.4	21.0K(1)	24.2/20.8	18.7	15.4	38.6	35.2
Zinc	47.4J(6)	88.3J(6)	51.5J(6)	3390J(6/4390J(6)	37.0J(6)	129J(6)	48.1J(6)	91.9J(6)	128J(6)	57.0J(6)/60.4J(6)	45.5J(6)	41.1J(6)	53.7	97.6

(1) Complete data base in Appendix A.
(2) Field duplicate sample results for both samples reported.
(3) NA - Not analyzed
(4) ND - Not detected

Qualifiers defined as follows:
U - Not detected at detection limit shown
B,BB - Value is considered to be a false positive due to blank contamination
UL(1) - Nondetect is biased low due to low MS % R
L(1) - Value is biased low due to low MS % R
L(2) - Value is biased low due to ICP interferences
K(1) - Value is biased high due to ICP interferences
UJ(1) - Nondetect is estimated due to low calibration curve correlation coefficient
UJ(2) - Nondetect is estimated due to low GFAA PDS % R
J(1) - Value is estimated because it is reported at a concentration less than the CRQL
J(2) - Value is estimated because initial calibration % RSD>30
J(3) - Value is estimated due to ICP interferences
J(4) - Value is estimated due to low calibration curve correlation coefficient
J(5) - Value is estimated due to low MSA correlation coefficient
J(6) - Value is estimated due to laboratory duplicate imprecistion: J(1) in footnote set V (App. A)
J(7) - Value is estimated due to high MS % R : J(2) in footnote set V (App. A)

As mentioned earlier, PAHs were also the most frequently detected organic compounds found in sediment during the SI, as well as those that were found at the highest concentrations. As during the SI (second round), the highest concentrations were noted in sample AL-SS-4, which is the sample location most upstream in the ephemeral drainage, as well as being that which is closest to the runway.

Of all the other organic chemicals found in these samples, none were found in the two samples collected from Pennypack Creek or samples AL-SS-3 or AL-SS-7. Bis(2-ethylhexyl)phthalate was the most frequently detected, in 8 of 13 samples. The concentrations of this compound ranged from 37 µg/kg to 1,500 µg/kg (which was the average of duplicate sample results). These concentrations are generally similar to the range reported in the SI (86 µg/kg to 1,148.8 µg/kg). On the other hand, butylbenzylphthalate was found only once, at a concentration of 53 µg/kg.

Dinitrotoluenes and N-nitrosodiphenylamine were found in two samples (AL-SS-2 and -4) that were collected from the southern boundary of the landfill in the ephemeral drainage.

Only one volatile organic chemical was detected in the sediment samples during the RI. Tetrachloroethene was detected in the most upstream sample from the drainage swale (AL-SS-13) at a concentration of 13 µg/kg. During the SI, only acetone and methylene chloride were detected in the sediment samples, both of which were attributed to potential laboratory contamination.

Three pesticides were detected in the sediment samples, with dieldrin being the most commonly found (in 6 of 13 samples) as well as that which was found at the highest concentration (490 µg/kg), as shown in Figure 5-6. Aldrin and endosulfan I were each only detected once (in sample AL-SS-1) at concentrations less than 20 µg/kg. Dieldrin and aldrin were also detected in sediment during the SI, with dieldrin being the most prevalent (at concentrations up to 220 µg/kg). The distribution of pesticides at the site and the low concentrations at which they were found are not indicative of a waste disposal activity, but are considered indicative of past pesticide application at the Air Station. Pesticides are therefore not considered to present a problem at this site or to be potential chemicals of concern, as one background soil sample contained 400 µg/kg dieldrin.

Many metals were found at the highest concentrations in the duplicate samples AL-SS-4/AL-SS-4B, which were located near the northern end of the landfill. These metals are barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, and zinc. During the SI, the same pattern generally held true. It is important to note that the next sample downstream (AL-SS-2) contained much lower concentrations of most metals that were more in line with the concentrations reported in the background samples. Lead concentrations do not notably decline downstream, but rather are observed at varying concentrations, with the second highest concentration being observed in an offbase sample (AL-SS-9,

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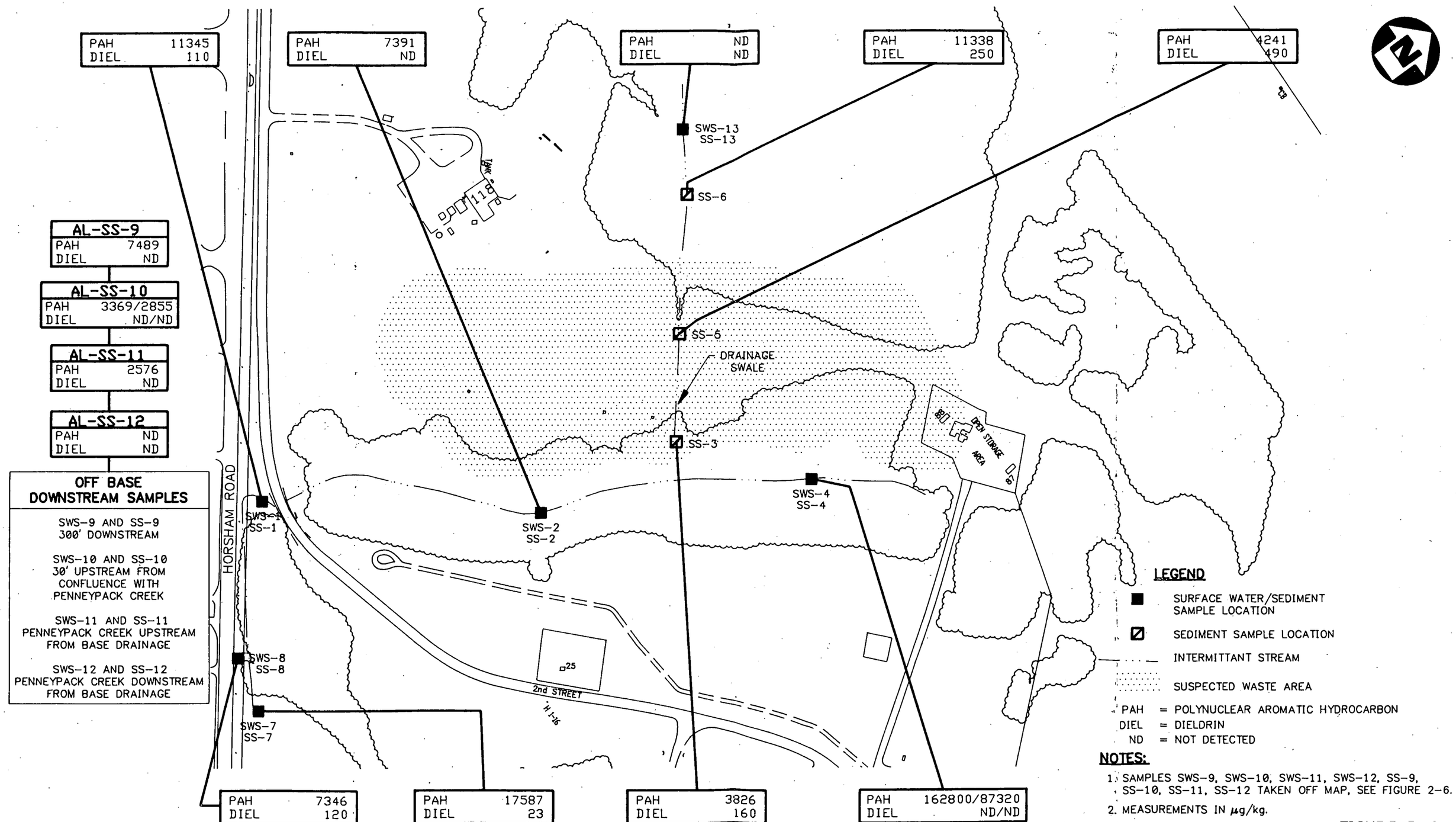

TOTAL CONCENTRATION IN SEDIMENT OF PAHs AND DIELDRIN
NAS SITE 2 – ANTENNA FIELD LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 5-6

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205 mg/kg). The fact that the ditch parallels roadways is the most likely explanation for the presence of lead in these samples (exhaust emissions). Many of the metals could be considered as potential chemicals of concern, such as antimony, barium, beryllium, chromium, cobalt, copper, lead, manganese, nickel, and zinc because they were found in at least one sample at a concentration exceeding the upper 95 percent confidence limit on the mean background concentration. Figure 5-7 presents some spatial information on selected metals.

The concentrations noted in Pennypack Creek were the lowest reported concentrations of metals overall, as indicated in Table 5-4. Several metals exhibited somewhat lower concentrations in the upstream sample and higher concentrations in the downstream sample, but with only two samples it is impossible to state whether this is indeed a significant difference. In any event, it appears as though the elevated concentrations of metals are fairly localized.

The remainder of this section will focus on those metals that were found in the sediment samples (other than in samples AL-SS-4/4B) at concentrations that exceeded the upper 95 percent confidence limits on the mean in the background soil samples.

Antimony was detected in only one sample (AL-SS-3) at a concentration of 11.5 mg/kg. Even when the mean concentration is calculated using one-half the detection limits for the nondetects, the mean exceeds the background concentration (3.5 mg/kg).

Arsenic was only found in one sample at a concentration that exceeded the background mean (5.0 mg/kg). All other reported concentrations of arsenic in the sediment samples ranged from 1.7 mg/kg to 4.4 mg/kg, which would make the site mean within the reported confidence limits on the background samples.

Mercury and thallium were also detected in one sample each that exceeded the background averages. Both of these occurrences were in sample AL-SS-6, which is located in the center of the landfill area.

In summary, polynuclear aromatic hydrocarbons and metals are the most notable sediment contaminants at the Antenna Field Landfill during both the SI and RI. Dieldrin was also detected in several of the onsite sediment samples at concentrations generally within the range reported for background samples. Contamination appears to be limited in extent, and primarily found in the samples collected from the center of the landfill area.

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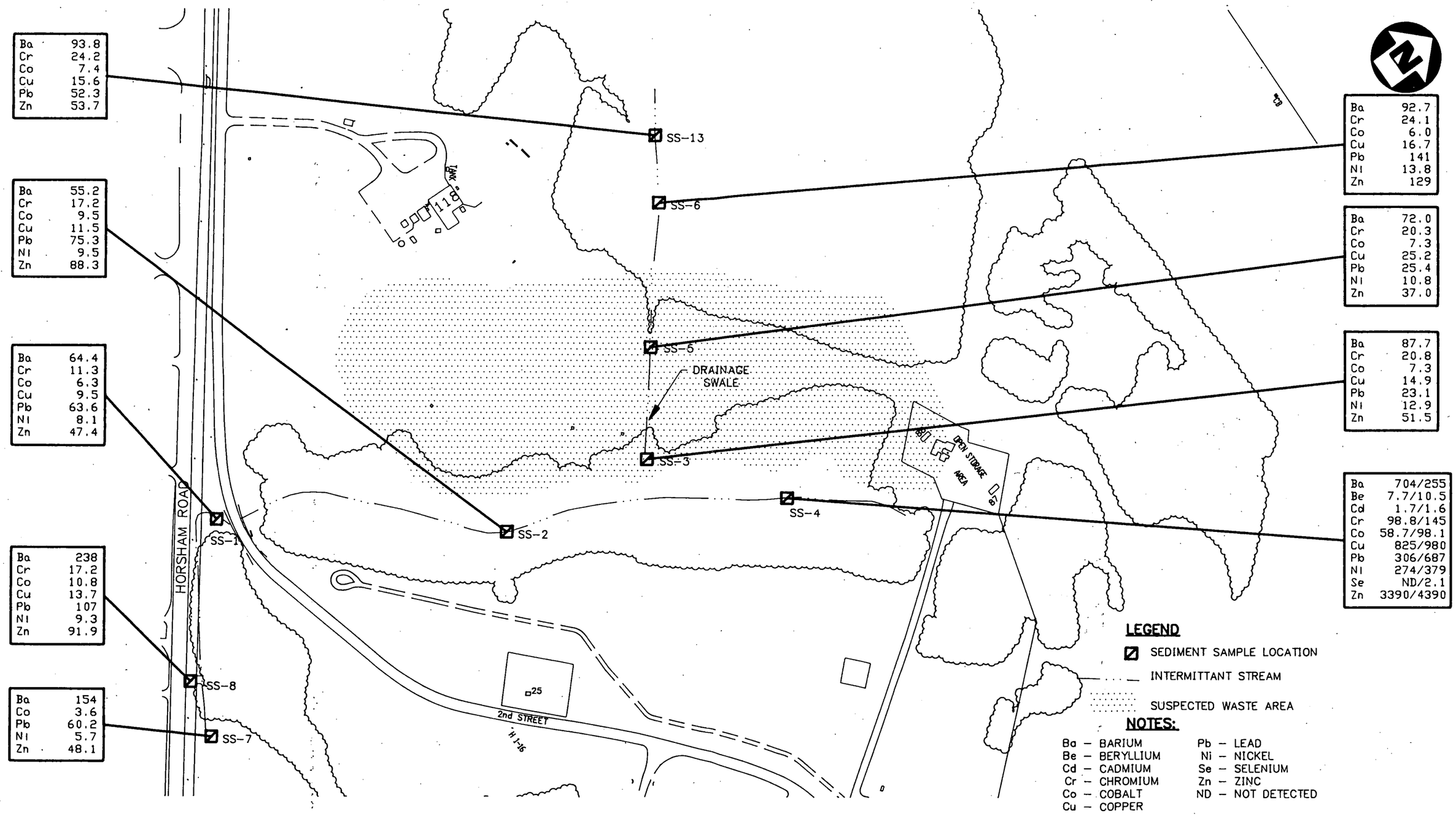

CONCENTRATIONS OF METALS IN ONSITE SEDIMENT (µg/kg)
NAS SITE 2 – ANTENNA FIELD LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 5-7

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5.6 CONTAMINANT FATE AND TRANSPORT

This section discusses the primary contaminant transport mechanisms acting at this site. The discussion is qualitative in nature.

The primary mechanism acting at this site is the erosion of contaminated soil from the landfill area and its migration via drainage swales to an unnamed creek. However, this effect appears to be localized in the immediate vicinity of the landfill, since little contamination was observed beyond the Air Station boundaries and in Pennypack Creek. Both metals and polynuclear aromatic hydrocarbons are most likely to migrate via bulk movement processes because of their tendency to adsorb to soil particles rather than to go into solution, which would result in their being found in the groundwater or surface water. Because the site is currently vegetated and little contamination would be expected at the surface, this mechanism may not be currently in effect.

Neither groundwater nor surface water transport of chemicals in solution appear to be significant at this site, given the low concentrations (or lack of identified contamination) in either of these media.

5.7 POTENTIAL HUMAN AND ENVIRONMENTAL RECEPTORS

This site is isolated in the southwestern corner of the Air Station. The property boundary is immediately south of the site, beyond which lies a residential area. However, because the base itself is fenced, potential receptors are limited to base personnel and unauthorized visitors.

The area is mowed as part of the routine maintenance procedures, and therefore adult base personnel involved in such activity could be exposed several months of the year on a regular basis (perhaps twice each month). Exposures could occur via incidental ingestion of and dermal contact with dust blown by the mowing equipment. Since no soil analytical data are available, exposures could only be determined for the portions of the drainage ditches that are dry and therefore could be mowed. The area of contamination is relatively small in comparison to the entire site area.

It is also possible that unauthorized trespassing may occur in this area. Persons entering the property would be likely to come into contact with surface water and sediment in the drainage ditches. Again, exposures would be limited in magnitude and duration.

Should the base be closed and this area developed for residential use at some time in the future, the residents could be exposed to sediment on a routine basis. In addition, there are no restrictions on the potential future installation of domestic wells in the shallow aquifer. Persons using this water (adults

and children) could be exposed to groundwater contaminants via ingestion, and dermal contact during showering. Inhalation of volatiles would not be an issue because no volatile or semivolatile organic chemicals were detected in groundwater.

The onsite drainage swales are not free-flowing, permanent streams, and therefore do not support healthy aquatic ecosystems. Farther downstream (i.e., offsite) Pennypack Creek is a large stream that supports aquatic life. These would be the only potential environmental receptors of contamination that originates at the Antenna Field Landfill.

5.8 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.8.1 Field Activities

Ten surface water and thirteen sediment samples were collected from the vicinity of the Antenna Field Landfill, including four surface water and sediment samples from off base, downstream locations. Three groundwater samples were collected from monitoring wells installed during the SI. No wells or borings were installed during RI work. All samples were analyzed for TCL volatiles, TCL semivolatiles, TCL pesticides/PCBs, and TAL metals.

5.8.2 Physical Characteristics

Bedrock at locations adjacent to the site were described in previous reporting (EA, May 1990) as a tan to red-brown sandstone underlying approximately 9 to 15 feet of silty clay to silty sand overburden material. No subsurface data are available to describe overburden within the waste disposal area.

Groundwater measurements from existing monitoring wells suggest a westward flow direction in the water table aquifer. The suspected presence of a shallow (2- to 3-foot depth) perched aquifer was not confirmed through observation of site wells. Leachate seeps observed during the SI were not found to exist during the period of RI work; however, this may be the result of unusually dry weather conditions prior to and during field activities.

5.8.3 Site Contamination

During the 1989 Site Inspection, low concentrations of several volatile organic chemicals were noted in the first round of groundwater samples collected from the well considered to be upgradient of the site. Samples collected from the other two wells contained dieldrin and/or phthalate esters at very low

concentrations. No volatile organic chemicals were detected in the surface water or sediment samples collected during 1989.

During 1991, an additional round of groundwater samples was collected. No organic chemicals were detected in the groundwater samples, and only a few low detections of phthalate esters were noted in the surface water during the RI. No volatile organic chemicals were detected in either second or third round groundwater samples or in any of the surface water samples collected during the SI. Therefore, it is assumed that the landfill did not receive wastes containing soluble volatile organic chemicals in large enough amounts to adversely affect either groundwater or surface water (via groundwater discharge).

Volatile organic chemicals were also not found in the sediment samples either during the SI or the RI, with the exception of a single detection of tetrachloroethene in Pennypack Creek at a concentration of 13 µg/kg. The primary organic sediment contaminants noted at this site were polynuclear aromatic hydrocarbons, which were found at maximum concentrations in the area closest to the landfill. PAHs are relatively insoluble and tend to migrate with the bulk movement of soil material rather than to go into solution and migrate with groundwater. It appears as though the prior practice of burning refuse at this site is the source of the PAHs. In addition, a number of metal (e.g., barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, and zinc) were detected at the northern end of the landfill, but the concentrations were found to decrease downstream.

5.8.4 Recommendations

Since the site was reportedly covered with clean soil and is currently well vegetated, there is little possibility of exposure. However, in order to ascertain that the soil is indeed clean in the absence of data from when it was emplaced, it may be necessary to collect surface soil samples from the landfill area. If the soil is found to be clean, the PAHs, etc., will not continue to migrate offsite via surface water runoff.

In addition, the general lack of groundwater and surface water contamination observed at the site does not necessitate the collection of additional samples of these media.

Since existing wells are located at or outside the area of landfilling and no soil borings have been completed, at least one monitoring well within the landfill is recommended. This work can be used to confirm groundwater conditions at the site and to determine by analysis of overburden soil samples collected during well installation if significant concentrations of leachable contaminants are present within the landfill area. However, based on PADER requirements and/or restrictions for drilling within a

landfill, this recommendation may not be applicable or may be modified to include groundwater sampling using temporary drive points installed into the uppermost portion of the shallow aquifer.

One other consideration for the next phase of investigation is the evaluation of possible aquatic biota effects. However, PAHs, etc., were not detected in the sediments of Pennypack Creek, which is the only water body sampled that would support aquatic biota (e.g., fish). Therefore, additional sampling for an environmental assessment is not required.

Upon receipt of the analytical data for the surface soil samples, a quantitative risk assessment can be performed, and a feasibility study can begin, if necessary.

6.0 9TH STREET LANDFILL - NAS SITE 3

6.1 SITE HISTORY AND DESCRIPTION

The 9th Street Landfill was used as an alternate disposal area following phase-out of the Antenna Field Landfill in 1960. The landfill was operative until its official closure in 1967.. Subsequent to closure, a salvage yard used for handling of empty drums, discarded equipment, and transformers containing PCBs was established over a major portion of the fill area. The site is located immediately north of 9th Street along the eastern boundary of NAS Willow Grove, as shown on Figure 1-2. A summary of wastes reportedly disposed of at the site was presented in the SI Report prepared by EA Engineering (May 1990).

It was concluded from previous work at the site that the 9th Street Landfill is a potential source of chlorinated hydrocarbons in groundwater. Additional concerns included pesticides in surface water and sediment and pesticides and cyanide in near-surface soils.

6.2 SUMMARY OF PREVIOUS SITE INVESTIGATIONS

Previous investigations at the 9th Street Landfill included both Preliminary Assessment (PA) and Site Inspection (SI) studies. PA findings indicated that the 9th Street Landfill was opened as a replacement for the Antenna Field Landfill. It was therefore presumed that the types of materials disposed of at the Antenna Field Landfill could also be present at the 9th Street Landfill. PA findings indicated that quantity of wastes disposed of was greater during the period of disposal at the 9th Street Landfill and that the practice of dumping wastes in trenches, burning, and then burying was employed. Based on these findings a Site Investigation was recommended.

Site investigation work included sampling and laboratory analysis of groundwater, surface water, sediment, and subsurface soil. Seven monitoring wells and six test borings were completed to obtain groundwater and soil samples and to characterize subsurface geological and hydrogeological conditions. Monitoring wells included four 4-inch-diameter shallow wells installed such that the screened interval intersected the water table, and three 2-inch-diameter wells screened from 60 to 80 feet in depth within an interpreted semi-confined aquifer. All aqueous samples were analyzed for Target Compound List (TCL) volatiles, semivolatiles, and pesticides/PCBs; total and dissolved Target Analyte List (TAL) metals; total organic carbon (TOC); total petroleum hydrocarbons (TPH), and cyanide. Soil samples were analyzed for TCL volatiles and semivolatiles and pesticides/PCBs, TAL metals, TOC, TPH, and cyanide.

Several volatile organic chemicals were detected in at least one onsite monitoring well during the SI. These chemicals include tetrachloroethene, trichloroethene, and 1,1,2,2-tetrachloroethane. At that time, tetrachloroethene was detected in the upgradient wells. Volatile organic chemicals were noted in both the water table wells and the deeper wells installed at depths of about 80 feet. Trace amounts of dieldrin were also reported in several wells. Of the metals, only cadmium was reported in the dissolved phase at a concentration that exceeded drinking water standards.

A few soil samples collected from the baseball diamond area contained polynuclear aromatic hydrocarbons (PAHs) and dieldrin, with infrequent detections of volatile organics and other pesticides. No metals were noted at concentrations greater than background. Cyanide was detected in both surface and subsurface soil samples. The presence of dieldrin and cyanide was the key impetus for the 1991 investigation.

No volatile or semivolatile organic chemicals or cyanide were detected in the surface water samples during the SI. PAHs were noted in the sediment samples, as were PCBs (Aroclor-1254 and Aroclor-1260) and dieldrin.

6.3 PHASE I REMEDIAL INVESTIGATION

Previous investigations at the landfill have revealed the presence of volatile organic chemicals in groundwater and soils. In order to further identify potential sources of contamination within the landfill, a test pit excavation program was conducted. Additional deep and shallow wells were installed to define the vertical and upgradient extent of volatile organic contamination. Because dieldrin and cyanide have been detected in soil samples from an active baseball field on the landfill, numerous surface and shallow subsurface soil samples were obtained in that area. Surface water and sediment samples were obtained to further define the migration of dieldrin from the site. Samples collected from the 9th Street Landfill were analyzed for TCL volatiles, semivolatiles, and pesticides/PCBs; TAL metals; and cyanide.

6.3.1 Soil Investigation

A total of 32 soil samples (16 surface and 16 shallow subsurface) were obtained over a 90- by 90-foot grid across the baseball field on the landfill. Beginning at the home plate area of the ball field, a sample location was placed every 30 feet to form a squared array of sample locations that extended a short distance beyond the infield portion of the baseball field. Sample locations are shown on Figure 6-1.

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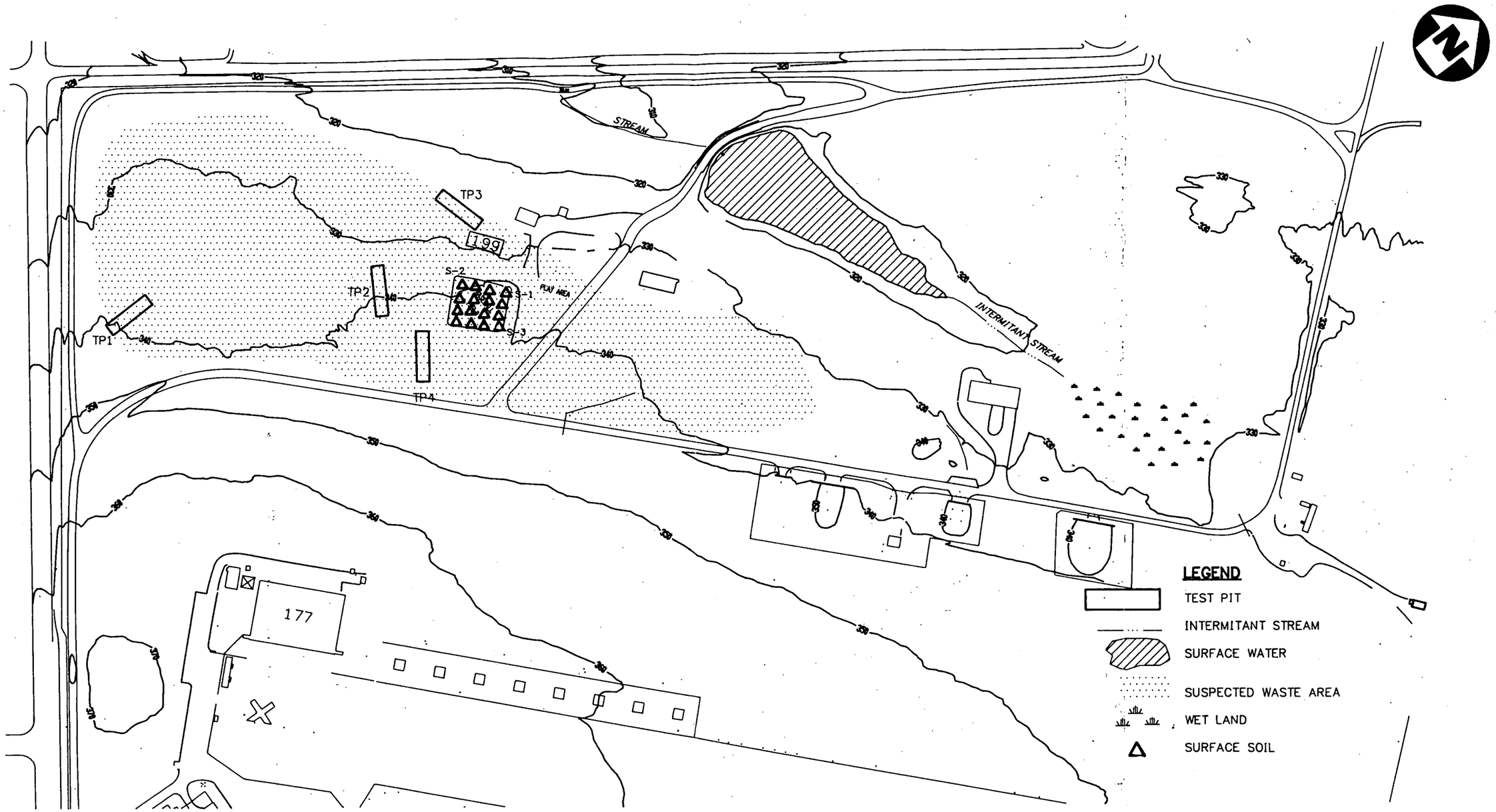

SURFACE SOIL AND TEST PIT SAMPLING LOCATIONS
NAS SITE 3 – 9th STREET LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 6-1

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Surface samples were collected with a stainless-steel trowel from the top 3 to 6 inches of soil and placed in the appropriate glass bottle ware. Subsurface samples were obtained with a hand bucket auger to a target depth of 3 feet. Augered holes were backfilled with the excavated material.

Four test pits were excavated as part of the field investigation. These test pits were located in accordance with the Draft Plan of Action (EA, May 1991) as shown on Figure 6-1, to investigate potential contaminant sources within the landfill. Test pit locations were selected on the basis of historical information and existing aerial photographs. The test pits were excavated with a backhoe to a depth no greater than 10 feet, and were approximately 100 feet in length. The excavated material was scanned with an organic vapor analyzer (OVA) and inspected for visual signs of contamination. Subsurface samples were collected based on visual and/or field screening indications of contamination. If no signs of contamination existed, one representative sample of the prevalent soil condition was obtained. A maximum of four samples were obtained from one test pit with a total of eight samples being collected from the four excavations.

6.3.2 Groundwater Investigation

Four monitoring wells were installed as part of the field investigation to supplement the seven existing wells. Three deep wells and one shallow well were installed. The three deep wells were drilled near existing well pairs to form three-well clusters consisting of a shallow, intermediate, and deep well. The single shallow well was drilled upgradient to identify the potential for any volatile organic contamination from the Army Helicopter facility. The locations of all new and existing monitoring wells at the 9th Street Landfill are shown on Figure 6-2, and well completion details are provided in Table 6-1.

All wells were installed using the methodology described in Section 2.1.3. The only exception was the surface installation of two of the three deep wells. These two wells were drilled to a confined aquifer, which created flowing artesian wells. Therefore, a sealed cap with a ball valve and a head pressure gauge were attached to the top of the PVC casing. The control knob of the ball valve was installed inside a steel protective casing with a locked cap.

All wells were purged and sampled as per the guidelines described in Section 2.1.4. The only exception is with regard to the flowing artesian wells: The natural flow rate was calculated and the required purge volume was allowed to discharge prior to sampling.

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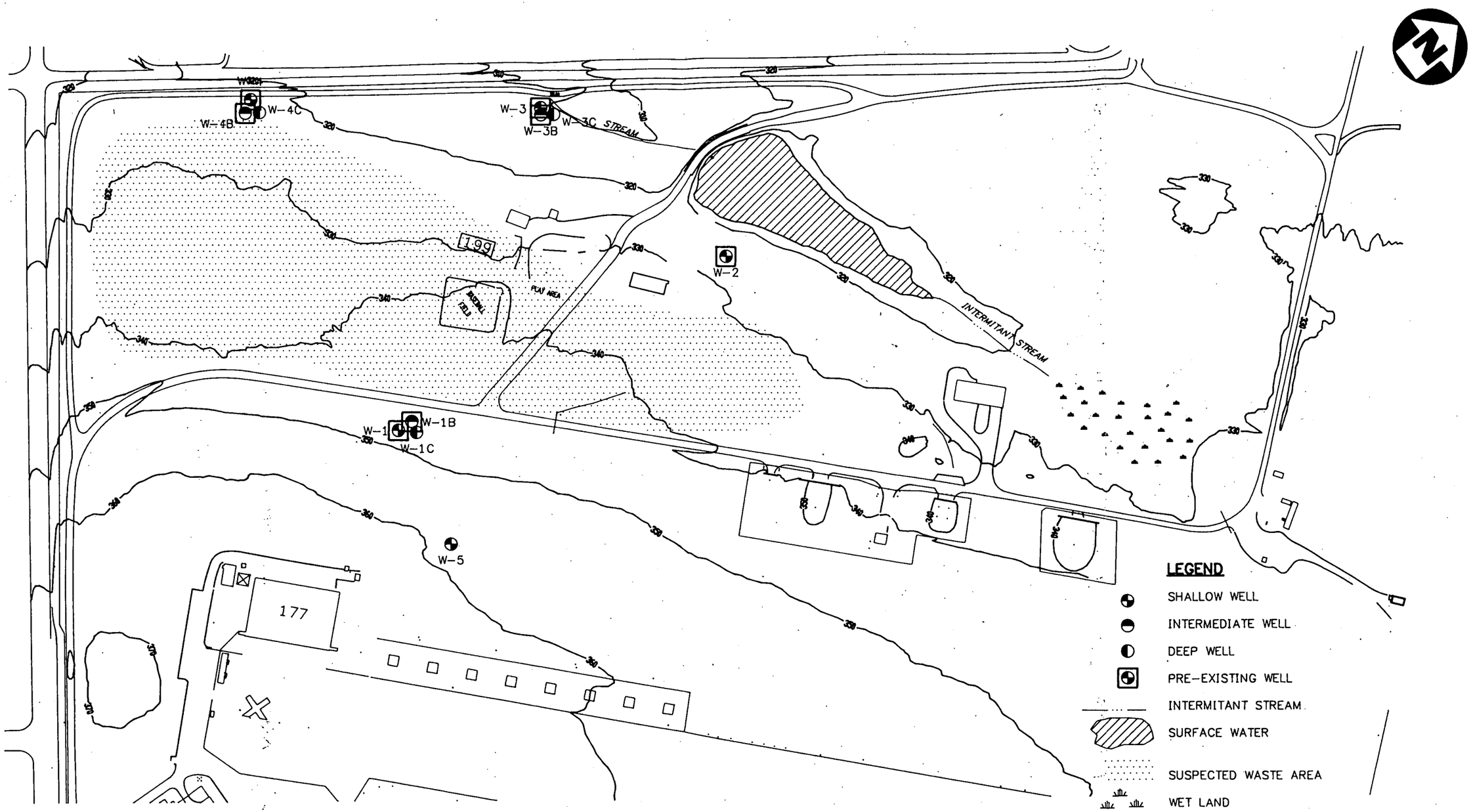

WELL LOCATIONS
NAS SITE 3 - 9th STREET LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

0 200 400
SCALE IN FEET

FIGURE 6-2

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TABLE 6-1

WELL COMPLETION DATA
NINTH STREET LANDFILL
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

HNUS Well Number	Total Depth(1)	Date Completed	Ground Elevation(2)	Elevation Top PVC(2)	Depth to Water(3)	Groundwater Elevation(2)	Screen(1)		Sand Pack(1)	
							From	To	From	To
9SLW-1C	179.5	09/11/91	346.2	347.50	15.10	332.40	159	179	156	179.5
9SLW-3C	171	09/12/91	313	315.00	Artesian Flow	317.30(4)	148.5	168.5	145	171
9SLW-4C	173	09/10/91	323	324.85	Artesian Flow	347.89(5)	148	168	145	169
9SLC-4C	38	09/11/91	359.9	362.90	32.30	330.60	17	37	15	37.5

(1) Measurements in feet from surface.
(2) Measurements in feet above sea level.
(3) Measurements from top of PVC.
(4) Calculated from 1.0 psi at top PVC and 1 psi = 2.304 feet of head.
(5) Calculated from 10.0 psi at top PVC and 1 psi = 2.304 feet of head.

Note: Water levels measured 09/20/91 09/23/91.

6.3.3 Surface Water and Sediment Investigation

Four surface water and sediment samples were collected from the unnamed tributary north of the landfill. The upstream sample location (9SL-SWS/SS-5) was in a wetland area that received drainage from the airfield. This drainage is channeled to a culvert that discharges into a pond formed by an earthen dam. One aqueous and one sediment sample were located at this discharge point (9SL-SWS/SS-1). A midstream sample point was located at a discharge pipe from the pond on the downgradient side of the earthen dam (9SL-SWS/SS-3). The final downgradient sample location was at the point where the unnamed tributary exits the base property (9SL-SWS/SS-4).

In addition, two sediment samples (9SL-SS-6 and -7) were collected from opposite ends of the pond. These samples of pond bottom sediment were obtained from a rowboat using a ponar dredge sampler. The sample was dredged from the surface sediment, collected in a stainless-steel bucket, and placed in the appropriate bottle ware. The remainder of the samples were collected on a different day, except for the aqueous upgradient fraction, which was collected on the third day of sediment sampling at the site. All samples were collected as described in Section 2.1.6. Surface water and sediment sample locations are shown on Figure 6-3.

6.4 SITE CHARACTERISTICS

6.4.1 Surface Features

The 9th Street Landfill is located in an undeveloped area between 9th Street and Dawes Road near the western boundary of the activity. The ground surface is well vegetated with a mixture of grass and woody vegetation. The ground surface slopes north toward a wetland area, intermittent stream, and recreation pond approximately 200 feet from the northern limit of waste disposal. Surface recreational facilities including a pavilion, playground, pond, and baseball field are located within or immediately adjacent to the site area.

6.4.2 Geology

The site geology has been characterized most recently during the RI phase activities. Subsurface investigation during the RI included drilling and installation of three deep monitoring wells and one shallow well. Boring logs associated with this work indicate that a silty clay material, grading downward to a decomposed siltstone and shale, overlies bedrock to a depth of 10 to 15 feet at the boring locations. Bedrock was consistently characterized on boring logs as an alternating sequence of sandstone, siltstone, and shale. No identifiable fractures were recorded at any locations. However,

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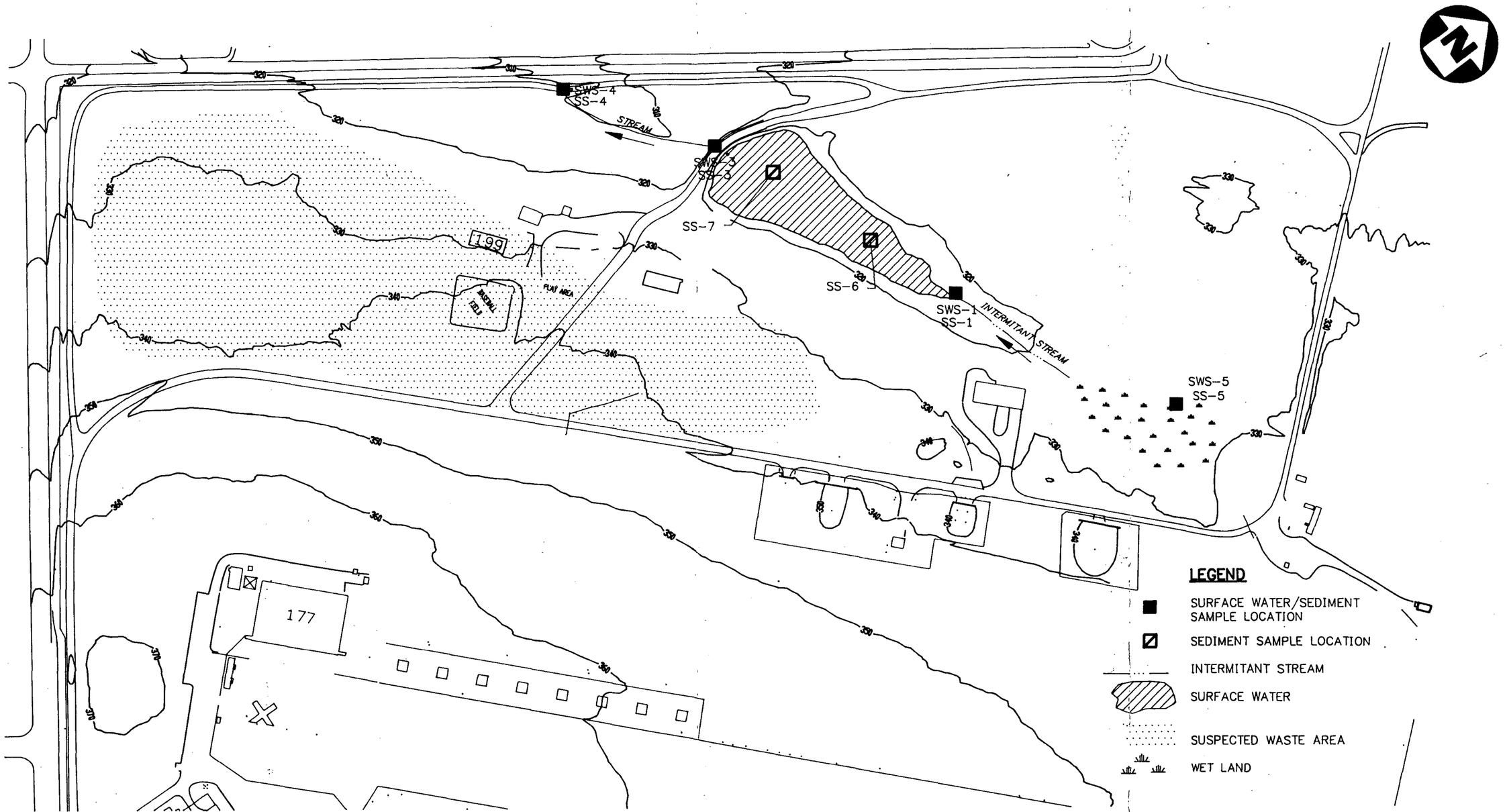

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
NAS SITE 3 – 9th STREET LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 6–3

HALLIBURTON NUS
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several zones of "softer" rock, typically associated with an increase in water yield, were logged. These observations during drilling may be associated with small or poorly developed fractures or with increased porosity and permeability of the rock at specific depths. General lithologic characteristics interpreted from boring logs are shown on cross section C-C' (Figure 6-4).

6.4.3 Hydrology

The ground surface in the vicinity of the 9th Street Landfill slopes at a grade of approximately 5 percent in a general north-northwest direction toward a surface water impoundment, a wetland area, and an unnamed intermittent drainage. The area is covered by a mixture of grass and woody vegetation which serves to impede surface runoff and increase infiltration of precipitation.

Surface water runoff from the site, as well as any groundwater discharge to surface drainages or the wetland area, flow into an impoundment north of the landfill area or enter the intermittent drainage downstream of the impoundment. Water passing through the impoundment overflow or entering the drainage farther downstream flows toward the north into an unnamed tributary of Park Creek, approximately 1.5 miles from its confluence with Little Neshaminy Creek.

6.4.4 Hydrogeology

Earlier studies performed at the activity and review of existing literature indicate that three general hydrogeologic zones exist in the vicinity of the 9th Street Landfill. These include shallow groundwater under water table conditions, a deeper artesian aquifer, and a transitional or semi-confined zone. This transitional zone is thought to interact hydraulically with both the water table and artesian aquifers. As discussed in Section 6.4.2, aquifer materials consist of an alternating sequence of rocks having varying permeability and porosity. The potentiometric head within individual horizons of the semi-confined zone may be expected to vary somewhat.

Site investigation during RI phase activities included installation of three deep wells in the artesian aquifer and one well in the shallow aquifer. Contouring of the potentiometric surface at these and seven additional wells installed during SI work indicates that flow directions differ between the water table and confined aquifers with general flow gradient toward the northwest in the shallow aquifer and toward the northeast in the deeper zone. A third flow direction was interpreted from water levels measured in intermediate depth (semi-confined) wells. However, because of variations in piezometric head observed to exist between individual horizons of the semi-confined zone and a lack of positive correlation between screened intervals within intermediate depth wells, these measurements may not be representative of actual flow gradients within the zone. Figures 6-5 and 6-6 are potentiometric surface

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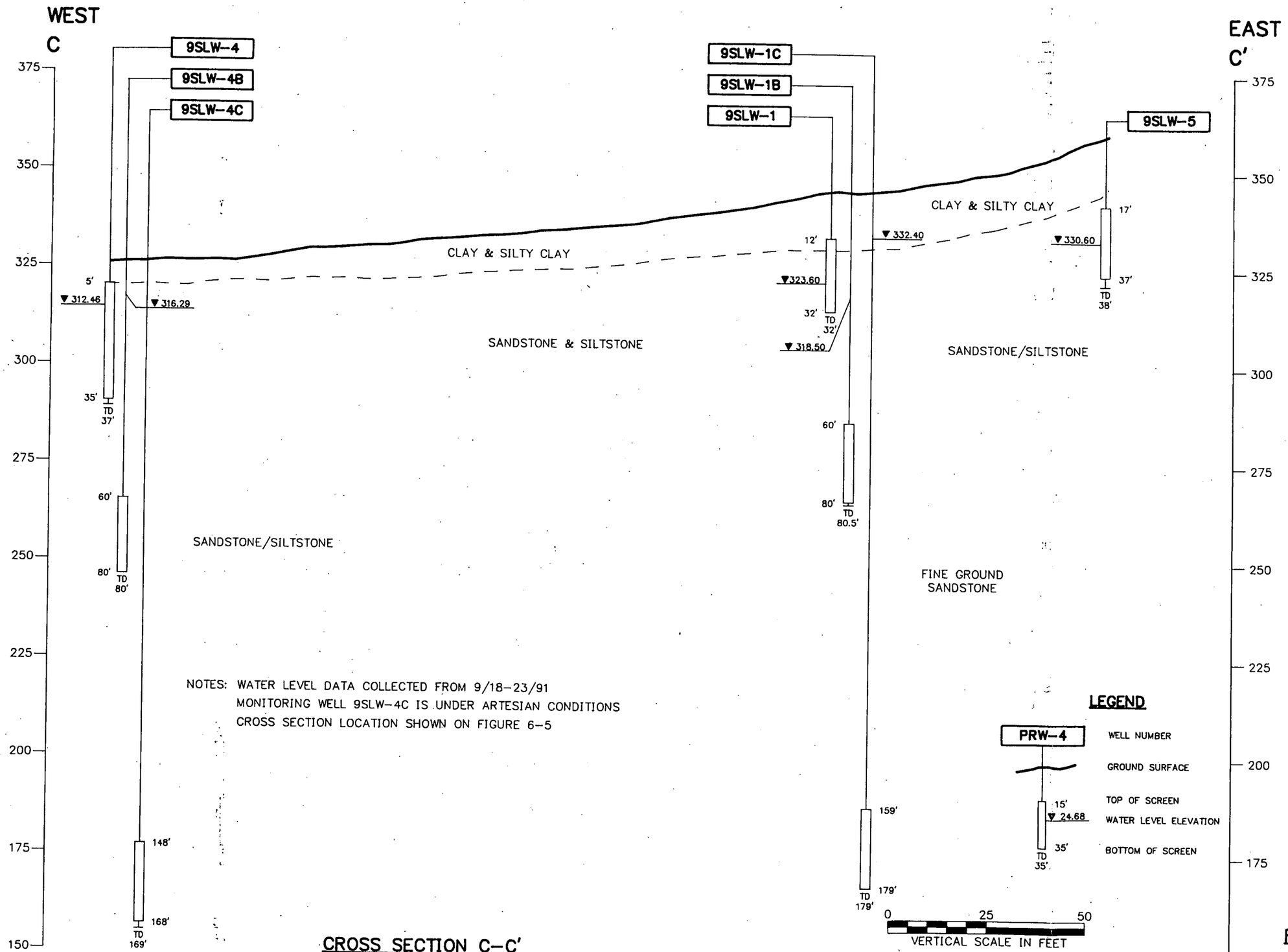

NOTES: WATER LEVEL DATA COLLECTED FROM 9/18-23/91
MONITORING WELL 9SLW-4C IS UNDER ARTESIAN CONDITIONS
CROSS SECTION LOCATION SHOWN ON FIGURE 6-5

CROSS SECTION C-C'
NAS SITE 3 - 9TH STREET LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 6-4

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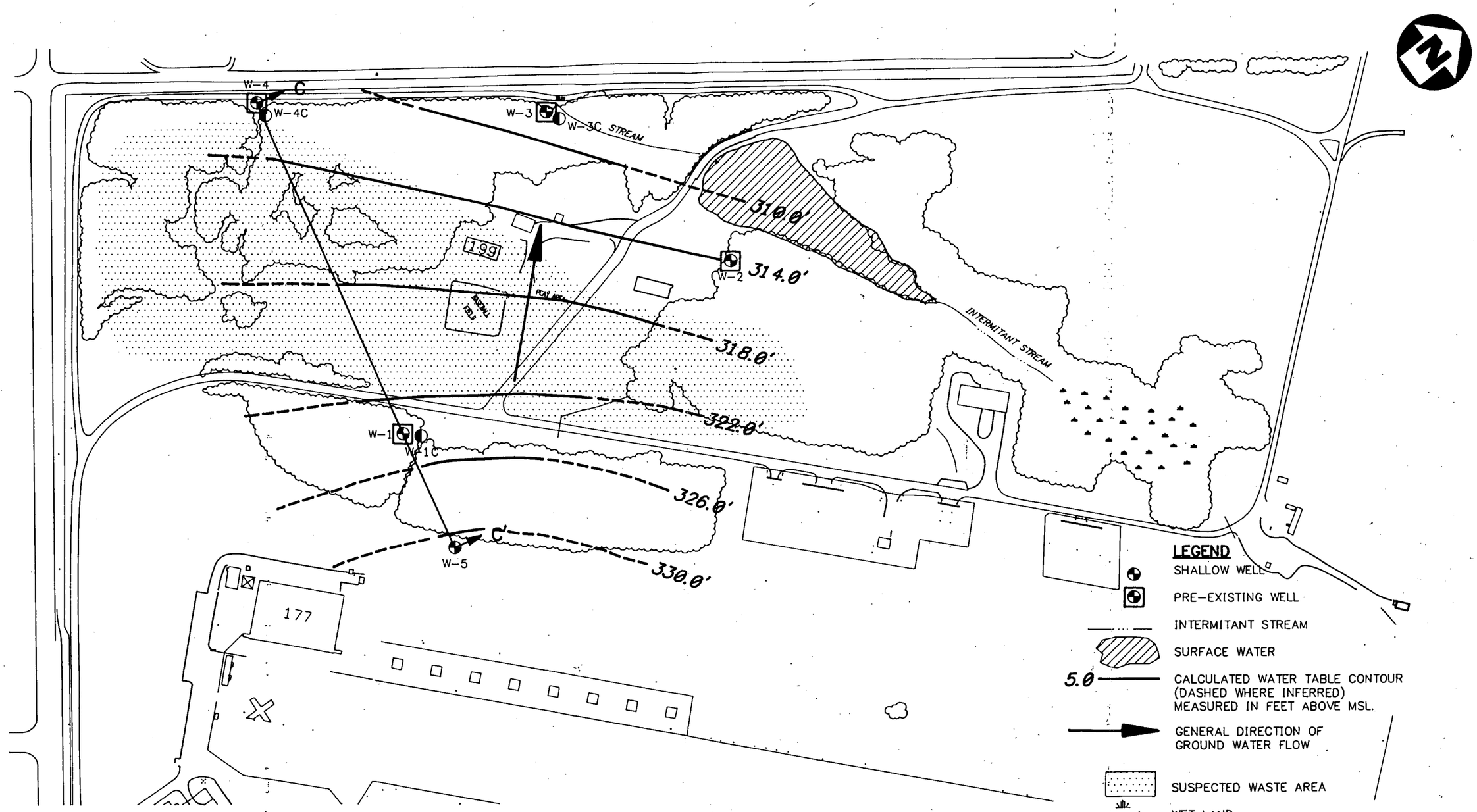

NOTE:

CONTOUR INTERVAL 4.0 FEET.
WATER TABLE CONTOURS IN FEET ABOVE MSL.
WATER LEVELS MEASURED ON 9/18 AND 9/20/91.

POTENTIOMETRIC SURFACE MAP OF SHALLOW MONITORING WELLS
NAS SITE 3 – 9th STREET LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

0 200 400
SCALE IN FEET

FIGURE 6-5

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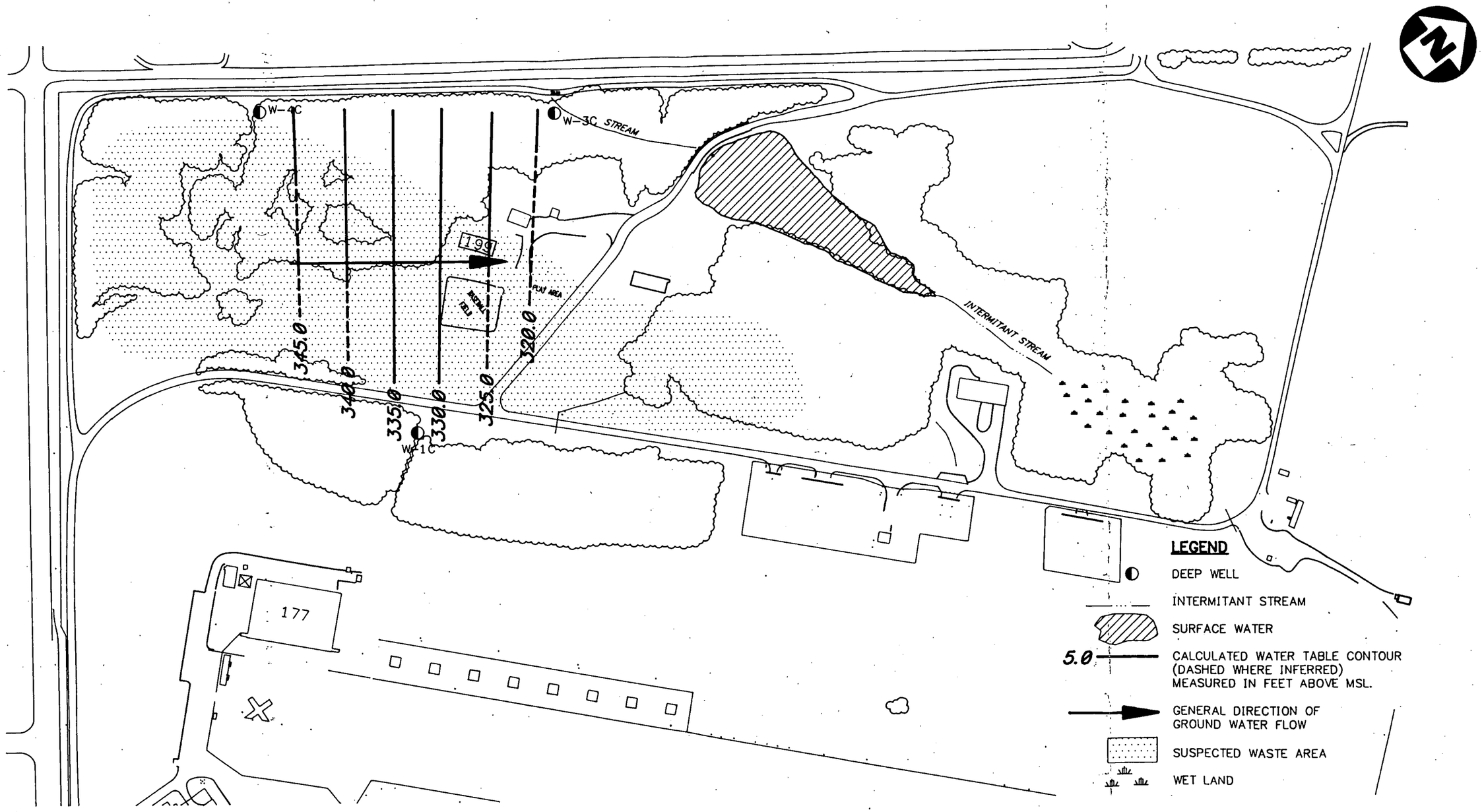

NOTE:

CONTOUR INTERVAL 5.0 FEET.
WATER TABLE CONTOURS MEASURED IN FEET ABOVE MSL.
WATER LEVELS MEASURED ON 9/20 AND 9/23/91.

0 200 400
SCALE IN FEET

FIGURE 6-6

POTENTIOMETRIC SURFACE MAP OF DEEP MONITORING WELLS
NAS SITE 3 – 9th STREET LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

HALLIBURTON NUS
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maps of the water table and artesian aquifers respectively and Table 6-2 provides water level data for all site wells. Piezometric elevations at flowing artesian well locations were calculated using pressure head measurements at the wells.

6.5 NATURE AND EXTENT OF CONTAMINATION

This section presents a brief discussion of the nature and extent of soil, groundwater, surface water, and sediment contamination associated with the 9th Street Landfill. The chemical analytical results are summarized in this section, with the emphasis on only those chemicals that were detected in at least one sample. The complete lists of analytes, including those for which analyses were conducted but which were not detected, are contained in Appendix A.

Several halogenated aliphatic chemicals were detected in wells 9SLW-1, -1B, -3, -3B, 4-, and -4B during the SI. These chemicals include tetrachloroethene, trichloroethene, and 1,1,2,2-tetrachloroethane at maximum concentrations of 75 µg/L, 6 µg/L, and 73 µg/L, respectively. At that time, tetrachloroethene was detected in the upgradient wells (9SLW-1 [up to 34 µg/L] and 9SLW-1B [up to 52.56 µg/L]), possibly indicating an upgradient source of groundwater contamination.

The pattern of contamination in the deeper and shallow wells varied across the site. The deeper wells at locations 1 and 3 (9SLW-1B and -3B) consistently contained higher concentrations of these volatile organic chemicals than the shallower wells, whereas the shallower well at location 4 (9SLW-4) contained higher concentrations than the deeper well. During the third round of sampling, methylene chloride was also detected (at concentrations less than 14 µg/L) in a few samples.

Trace levels of dieldrin were also reported in several wells during the SI. Concentrations ranged from 0.01 µg/L in well 9SLW-2 to 0.02 µg/L in well 9SLW-3 during the first round of sampling only. In addition, dimethylphthalate was detected once (10 µg/L) and bis(2-ethylhexyl)phthalate was detected in 3 samples collected during Round 3 (2 to 4 µg/L).

The maximum concentration of dissolved cadmium in well 9SLW-4 (11.5 µg/L) exceeded the MCL (5 µg/L), but cadmium was not detected in the total metals fraction. Cadmium also exceeded the MCL in 3 other samples analyzed for dissolved metals. The concentrations of total lead ranged from 1.3 to 55.8 µg/L, as compared to action level of 15 µg/L.

A few soil samples collected from the baseball diamond area contained polynuclear aromatic hydrocarbons (PAHs) and dieldrin, with infrequent detections of volatile organics and other pesticides. Individual PAHs were noted at concentrations ranging from 130 µg/kg (2-methylnaphthalene) to

TABLE 6-2

WATER LEVEL DATA[1]
NINTH STREET LANDFILL
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Well Number	Top PVC Elevation	Ground Elevation	Water Level[2]	Water Elevation
9SLW-1	348.41	346.35	24.81	323.60
9SLW-1B	347.90	346.08	29.40	318.50
9SLW-1C	347.50	346.20	15.10	332.40
9SLW-2	327.07	324.91	12.84	314.23
9SLW-3	313.88	311.87	5.58	308.30
9SLW-3B	314.67	312.49	Artesian	318.58[3]
9SLW-3C	315.00	313.00	Artesian	317.30[4]
9SLW-4	325.41	323.36	12.95	312.46
9SLW-4B	324.79	322.86	8.50	316.29
9SLW-4C	324.85	323.00	Artesian	347.89[5]
9SLW-5	362.90	359.00	32.30	330.60

(1) Measurements in feet above MSL, except when noted.
(2) Measurements in feet below top of PVC.
(3) Calculated from 1.7 psi at top of PVC and 1 psi = 2.304 feet of head.
(4) Calculated from 1.0 psi at top of PVC and 1 psi = 2.304 feet of head.
(5) Calculated from 10.0 psi at top of PVC and 1 psi = 2.304 feet of head.

Note: Measurements taken 09/18/91 through 09/23/91.

2,600 µg/kg (dibenz(a,h)anthracene). Dieldrin was detected in all surface soil samples at concentrations ranging from 89 to 1,300 µg/kg, as well as in several composite subsurface samples (up to 129 µg/kg). Aroclor-1260 was detected in 3 samples at concentrations of 24 to 61 µg/kg. No metals were noted at concentrations greater than background. Cyanide was also detected in both surface (0.25 to 0.35 mg/kg) and subsurface (0.12 to 0.4 mg/kg) soil samples. One subsurface soil sample also contained 1,1,1-trichloroethane (22 µg/kg) and toluene (180 µg/kg).

No volatile or semivolatile organic chemicals or cyanide were detected in the surface water samples during the previous investigation. Dieldrin was noted in all first round surface water samples (0.03 to 0.06 µg/L), but was not detected during later sampling rounds. PAHs were noted in the sediment samples, as were PCBs (Aroclor-1254 and Aroclor-1260) and dieldrin. The highest concentrations of PAHs were consistently found in the most downstream location (9SL-SS-4), near the road. The concentration of total PAHs in this location was as high as 194.6 mg/kg. Aroclor concentrations in 3 samples ranged from 24 to 61 µg/kg, and the maximum concentration of dieldrin was reported at 300 µg/kg.

The analytical results from the SI were used to develop the scope of the Remedial Investigation to define soil, groundwater, surface water, and sediment contamination at the 9th Street Landfill. The results of the 1991 investigation are discussed in the following sections.

6.5.1 Surface and Subsurface Soil

Sixteen soil boring locations were located on the baseball diamond on a 30-foot grid spacing. Both surface (3 to 6 inches) and shallow subsurface (3 feet) soil samples were collected for a total of 32 samples, not including duplicates. Seven test pit samples were also collected from outlying areas.

As shown in Table 6-3, very few volatile organic chemicals were detected in these soil samples and when they were detected, they were found at concentrations below the Contract Required Detection Limit (CRDLs) (e.g., 2 to 3 µg/kg). The results are comparable to the SI results discussed in the preceding section. The most prevalent organic chemicals found at the site were the semivolatile organic chemicals, particularly polynuclear aromatic hydrocarbons (PAHs) and phthalate esters. The occurrence of these chemical classes was widespread and the concentrations varied widely.

While the PAHs were found at the highest concentrations, their presence is not unexpected in an area in which refuse was burned. PAHs are combustion byproducts, and the concentrations observed are somewhat higher than those reported in areas along highways in the United States or Canada (Edwards, 1983; Santodonato et al., 1982; ATSDR, 1989). The highest concentrations of PAHs were

TABLE 6-3

ORGANIC DATA SUMMARY TABLE - SOIL
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	CRDL (μg/kg)[1]	Frequency of Detection	Data Completeness (%)	Range of Sample Quantitation Limits (μg/kg)	Range of Detected Concentrations (μg/kg)	95% UCL[2] (μg/kg)	Mean of All Values[3] (μg/kg)
Benzene	10	1/40	100	5-30	3	3[6]	3.2
Chlorobenzene	10	1/40	100	5-30	2	2[6]	3.2
Toluene	10	1/40	100	5-30	2	2[6]	3.2
Trichloroethene	10	1/40	100	5-30	2	2[6]	3.2
1,2,4-Trichlorobenzene	10	1/40	100	350-13250[4]	150	150[6]	440
1,2-Dichlorobenzene	10	9/40	100	350-13250[4]	39J[5]-3600	880	500
1,4-Dichlorobenzene	10	13/40	100	350-13250[4]	39J-880J	760	420
2-Methylnaphthalene	10	8/40	100	350-1100	55J-6900J[4]	770	420
Acenaphthene	10	7/40	100	350-1200	95J-23000J[4]	2100	900
Acenaphthylene	10	3/40	100	350-13250[4]	38J-280J	280[6]	440
Anthracene	10	11/40	100	350-1200	42J-46500[4]	4200	1700
Benzo(a)anthracene	10	28/40	100	370-1200	39J-44500[4]	4400	2000
Benzo(a)pyrene	10	28/40	100	370-1200	43J-34000[4]	3500	1600
Benzo(b)fluoranthene	10	31/40	100	370-1200	45J-37500[4]	3900	1800
Benzo(g,h,i)perylene	10	19/40	100	350-1200	39J-9700[4]	1100	570
Benzo(k)fluoranthene	10	29/40	100	370-1200	39J-24500[4]	2600	1300
Bis(2-ethylhexyl)phthalate	10	18/40	100	350-13250[4]	38J-860	760	410
Chrysene	10	33/40	100	370-1200	43J-36500[4]	3700	1800

TABLE 6-3
ORGANIC DATA SUMMARY TABLE - SOIL
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYVANIA
PAGE 2

Chemical	CRDL (μg/kg)(1)	Frequency of Detection	Data Completeness (%)	Range of Sample Quantitation Limits (μg/kg)	Range of Detected Concentrations (μg/kg)	95% UCL(2) (μg/kg)	Mean of All Values(3) (μg/kg)
Di-n-butylphthalate	10	2/28	70.0	350-13250(4)	43J-370J	370(6)	570
Dibenz(a,h)anthracene	10	6/40	100	350-1200	49J-2805J(4)	430	290
Dibenzofuran	10	7/40	100	350-1200	73J-20000(4)	1900	830
Fluoranthene	10	36/40	100	380-1200	42J-106000(4)	10000	4500
Fluorene	10	7/40	100	350-1200	150J-28500(4)	2600	1100
Indeno(1,2,3-cd)pyrene	10	22/40	100	350-1200	39J-13800(4)	1500	730
Naphthalene	10	7/40	100	350-1100	210J-9450J(4)	1300	720
Phenanthrene	10	35/40	100	380-1200	38J-151000(4)	14000	5500
Pyrene	10	35/40	100	380-1200	47J-94000(4)	9100	4000
Aroclor-1254	0.05	2/40	100	170-1800	490-810	210	150
Dieldrin	0.05	27/40	100	17-38	25-580	120	88
Endosulfan I	0.05	2/40	100	8.5-91	23-30	10	7.4
Endrin	0.05	1/40	100	17-180	25	18	13
Heptachlor Epoxide	0.05	2/40	100	8.5-91	12-15	9.1	6.8

(1) Contract required detection limit.
(2) Upper 95% confidence limit onthe arithmetic average.
(3) Arithmetic average.
(4) Value reported is average of duplicate sample results.
(5) J - Estimated value.
(6) UCL exceeds maximum detected, therefore maximum reported.

found in the subsurface soil sample from location 6 (9SL-S6B and its duplicate 9SL-S6BD), followed by samples 9SL-S3B, 9SL-S4, and that sample collected from test pit 4 (9SL-TP4-S3). These sample locations are shown in Figure 6-1.

The maximum concentration of benzo(a)pyrene found on site was 34,000 µg/kg, and the maximum concentration of fluoranthene was 106,000 µg/kg. Other maximum concentrations of PAHs ranged from 280 µg/kg (acenaphthylene) to 151,000 µg/kg (phenanthrene). The concentrations are more than an order of magnitude greater than the maxima reported in the SI. The minimum detected concentrations were frequently below the sample quantitation limits (and therefore qualified as "estimated"). Figure 6-7 presents the distribution of benzo(a)pyrene, and total PAHs (excluding benzo(a)pyrene) in the baseball field area.

Dieldrin was also commonly found in the onsite soil samples (27 of 40 samples) at concentrations ranging as high as 580 µg/kg. However, the upper confidence limit (UCL) on the mean of these samples is below the background UCL, and therefore the concentration of dieldrin on site is probably less than that found in the background samples. As an additional point of comparison, the maximum concentration detected during the SI was 1,300 µg/kg. Dieldrin concentrations are also shown in Figure 6-7. Three other pesticides were also detected (in either one or two samples each) at concentrations ranging from 12 to 30 µg/kg.

Aroclor-1254 (a polychlorinated biphenyl) was found in two soil samples at concentrations of 490 and 810 µg/kg. Both these samples were collected from test pit 2 (9SL-TP2-S1 and -S2) from depths of less than 10 feet.

The inorganic analytical results for the RI soil samples are summarized in Table 6-4. The table also includes information on the 10 base background samples discussed in Section 2.4. Cyanide was not detected in any soil sample. Four metals were found at average concentrations (using the confidence limits on the means) that exceed the background results (antimony, arsenic, copper and thallium). The highest concentrations of these metals were found in either test pit 2 or test pit 4 (in samples designated by 9SL-TP2 or 9SL-TP4), with the exception of thallium, which was found at its maximum concentration in sample 96L-S7B. The results presented in Appendix A indicate that the baseball diamond area contains lower contaminant concentrations than the two test pits.

The nature and extent of soil contamination at the 9th Street Landfill may be summarized as follows. The primary contaminants in both concentration and distribution in the soil at the site are the polynuclear aromatic hydrocarbons, and to a lesser extent bis(2-ethylhexyl)phthalate and dieldrin. The highest concentrations of the PAHs were found primarily in the subsurface soil samples collected from

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9SL-S1	
SURFACE	
PAH	4660
BaP	450
DIEL	68
3 FEET	
PAH	16673
BaP	1400
DIEL	580

9SL-S2	
SURFACE	
PAH	579
BaP	54 J
DIEL	37
3 FEET	
PAH	376
BaP	44 J
DIEL	63

9SL-S3	
SURFACE	
PAH	803
BaP	62 J
DIEL	140
3 FEET	
PAH	152950
BaP	9300
DIEL	210

9SL-S4	
SURFACE	
PAH	749
BaP	59 J
DIEL	75
3 FEET	
PAH	93270
BaP	7000
DIEL	230

9SL-S5	
SURFACE	
PAH	325
BaP	ND
DIEL	47
3 FEET	
PAH	11251
BaP	870
DIEL	140

9SL-S6	
SURFACE	
PAH	766
BaP	57 J
DIEL	28
3 FEET	
PAH	905300/343010
BaP	48000/20000
DIEL	260/220

9SL-S7	
SURFACE	
PAH	377
BaP	ND
DIEL	42
3 FEET	
PAH	2568
BaP	310 J
DIEL	290

9SL-S8	
SURFACE	
PAH	378
BaP	ND
DIEL	160
3 FEET	
PAH	899
BaP	120 J
DIEL	91

9SL-S9	
SURFACE	
PAH	555
BaP	47 J
DIEL	31
3 FEET	
PAH	1153
BaP	120 J
DIEL	120

9SL-S10	
SURFACE	
PAH	1336
BaP	97 J
DIEL	41
3 FEET	
PAH	1212
BaP	100 J
DIEL	95

9SL-S11	
SURFACE	
PAH	150
BaP	ND
DIEL	ND
3 FEET	
PAH	4610
BaP	400 J
DIEL	120

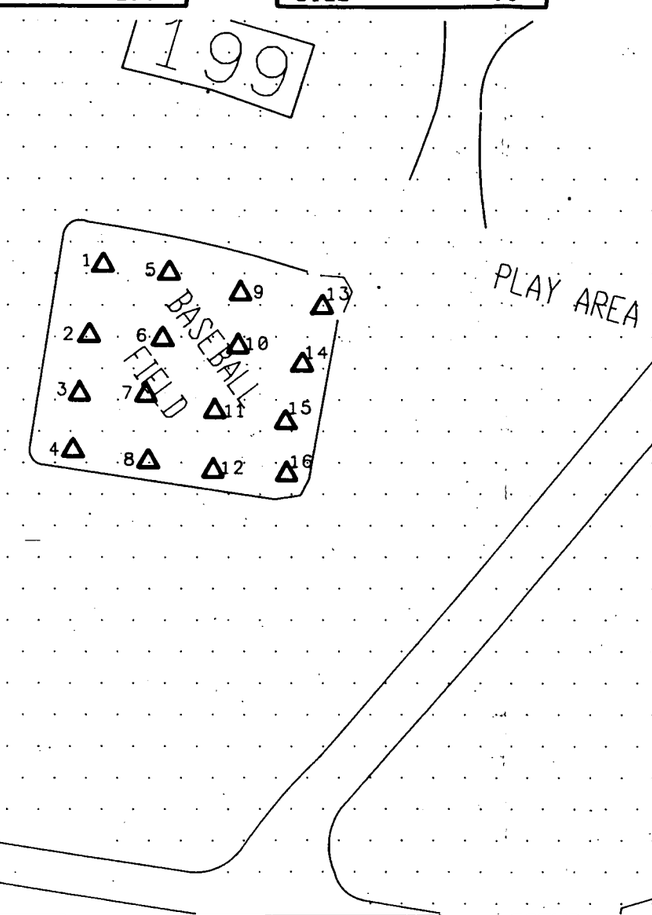
9SL-S12	
SURFACE	
PAH	390
BaP	ND
DIEL	25
3 FEET	
PAH	1316
BaP	130 J
DIEL	27

9SL-S13	
SURFACE	
PAH	611
BaP	49 J
DIEL	73
3 FEET	
PAH	1252
BaP	120 J
DIEL	130

9SL-S14	
SURFACE	
PAH	160
BaP	ND
DIEL	ND
3 FEET	
PAH	13057/12000
BaP	1700/880
DIEL	290/150

9SL-S15	
SURFACE	
PAH	497
BaP	43 J
DIEL	ND
3 FEET	
PAH	1513
BaP	170 J
DIEL	ND

9SL-S16	
SURFACE	
PAH	306/164
BaP	ND/ND
DIEL	ND/ND
3 FEET	
PAH	1186
BaP	120 J
DIEL	ND



LEGEND

△ SURFACE SOIL SAMPLE LOCATION

SUSPECTED WASTE AREA

PAH = TOTAL POLYNUCLEAR AROMATIC HYDROCARBONS (EXCLUDING BaP)

BaP = BENZO(a)PYRENE

DIEL = DIELDRIN

ND = NOT DETECTED

NOTE: MEASUREMENTS IN $\mu g/kg$

0 60 120
SCALE IN FEET

CONCENTRATION OF PAHs AND DIELDRIN IN SOIL
NAS SITE 3 – 9th STREET LANDFILL
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 6–7

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TABLE 6-4
INORGANIC DATA SUMMARY TABLE - SOIL
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	CRDL (mg/kg)[1]	Frequency of Detection	Data Completeness (%)	Range of Sample Quantitation Limits (mg/kg)	Range of Detected Concentrations (mg/kg)	95% UCL[2] (mg/kg)	Mean of All Values (mg/kg)	Background Samples		
								Range of Detected Concentrations (mg/kg)	95% UCL (mg/kg)	Mean of All Values (mg/kg)
Aluminum	40	40/40	100	NA[3]	9,010-2,9100	16,900	15,700	18,200-26,500	22,700	21,000
Antimony	12	3/25	62.5	5.5-12.8	10.4-14.8	6.0	5.0	3.3-4.9	3.5	2.5
Arsenic	2	30/33	82.5	NA	3.2-17.9	6.2	5.4	2.3-5.9	5.0	4.1
Barium	40	40/40	100	NA	58.75[4]-330	120	100	80.2-217	156	111
Beryllium	1	23/23	57.5	NA	1.0-1.4	1.3	1.2	0.61-1.3	1.2	1.1
Cadmium	1	21/38	95.0	0.65-0.98	1.3-3.9	3.0	2.7	4.3-6.0	5.1	4.7
Calcium	1000	40/40	100	NA	277-86,400	8,310	4,950	828-2,340	1,790	1,420
Chromium	2	39/40	100	17.0	13.7-32.0	23.0	21.6	18.8-27.9	26.2	24.1
Cobalt	10	40/40	100	NA	6.0-21.5	8.9	8.8	6.3-9.7	8.9	8.2
Copper	5	40/40	100	NA	7.1-204	22.3	17.4	11.5-27.5	19.7	15.5
Iron	20	40/40	100	NA	14,000-30,200	22,700	21,200	18,900-25,700	23,500	21,700
Lead	0.6	40/40	100	NA	3.7-118	36.5	29.2	16.2-199	105	58.8
Magnesium	1000	40/40	100	NA	704-50,200	4,860	3,310	1,580-2,460	2,260	2,070
Manganese	3	40/40	100	NA	334-3,030	823	675	256-1,360	843	519
Mercury	0.10	5/40	100	0.09-0.11	0.10-0.62	0.07	0.06	0.12-0.19	0.10	0.06

TABLE 6-4
INORGANIC DATA SUMMARY TABLE - SOIL
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA
PAGE 2

Chemical	CRDL (mg/kg)[1]	Frequency of Detection	Data Completeness (%)	Range of Sample Quantitation Limits (mg/kg)	Range of Detected Concentrations (mg/kg)	95% UCL[2] (mg/kg)	Mean of All Values (mg/kg)	Background Samples		
								Range of Detected Concentrations (mg/kg)	95% UCL (mg/kg)	Mean of All Values (mg/kg)
Nickel	8	40/40	100	NA	9.4-39.0	13.8	12.6	13.5-19.2	16.9	15.8
Potassium	1000	39/40	100	522	426-3,010	911	769	731-1,390	1,080	928
Silver	2	2/40	100	1.1-1.6	3.9-4.9	0.80	0.73	0.81-1.4	1.1	0.86
Sodium	100	17/40	100	876-1,090	309-884	476	454	29.5-79.6	59.8	49.1
Thallium	2	16/40	100	0.15-0.48	0.35[4]-0.66	0.34	0.28	0.03-0.26	0.25	0.18
Vanadium	10	40/40	100	NA	18.6-41.4	32.3	30.6	27.5-40.6	35.2	32.5
Zinc	4	40/40	100	NA	20.7-441	78.3	57.0	40.1-170	97.6	63.1

(1) Contract required detection limit.
(2) Upper 95% confidence limit.
(3) NA - Only positive results reported for this chemical.
(4) Average of duplicate sample results.

the baseball diamond area. It is assumed that during construction of this facility, clean soil was emplaced and therefore the pattern of contamination shows that the old landfill surface where burning occurred was covered.

A few metals were found at concentrations in the soil at the 9th Street Landfill that exceeded average background concentrations, however no metals were reported as exceeding regional levels during the SI. The metals of potential concern are antimony, arsenic, copper, and thallium. The maximum concentrations of these metals were found in the subsurface soil samples collected from two test pits located south of the ball field. It should be noted however, that the mean concentrations presented in Table 6-4 are at levels that do not present any immediate health threat to site receptors under current land use conditions.

6.5.2 Groundwater

Groundwater samples from five monitoring well locations were collected for analysis of Target Compound List volatiles, semivolatiles, pesticides and PCBs, and Target Analyte List metals (both total and dissolved) during the RI. Three intervals are monitored by these wells, the depths of which are referred to as shallow, intermediate, and deep.

The analytical results for the shallow wells are summarized in Table 6-5. The potentiometric surface map for the shallow aquifer indicates that groundwater at this depth flows from southeast to northwest across the landfill area. Thus, well clusters 2, 3, and 4 are considered to be downgradient wells, and locations 1 and 5 are upgradient of the landfill.

Tetrachloroethene (PCE) was found in four of five shallow wells at a maximum concentration of 61 µg/L (9SLW-4), which is similar to the concentrations reported in the SI. No other organic chemicals were detected in any of the shallow downgradient wells. PCE was also detected historically in shallow well 9SLW-1, thereby prompting the installation of a well farther upgradient (9SLW-5) during this investigation. During this most recent sampling round, however, the sample from this new well (9SLW-5) was found to contain tetrachloroethene (7 µg/L) and two phthalate esters (each at concentrations of 1 µg/L). These results appear to indicate the presence of an upgradient source of contamination.

The analytical data presented in Table 6-5 also show that the concentrations of most potentially toxic metals do not appreciably increase in the downgradient wells (dissolved analyses). The variation in metals concentrations in the unfiltered samples (total metals results) is most likely the result of the presence of suspended sediment in the water. Several toxic metals were found only in the unfiltered

TABLE 6-5

CHEMICALS DETECTED IN SHALLOW GROUNDWATER SAMPLES (µg/L)[1]
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	9SLW-1[2] (314.4'-334.4')[3] (Upgradient)		9SLW-2 (301.9'-320.9')		9SLW-3 (291.9'-307.9')		9SLW-4 (286.4'-319.4')		9SLW-5 (322.9'-342.9') (Upgradient)	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Tetrachloroethene	15/15	-	5U	-	8	-	61	-	7	-
2-Chlorophenol	33U/1J	-	10U	-	10U	-	10U	-	10U	-
Bis(2-ethylhexyl)phthalate	33U/10U	-	10U	-	10U	-	10U	-	1J	-
Di-n-octylphthalate	33U/10U	-	10U	-	10U	-	10U	-	1J	-
Aluminum	4000/6530	141BB/141BB	214BB	137BB	214BB	128BB	551BB	105BB	18500J(1)	77B
Antimony	45U/45U	47/45U	45U	45U	45U	45U	45U	45U	45U	45U
Arsenic	2U/2U	2U/2U	2U	2U	2U	2U	2U	2U	2.1J(2)	2UJ(1)
Barium	269/303	135/143	99	103	154	145	306	334	172	61
Calcium	8420/8120	7730/8050	6820	7340	15100	14400	22900	26100	5020	11500
Copper	2U/2U	7BB/7BB	6BB	6BB	7BB	7BB	7BB	6BB	32B	7
Iron	5680/8880	54/43	328	223	243	42BB	562	38BB	14,300	37B
Lead	4.8/4.8	1U/1U	1.4	1U	1U	1U	1U	1U	2.6	1.6B
Magnesium	2480/2880	1730/1760	2940	3140	4570	4340	8460	9620	2200	2840
Manganese	136/160	18/19	15	3BB	10BB	2BB	50	1BB	316	16
Mercury	0.2U/0.2U	0.2U/0.2U	0.2U	0.2U	0.2U	0.2U	0.2U	0.2U	1.7	0.2U
Potassium	2140U/2790	2140U/2140U	2140U	2140U	2140U	2140U	2140U	2140U	2140U	2140U
Sodium	11700/11800	12400/12000	6680	6840	7700	7270	7780	8680	6600	11800
Vanadium	8BB/12	4U/4U	4U	4U	4U	4U	5BB	4BB	16	4U
Zinc	17BB/21BB	10BB/27	8BB	19BB	8BB	11BB	8BB	6BB	39	18

(1) Complete analytical data base in Appendix A.
(2) Field duplicate sample results for both samples reported.
(3) Screened interval elevation (NGVD 1929).

Qualifiers defined as follows:
U - Not detected at detection limit shown.
B, BB - Value is considered to be a false positive due to blank contamination.
J - Value is estimated by the laboratory because it is reported at a concentration less than the CRQL.
J(1) - Value is estimated due to laboratory duplicate RPD outside QC limits.
J(2) - Value is estimated due to GFAA calibration coefficient <0.995.
UJ(1) - Nondetect is estimated by the GFAA calibration coefficient <0.995.

samples (e.g., arsenic, lead, mercury, and vanadium), while other metals such as barium, manganese, and zinc were found in both the filtered and the unfiltered fractions. It should be noted that the highest concentrations of several metals in the total fraction were found in upgradient wells (e.g., arsenic, lead, manganese, vanadium, and zinc). With the exception of manganese, none of these metals were detected in any downgradient well samples. Therefore, the general occurrence of metals does not appear to indicate a major source of metals contamination in the landfill area.

Table 6-6 presents a summary of the chemical analytical results for the intermediate and deep wells (designated as "B" and "C", respectively). In the deeper zone, groundwater flows from southwest to northeast, as shown in Figure 6-6. Because contamination was detected in the "B" wells during earlier investigations, deeper wells were installed to help determine the vertical extent of contamination near the landfill. The deeper aquifer ("C" wells) was found to exist under confined conditions, and the hydrogeologic gradient is upward.

Tetrachloroethene was again detected in the intermediate depth wells surrounding the 9th Street Landfill at a concentration as high as 56 µg/L (9SLW-4B). This chemical was also again found in the slightly upgradient intermediate depth well (9SLW-1B) at a concentration of 29 µg/L. The only other organic chemicals detected in the wells during this latest sampling event were toluene (6 µg/L in 9SLW-1C), and two phthalate esters, which were also found at their maximum concentrations in well 9SLW-1C. However, this deepest well has an upward vertical gradient and is located cross-gradient of the landfill. Therefore, a potential explanation for the presence of these relatively insoluble contaminants (phthalate esters) in this deep well is blank contamination (see Section 2.5). In addition, toluene has never been detected previously in any of the groundwater or soil samples collected at this site.

Both total and dissolved metals concentrations were measured in unfiltered and filtered samples (respectively) collected from each deep well. These results are also presented in Table 6-6. Most metals were found at higher concentrations in the unfiltered samples (total metals results), which is the typical pattern of occurrence. No distinct patterns of contamination were observed for metals in these wells. In several cases (such as for arsenic, lead, and manganese), the concentrations in the slightly upgradient wells (9SLW-1B and -1C) were somewhat greater than in the downgradient wells. Of these, only the concentrations of arsenic in well 9SLW-1C exceed the reported concentrations in the corresponding shallow well (9SLW-1). However, the presence of metals in the unfiltered samples is more related to the presence of suspended sediment in the sample matrix whose source is the natural earth materials surrounding the well screen than to the existence of inorganic contamination. In particular, at this site that has only three wells in each of the deeper monitoring zones, no distinct

TABLE 6-6

CHEMICALS DETECTED IN DEEP GROUNDWATER SAMPLES (µg/L)[1]
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	Intermediate						Deep					
	9SLW-1B (266.1'-286.1')[3]		9SLW-3B (231.5'-254.5')		9SLW-4B (242.9'-262.9')		9SLW-1C (167.2'-187.2')		9SLW-3C[2] (144.5'-164.5')		9SLW-4C (155.0'-175.0')	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Tetrachloroethene	29	-	35	-	56	-	5U	-	5/5	-	5U	-
Toluene	5U	-	5U	-	5U	-	6	-	5U/5U	-	5U	-
Bis(2-ethylhexyl)phthalate	10U	-	1J	-	1J	-	4J	-	10U/10U	-	1J	-
Di-n-octylphthalate	10U	-	2J	-	2J	-	5J	-	10U/10U	-	2J	-
Aluminum	363B	73B	72UJ(2)	72B	379B	72B	2480	72U	87B/87B	72U/72U	87B	72U
Arsenic	2UJ(1)	2UJ(1)	2UJ(1)	2UJ(1)	2UJ(1)	2UJ(1)	7.4J(1)	5.2J(1,2)	2.4J(1)/ 2.4J(1)	3.8J(1,2)/ 2.8J(1,2)	2UJ(1)	2U
Barium	263	255	250	263	326	358	379	49	175/177	184/175	405	431
Cadmium	4U	4U	4	4U	4U	4U	4U	4U	4U/4U	48/4U	4U	4U
Calcium	12700	12600	19500	20000	18800	22000	57000	5020	16900/17700	18400/17600	24000	25200
Chromium	13B	7U	7U	7U	12B	7U	7U	8	14B/7U	7U/7U	7U	7U
Iron	508	45B	43B	48B	757	54B	1660	40B	80B/43B	41B/39B	35B	50B
Lead	1.6	1.6	1U	1.1U	1.7	1U	7.6	1U	1U/1U	1U/1.6	1U	1U
Magnesium	2380	2370	7710	7800	5330	6080	9790	3760	10200/10500	11400/10600	6440	6630
Manganese	37	5B	1	1B	226	2B	103	1B	2/1	2B/1B	1	2B
Potassium	21400	2140U	2140U	2140U	2140U	2140U	62600	45900	21400/21400	21400/2140U	2140U	2140U
Sodium	9560	8410	6090	6090	9880	9840	30700	23700	5930/6120	5560/5460	8900	8170
Zinc	5B	11	5B	14	9B	13	14B	5	3B/7B	10/5	3B	6

(1) Complete analytical data base in Appendix A.
(2) Field duplicate sample results for both samples reported.
(3) Screened interval elevation (NGVD 1929).

Qualifiers defined as follows:
U - Not detected at the detection limit shown.
B - Value is considered to be a false positive due to blank contamination.
J(1) - Value is estimated due to GFAA calibration correlation coefficient <0.995.
J(2) - Value is estimated due to low GFAA %R.
J - Value is estimated by the laboratory because it is reported at a concentration less than the CRQL.

plumes of inorganic contamination were identifiable. In addition, the concentrations of arsenic, lead, and manganese are all below current MCLs.

Because tetrachloroethene has consistently been detected in a near-upgradient well cluster (9SLW-1/9SLW-1B), a deeper well was installed at that location and a shallow well was installed farther upgradient (9SLW-5). The more upgradient well was also found to contain tetrachloroethene (7 µg/L). This fact appears to indicate that the landfill is not the sole source of the volatile organics detected in the downgradient wells (9SLW-3 and -4 clusters). In addition, the general lack of volatile organics in the soil samples collected from both test pits and the shallow grid indicate that another source area is probable. Neither semivolatile nor metals appear to be present in groundwater at elevated levels at this site.

6.5.3 Surface Water and Sediment

6.5.3.1 Surface Water

Four surface water samples were collected for chemical analysis from the pond and stream located north of the landfill. Sample location 4 (9SL-SWS-4) is downstream of the pond, location 3 (9SL-SWS-3) is at the pond outlet, location 1 (9SL-SWS-1) is at the pond inlet, and location 5 (9SL-SWS-5) is in the marshy area farther upstream.

Each surface water sample was analyzed for TCL volatile organics, semivolatile organics, pesticides and PCBs, and TAL metals. As shown in Table 6-7, no organic chemicals were detected in any of the surface water samples with the exception of bis(2-ethylhexyl)phthalate, which was found in sample 9SL-SWS-1 at a concentration of 1 µg/L. These results are consistent with the SI results, in which no organics were detected. The presence of bis(2-ethylhexyl) phthalate at such a low concentration may be the result of blank contamination (see Section 2.5). As for the metals results, in some cases the result for the outlet sample (9SL-SWS-3) are below those reported for the inlet sample (9SL-SWS-1) (e.g., copper, lead, and zinc), while for other metals the opposite is true (e.g., antimony, barium, and manganese). However, no great significance can be ascribed to this situation given the low overall concentrations and the fact that the samples were not filtered and would therefore have contained some amount of suspended sediment. It is difficult to correlate metals results in the RI to those of the SI because the concentrations will vary based on the amount of suspended sediment in the sample, which can vary over time with flow conditions, etc.

TABLE 6-7

CHEMICALS DETECTED IN SURFACE WATER SAMPLES (µg/L)[1]
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	9SL-SWS-1 Pond Inlet	9SL-SWS-3 Pond Outlet	9SL-SWS-4 Downstream	9SL-SWS-5 Upstream
Bis(2-ethylhexyl)phthalate	1J	10U	10U	2BB
Aluminum	1030	74BB	157	838
Antimony	45U	64	45U	45U
Barium	42	99	94	15
Beryllium	5	5	5	3BB
Calcium	13100	19100	10400	8900
Copper	9	4	5	7BB
Iron	1360	1940	685	1490
Lead	9.6	1.1	1.4	1.8
Magnesium	3150	4240	3590	3030
Manganese	112	1550	315	67
Nickel	12	12U	12U	19
Potassium	2560	2670	2140U	4060
Sodium	4450U	4800	246000	4450U
Vanadium	4U	4U	4U	6
Zinc	14	7	17	23

[1] Complete analytical data base in Appendix A.
Qualifiers defined as follows:
U - Not detected at detection limit shown.
J - Value is estimated by the laboratory because it is reported at a concentration less than the CRQL.
BB - Value is considered to be a false positive due to blank contamination.

6.5.3.2 Sediment

Sediment samples were collected from the same locations as were the surface water samples, with the addition of two sampling points in the pond itself (9SL-SS-6 and -7). The sediment samples were also analyzed for the TCL and TAL analytes. The positive analytical results are summarized in Table 6-8.

One sediment sample was found to contain 430 µg/kg acetone, however no other volatile organic chemicals were detected. This concentration could not be attributed to blank contamination based on the presence of acetone in associated blank samples. Several of the samples contained polynuclear aromatic hydrocarbons (PAHs). PAHs were also detected during the SI, but were found at the maximum concentrations farthest downstream (9SL/SS-4). The two samples collected from the bottom of the pond (9SL-SS-6 and 7) contained the greatest number of PAHs at the greatest concentrations during the RI, which were lower (115 mg/kg) than those reported in the SI for 9SL/SS-4. This pond receives drainage from roadways and local developed areas that commonly contains PAHs resulting from exhaust emissions. The PAH contamination appears at this time to be centered on the pond itself, with the upstream and downstream samples less contaminated. The downstream sample 9SL/SS-4, which contained the greatest concentrations of total PAHs during the SI (196.4 mg/kg), contained only 4.7 mg/kg PAHs in 1991.

Dieldrin was detected in three of six sediment samples at a maximum concentration of 1,400 µg/kg in the marshy area (9SL-SS-5), which is upstream of the site. The maximum concentration of dieldrin noted during the SI was 300 µg/kg. The presence of dieldrin and aldrin appears to be related to the prior application of pesticides rather than to the disposal of such chemicals in the landfill. Aldrin was found in two sediment samples at a maximum concentration of 120 µg/kg, which was also located in the marshy area (9SL-SS-5). No other pesticides were detected in any of the sediment samples. Dieldrin was also detected during the SI. In addition, PCBs were detected in several SI sediment samples at concentrations up to 61 µg/kg, but were not detected in 1991.

The greatest concentrations of several metals were found in the samples collected from the bottom of the pond. These metals are arsenic (5.4 mg/kg), cadmium (10.3 mg/kg), chromium (55.7 mg/kg), cobalt (13.1 mg/kg), copper (38.5 mg/kg), lead (279 mg/kg), nickel (30.2 mg/kg), vanadium (61.2 mg/kg), and zinc (208 mg/kg). In particular, all of these maxima were found in sample 9SL-SS-7. Individually, the concentrations listed above are all greater than the reported background concentrations.

The lowest concentrations of several metals such as cadmium, nickel, vanadium, and zinc were reported in the sample collected downstream of the pond (9SL-SS-4). During the SI, the concentration

TABLE 6-8
CHEMICALS DETECTED IN SEDIMENT SAMPLES[1]
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	9SL-SS-1 (µg/kg) Pond Inlet	9SL-SS-3 (µg/kg) Pond Outlet	9SL-SS-4 (µg/kg) Downstream	9SL-SS-5 (µg/kg) Upstream	9SL-SS-6 (µg/kg) Pond Bottom	9SL-SS-7 (µg/kg) Pond Bottom
Acetone	40BB	7BB	150BB	9BB	5BB	430
Ethylbenzene	8U	8U	8U	13U	10U	6J
Acenaphthene	460U	1,700U	850U	1,600U	670J	2,500U
Acenaphthylene	460U	1,700U	850U	1,600U	340J	2,500U
Anthracene	460U	1,700U	850U	1,600U	1,400J	2,500U
Benzo(a)anthracene	460U	1,700U	300J	1,600U	6,300	760J
Benzo(b)fluoranthene	460U	1,700U	400J	1,600U	10,000	1,700J
Benzo(k)fluoranthene	460U	1,700U	430J	1,600U	5,700	1,600J
Benzo(g,h,i)perylene	460U	1,700U	110J	1,600U	3,300	490J
Benzo(a)pyrene	49J	1,700U	350J	1,600U	8,000	1,300J
Chrysene	48J	1,700U	410J	1,600U	9,300	1,400J
Dibenz(a,h)anthracene	460U	1,700U	850U	1,600U	260J	2,500U
Fluoranthene	130J	1,700U	920	210J	23,000	2,600
Fluorene	460U	1,700U	850U	1,600U	1,800J	2,500U
Indeno(1,2,3-cd)pyrene	460U	1,700U	140J	1,600U	4,100	670J
Naphthalene	460U	1,700U	850U	1,600U	360J	2,500U
Phenanthrene	93J	1,700U	730J	1,600U	20,000	1,600J
Pyrene	110J	1,700U	960	200J	21,000	2,900
Benzoic Acid	2300U	8,300U	4,100U	710J	11,000U	12,000U
Bis(2-ethylhexyl) phthalate	460U	1,700U	850U	1,600U	1,800BB	4,300
Dibenzofuran	460U	1,700U	850U	1,600U	910J	2,500U
Aldrin	11U	10U	80	120	140U	30U
Dieldrin	22U	31	94	1,400	280U	61U

TABLE 6-8
CHEMICALS DETECTED IN SEDIMENT SAMPLES(1)
NINTH STREET LANDFILL SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA
PAGE TWO

Chemical	9SL-SS-1 (mg/kg) Pond Inlet	9SL-SS-3 (mg/kg) Pond Outlet	9SL-SS-4 (mg/kg) Downstream	9SL-SS-5 (mg/kg) Upstream	9SL-SS-6 (mg/kg) Pond Bottom	9SL-SS-7 (mg/kg) Pond Bottom
Aluminum	1800	7140	11900	19900	9230	30900
Arsenic	2.4	2.2	3.0	3.3B	3.7	5.4
Barium	118	59.3	70.4	137	868	212
Beryllium	1.3	0.96BB	1.3	1.7	0.63BB	2.1BB
Cadmium	1.1U	2.2	1.5	1.4U	6.3	10.3
Calcium	1130	34800	2880	1380	17500	2130
Chromium	22.4	20.1	20.1	25.0	28.2	55.7
Cobalt	8.5	7.2	8.7	7.8	8.9	13.1
Copper	25.6	8.8	14.9	21.0	18.7	38.5
Iron	15800	25400	17700	17400	16800	30700
Lead	49.9	5.4	27.0	65.4	189	279
Magnesium	1830	22000	1870	2260	11700	3690
Manganese	131	501	363	173	375	463
Mercury	0.13U	0.11U	0.42	0.15U	0.19U	0.30U
Nickel	13.9	16.5	12.9	15.5	14.6	30.2
Potassium	862	1260	870	972	1060	1470U
Thallium	0.59	0.45U	0.40U	0.68U	0.74	1.3U
Vanadium	29.1	32.5	26.2	38.2	29.2	61.2
Zinc	47.8	66.2	53.0	76.0	147	208

(1) Complete analytical data base in Appendix A.
Qualifiers defined as follows:
U - Not detected at detection limit shown.
J - Value is estimated by the laboratory because it is reported at a concentration less than the CRQL.
BB - Value is considered to be a false positive due to blank contamination.

of cadmium at this location exceeded background levels. Other metals were found at the lowest concentrations in the pond outlet sample (9SL-SS-3), such as copper, lead, and cobalt.

6.6 CONTAMINANT FATE AND TRANSPORT

The primary contaminant migration process acting at this appears to be the erosion of contaminated soil and transport via surface runoff to nearby creeks. This mechanism is probably no longer active at the landfill given the fact that the surface soil samples collected from the ball field area are clean and the original landfill area is covered with clean soil and vegetated. However, the shallow subsurface soil samples collected from the baseball diamond area contained high concentrations of PAHs, which are generally considered to be insoluble. These types of contaminants have high organic carbon partition coefficients and low solubilities, and therefore are more likely to migrate with the bulk movement of soil such as that which occurs during storm events. This mechanism can be used to explain the prevalence of these types of chemicals in the sediment samples collected from the pond and drainage ways near the site. It is unlikely that loading to the pond from the landfill continues today given the fact that the surface soils are clean.

There is some indication that the subsurface media have affected groundwater quality in this area. The groundwater was found to contain several organic chemicals, however, these chemicals were found in both the upgradient wells (at low concentrations) and the downgradient wells. No distinct upgradient sources of contamination have been identified, however, because the concentrations increase slightly downgradient of the site, the landfill itself cannot be ruled out as a source of contamination although the concentrations of volatile organics in the test pit and grid soil samples were very low (2 to 3 µg/kg). Soluble chemicals such as tetrachloroethene generally have low organic carbon partition coefficients and therefore tend to go into solution with infiltrating precipitation. Once in the groundwater, these chemicals migrate as a solute in the direction of groundwater flow. Other mechanisms acting on chemicals in solution are diffusion and dispersion as they move downgradient.

There is some possibility of wind erosion of soil particulates from the baseball diamond area. The field itself is not vegetated, and therefore fine-grained particulates can be entrained by the wind and carried off site. However, at this site, the surface soil is generally free of contamination, and therefore this mechanism will result in little migration of contamination.

6.7 POTENTIAL HUMAN AND ENVIRONMENTAL RECEPTORS

The most obvious potential receptors for contamination found at the 9th Street Landfill are those persons playing baseball or softball at the baseball diamond. However, since the surface soils are

generally free of contamination, exposures would be minimal given the expected frequency and duration. Persons playing ball would be exposed via dermal contact with soil, some minor amount of incidental ingestion, and inhalation of dust if the field is dry. Potential receptors at the ball field include both adults and children (from the ages of about 6 to 16).

Because access to the pond is not restricted, persons could also be exposed to contaminated sediment and surface water in the pond or the creek. Adults are unlikely to come in contact with these media under the current site conditions, however children are potential receptors. Again, children ages 6 to 16 would be the most likely receptors given the play patterns of children of this age. Children could be exposed via both incidental ingestion of and dermal contact with both sediment and surface water during play.

Adult base personnel who are involved with field maintenance activities such as mowing and grading could also be exposed to contaminated soil in this area. Exposures of these personnel would also be limited to the surface soil under current land use conditions, however, the surface soils contain only low concentrations of contaminants. These persons could be exposed via incidental ingestion of soil, direct dermal contact with soil, and via inhalation of dust. Another potential exposure route that could occur at this site is the disturbance of the surface soil such as during construction. This could bring the contaminated subsurface soil containing PAHs to the surface where people could be readily exposed. The same exposure routes would apply as did for the maintenance scenario.

Should land use change (i.e., with base closure), several other potential exposure routes could occur. First, the construction of homes in this area could result in disturbance of the soil, which could ultimately expose soils from depths of up to about 12 feet at the surface. Exposures of both adult and child residents at that time could occur to a mixture of the surface and subsurface soil. Residents could be exposed via ingestion and direct dermal contact. In addition, there exists the possibility that shallow domestic wells could be installed, thereby exposing these future residents to groundwater contaminants via ingestion, direct dermal contact, and inhalation of volatiles emitted during showering.

Aquatic life residing in the pond could also be affected by site related contamination. Most at risk would be the bottom-feeding organisms that would be most likely to ingest sediment containing PAHs, pesticides, and other bioaccumulative contaminants. However, no adverse effects have been noted thus far in the resident biota.

6.8 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

6.8.1 Field Activities

Site investigation work at the 9th Street Landfill included the installation of 3 deep and 1 shallow monitoring well, excavation and sampling at 4 test pit locations, collection of 16 surface soil samples, and 16 shallow (2 feet) subsurface soils, and collection of 6 sediment and 4 surface water samples. All samples were analyzed for TCL volatiles, semivolatiles, and pesticides/PCBs, TAL metals, and cyanide.

6.8.2 Physical Characteristics

Overburden generally consisting of clay material grading downward to a decomposed siltstone and shale overlies bedrock to a depth of 10 to 15 feet below the ground surface. Bedrock consists of alternating layers of sandstone, siltstone, and shale.

At least two distinct hydrogeologic zones were identified during site work. A water table aquifer and a deeper, artesian zone were investigated. In addition, previously installed wells suggest that an intermediate, or transition zone between the two aquifers exists. Groundwater flow direction was calculated on the basis of measured piezometric level to differ significantly between all three hydrogeologic zones.

6.8.3 Site Contamination

A previous investigation (the SI) at the 9th Street Landfill determined that volatile organic chemicals were present in the groundwater, but that volatile organics were not prevalent soil contaminants. Volatile organics were detected in a sample from an upgradient well. Cyanide was considered to be a significant soil contaminant, and its presence in soil at the baseball diamond area triggered the RI. PAHs and dieldrin were also detected in the soil samples. No organic chemicals were noted in the surface water samples, however PAHs, PCBs, and dieldrin were detected in one or more sediment samples. These data indicated that offsite migration of contamination had occurred at the 9th Street Landfill.

Based on the results of the SI, a soil sampling grid was located on the baseball diamond area for the collection of surface and shallow subsurface (3-foot-deep) soil samples. In addition, several test pits were located in outlying portions of the site. The most prevalent soil contaminants observed in these samples were PAHs, whose presence is most likely related to the past practice of burning waste

materials at the landfill prior to burial. Dieldrin was also commonly detected in the soil samples, however it was found at concentrations that were similar to those reported in the background samples (see Section 2.4). Aroclor-1260 was detected in two samples at a maximum concentration of 890 µg/kg. Overall, only a few volatile organic chemicals were detected in the soil samples, and these were found at concentrations of 2 to 3 µg/kg.

The groundwater samples, on the other hand, contained tetrachloroethene at concentrations ranging from 7 to 61 µg/L. Because PCE was detected during the SI in an upgradient well, another shallow well was installed farther upgradient (9SLW-5). This new well was also found to contain PCE, albeit at a lower concentration. The concentration of PCE increases slightly from the upgradient wells to the downgradient wells. However, since no onsite source areas were noted in the data, it is assumed that either an upgradient source exists (e.g., the Army Helicopter facility) or that source areas onsite have been washed out.

No organic chemicals were detected in any of the surface water samples collected in 1991 with the exception of one detection of bis(2-ethylhexyl)phthalate at a concentration of 1 µg/L. This fact is generally consistent with the results of the SI in which no organic chemicals were detected.

Sediment samples collected from the bottom of the pond contained the highest concentrations of PAHs. This fact is most likely the result of particulate-laden runoff from the surrounding area (containing PAHs related to the burning of waste materials) entering the pond and settling. Some PAHs were detected outside the pond but the concentrations were much lower in general. Several metals were also found at their maximum concentrations in the pond sediment samples (arsenic, cadmium, chromium, cobalt, copper, lead, nickel, vanadium, and zinc). The concentrations of these metals were greater than those in the background soil samples.

6.8.4 Recommendations

Because the upgradient extent of tetrachloroethene contamination has not been defined, nor has the source of this chemical been identified, additional groundwater investigation is recommended. The investigation should include soil sampling in suspected source areas, as well as collection of groundwater samples. Analyses can focus on volatile organic chemicals since neither semivolatiles, pesticides, PCBs, nor metals were found to be significant groundwater contaminants. While there are adequate data to conduct a risk assessment, the feasibility study will require delineating of the extent of contamination.

The extent of sediment contamination has been well-defined (i.e., confined to the pond, for the most part). Because erosion is no longer occurring, additional soil or sediment sampling for PAHs or pesticides/PCBs, or metals is not needed if the cover material can be confirmed to be clean. There is adequate soil, surface water, and sediment data to conduct a quantitative risk assessment and proceed to a feasibility study.

7.0 FIRE TRAINING AREA - NAS SITE 5

7.1 SITE HISTORY AND DESCRIPTION

The Fire Training Area was used from 1942 until 1975 for large-scale firefighting exercises, which included the disposal and burning of flammable liquid wastes generated by the activity. Wastes, including solvents, paint chemicals, xylenes, toluene, and various petroleum compounds, were consumed at the rate of at least 4,000 gallons per year in firefighting exercises (EA, May 1990). The area was also reportedly used for drum storage of these flammable materials during the period between burning exercises. The site is located in the south-central portion of the activity approximately midway between Runway 10/28 and State Route 463 (Figure 1-2). Areas designated as drum storage and burn areas by EA Engineering (May 1991) cover an irregularly shaped surface area of approximately 1.25 acres immediately south of Taxiway Juliet. The Fire Training Area was determined from interpretation of previous site work to be a source of chlorinated and non-chlorinated hydrocarbons in the water table aquifer.

7.2 SUMMARY OF PREVIOUS SITE INVESTIGATIONS

Previous investigations at the Fire Training Area included both a Preliminary Assessment (PA) and a Site Inspection (SI). The PA indicated that various flammable liquids, including petroleum, oil, and lubricants (POL), solvents, and paint chemicals were disposed of or consumed during site training exercises. The area was also used as a drum storage site between training exercises. Based on this information it was believed that a threat of residual soil contamination and continued release of contaminants to the groundwater through infiltration was possible. For this reason the site was recommended for SI activities.

Site investigation work included sampling and laboratory analysis of groundwater and subsurface soil. Four 4-inch-diameter monitoring wells and 4 soil test borings were completed to obtain groundwater and soil samples and to provide geological and hydrogeological information related to the site. Three samples were collected from each monitoring well over a 6-month period and analyzed for volatile organics, petroleum hydrocarbons (TPH), and total organic carbon (TOC). One sample was obtained from each boring location for volatiles analysis and a composite sample of the four borings was collected and analyzed for TPH and TOC.

A variety of solvents (e.g., trichloroethene and 1,1,1-trichloroethane) and fuel-type constituents (e.g., benzene) were detected in one or more groundwater samples collected during the SI. Contamination was confined to the center of the fire training area.

The soil samples collected from a boring in the central portion of the site contained the highest concentrations of and the greatest variety of volatile organic chemicals. For example, 1,1,1-trichloroethane was detected at a concentration of 5,700 µg/kg and trichloroethene was detected at a concentration of 2,000 µg/kg. The concentrations of total petroleum hydrocarbons ranged from 22 mg/kg to 830 mg/kg.

7.3 PHASE I REMEDIAL INVESTIGATION

Previous investigations at the Fire Training Area have indicated that at least one source of volatile organic contamination is present at the site. Therefore, several soil borings were completed to further define the source areas. Additional shallow and intermediate wells were installed to further define the vertical and horizontal extent of groundwater contamination. As a result of the nature of the suspected release(s) at the Fire Training Area, samples obtained during the RI work were analyzed only for TCL volatiles.

7.3.1 Soil Investigation

A total of 12 soil borings were drilled as part of the field investigation. These include FTAB-5 through FTAB-16. Borings numerically preceding FTAB-5 were installed during the SI. The borehole drilling and sampling was completed using truck mounted drilling equipment and procedures described in Section 2.1.1. All boreholes were located as specified in the Draft Plan of Action, with the exception of borehole FTAB-12, which was moved to an area north of the burn area (near FTAW-2) to provide additional information in the upgradient direction. Borehole locations are shown on Figure 7-1.

7.3.2 Groundwater Investigation

As part of the field investigation, six monitoring wells (three deep wells and three shallow wells) were installed to supplement four existing wells at the site. One deep well was drilled near an existing shallow well and the remaining two deep wells were drilled in conjunction with two new shallow wells creating a total of three well pairs at the site. The third shallow well (FTAW-5) was located southwest of the site. One well pair location (FTAW-7, -7B) was moved approximately 100 feet south from the planned location due to the proximity of a small pond and concern that the pond might be adversely

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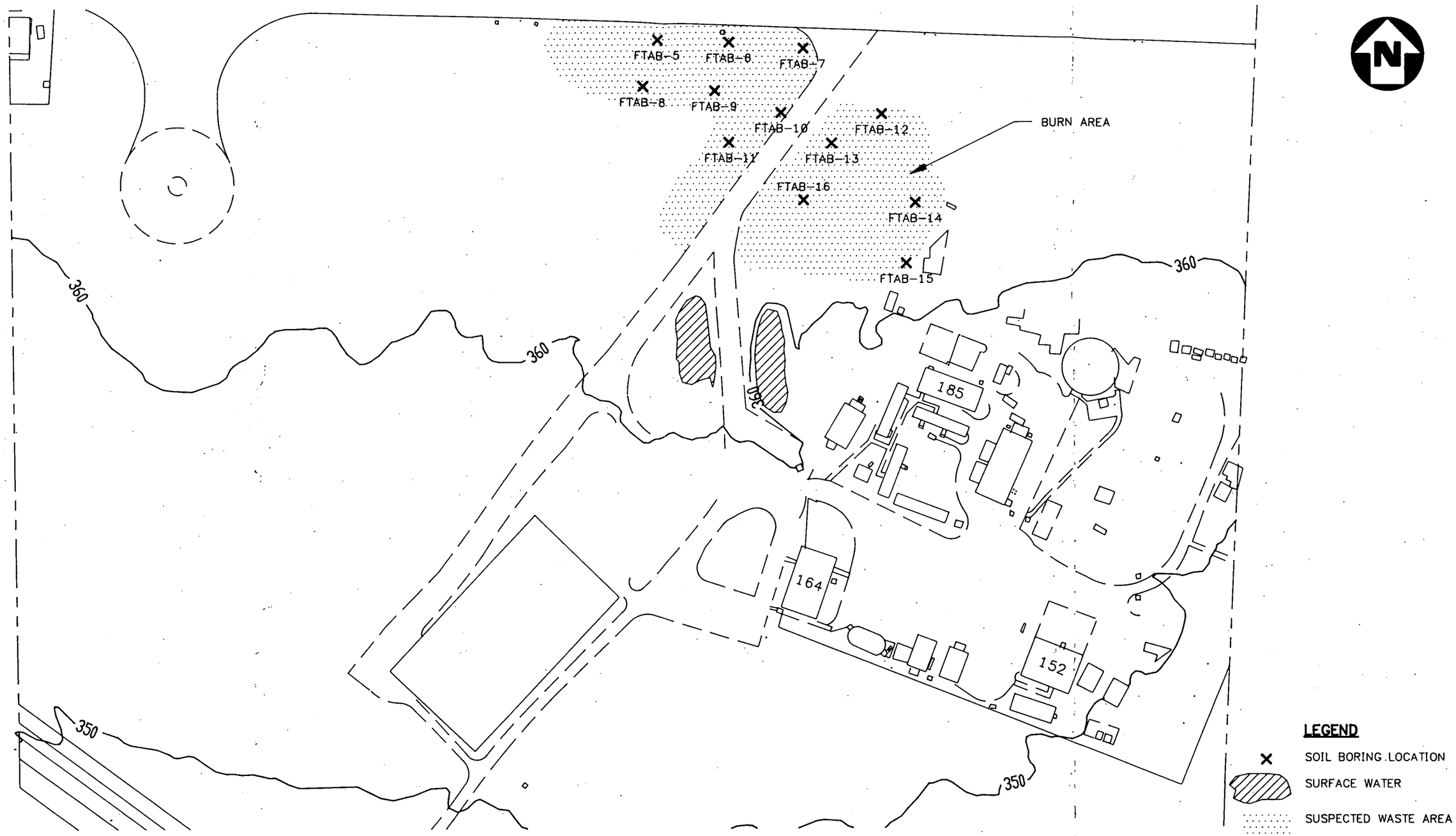

SOIL BORING LOCATIONS
NAS SITE 5 - FIRE TRAINING AREA
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

0 100 200
SCALE IN FEET

FIGURE 7-1

HALLIBURTON NUS
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affected by drilling. The locations of all new (RI) and existing (SI) wells are shown on Figure 7-2, and well completion details are provided in Table 7-1.

All wells were installed using the methodologies described in Section 2.1.2, with only a few minor exceptions. In addition to test boring samples, one subsurface soil sample was obtained from well boring FTAW-7 to provide supplemental data for the area downgradient of the burn area. Bumper pipes were installed for protection of wells FTAW-7, -7B, and -1B because of their proximity to an access road and a parking lot.

7.3.3 Surface Water and Sediment Investigation

No surface water or sediment samples were collected during RI phase activities at the Fire Training Area, in accordance with the investigation Plan of Action (EA, August 1991).

7.4 SITE CHARACTERISTICS

7.4.1 Surface Features

The Fire Training Area (NAS Site 5) is located immediately adjacent to Taxiway Juliet and is divided into two areas of approximately equal size by a paved roadway. The Marine Corps Reserve compound is located within 100 feet of the southeast corner of the suspected waste disposal area and two small ponds lay immediately south of the site. The area of suspected waste disposal is primarily covered by grasses, with some woody and brushy vegetation present along the south side of the area. A burn area used during training exercises is located in the south central portion of the site, as shown on Figure 7-1.

7.4.2 Geology

Geological investigation during RI phase activities at the Fire Training Area included completion of 12 test borings through the waste disposal area and installation of three intermediate and three shallow monitoring wells adjacent to the site. Borings in what is suspected to have been a former waste and equipment storage and salvage area were advanced to the top of bedrock, which was found at depths ranging from 8 to 22 feet. Overburden material was described as a red to brown silty clay and clay material extending from near the ground surface to the top of weathered bedrock throughout the waste disposal area. One borehole, FTAB-16, intersected coarser-grained sandy material from a depth of 7 feet to the top of bedrock at 15 feet. Monitoring well borings encountered the top of bedrock at depths ranging from approximately 10 to 16 feet below the ground surface. The upper surface of the

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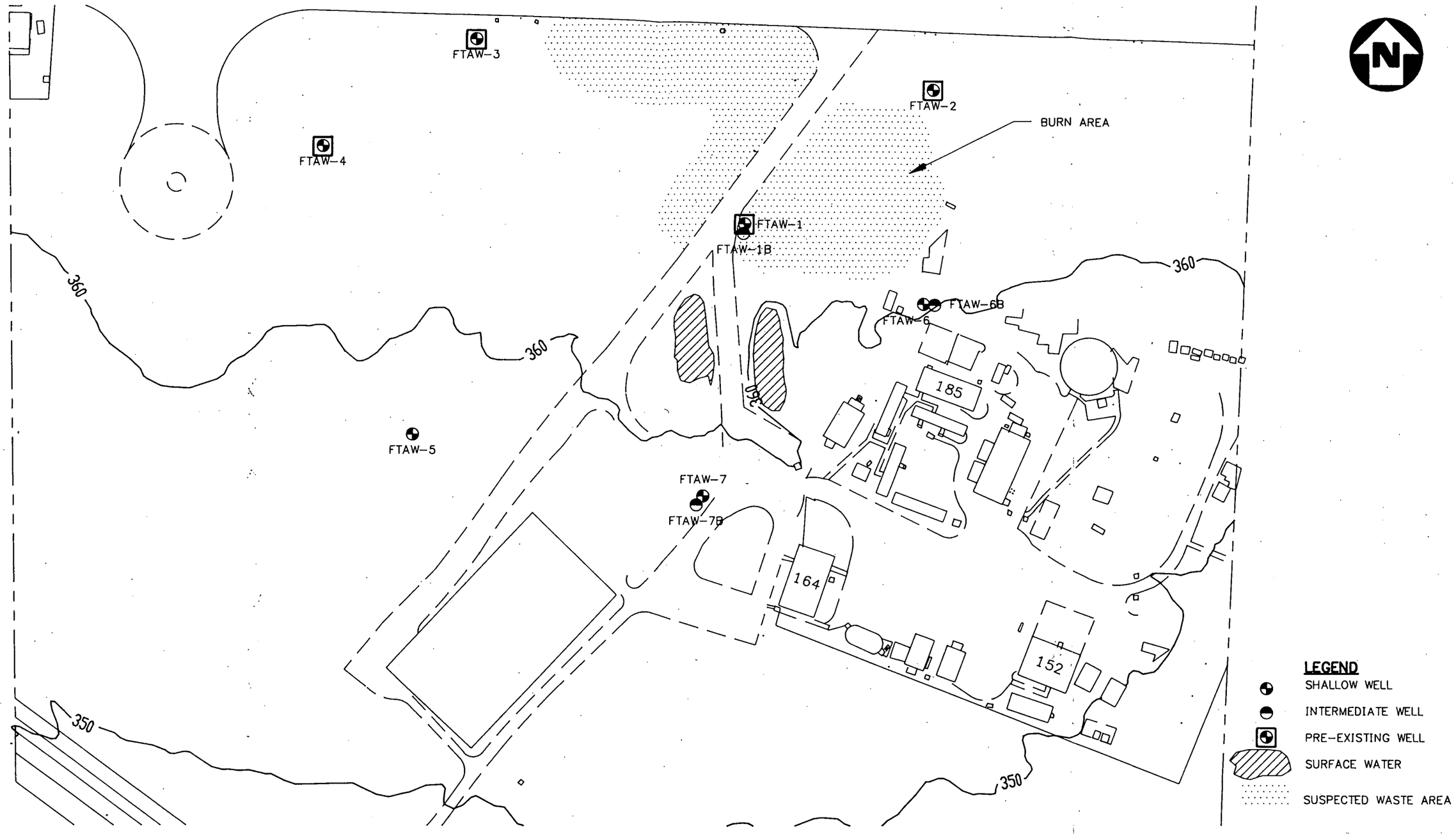

WELL LOCATIONS
NAS SITE 5 – FIRE TRAINING AREA
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

0 100 200
SCALE IN FEET

FIGURE 7-2

HALLIBURTON NUS
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TABLE 7-1

WELL COMPLETION DATA
FIRE TRAINING AREA
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

HNUS Well Number	Total Depth(1)	Date Completed	Ground Elevation(2)	Elevation Top PVC(2)	Depth to Water(3)	Groundwater Elevation(2)	Screen(1)		Sand Pack(1)	
							From	To	From	To
FTAW-1B	85	09/04/91	363.4	364.56	27.20	337.36	74.5	84.5	71	85
FTAW-5	41	09/04/91	358.9	360.84	23.40	337.44	20	40	17	40.5
FTAW-6	38	09/05/91	360.8	363.30	25.00	338.30	17.5	37.5	15	38
FTAW-6B	84.5	09/09/91	360.7	362.0	24.50	337.50	74	84	71	84.5
FTAW-7	29	09/04/91	359.7	361.65	24.00	337.65	6	26	5	29
FTAW-7B	85	09/10/91	359.6	361.12	24.50	336.62	74	84	72	85

(1) Measurements in feet from surface.
(2) Measurements in feet above sea level.
(3) Measurements from top PVC.

Note: Water levels measured 09/19/91.

bedrock was described as siltstone and shale grading to fine sand with depth in the vicinity of the burn area and Marine Reserve Compound (FTAW-13 and FTAW-6) and as siltstone and very fine-grained sandstone south and west of the burn and storage areas at FTAW-5 and FTAW-7. Cross section D-D' (Figure 7-3) shows the general lithologies encountered at site boreholes. Fine-grained sandstone was primarily logged throughout the remaining portions of the well borings to depths ranging up to 87 feet. Possible fractures were logged infrequently during drilling. Distinct increases in water yield were consistently encountered with increasing borehole depth. The alternating sequence of sandstone, siltstone, and shale commonly encountered at the three other RI study areas was significantly less pronounced in Fire Training Area boreholes, with water yield increases often occurring in zones logged as being relatively homogeneous. In the absence of distinct bedding plane fractures, this increase in yield may be attributable to other fracturing or variations in primary porosity/permeability.

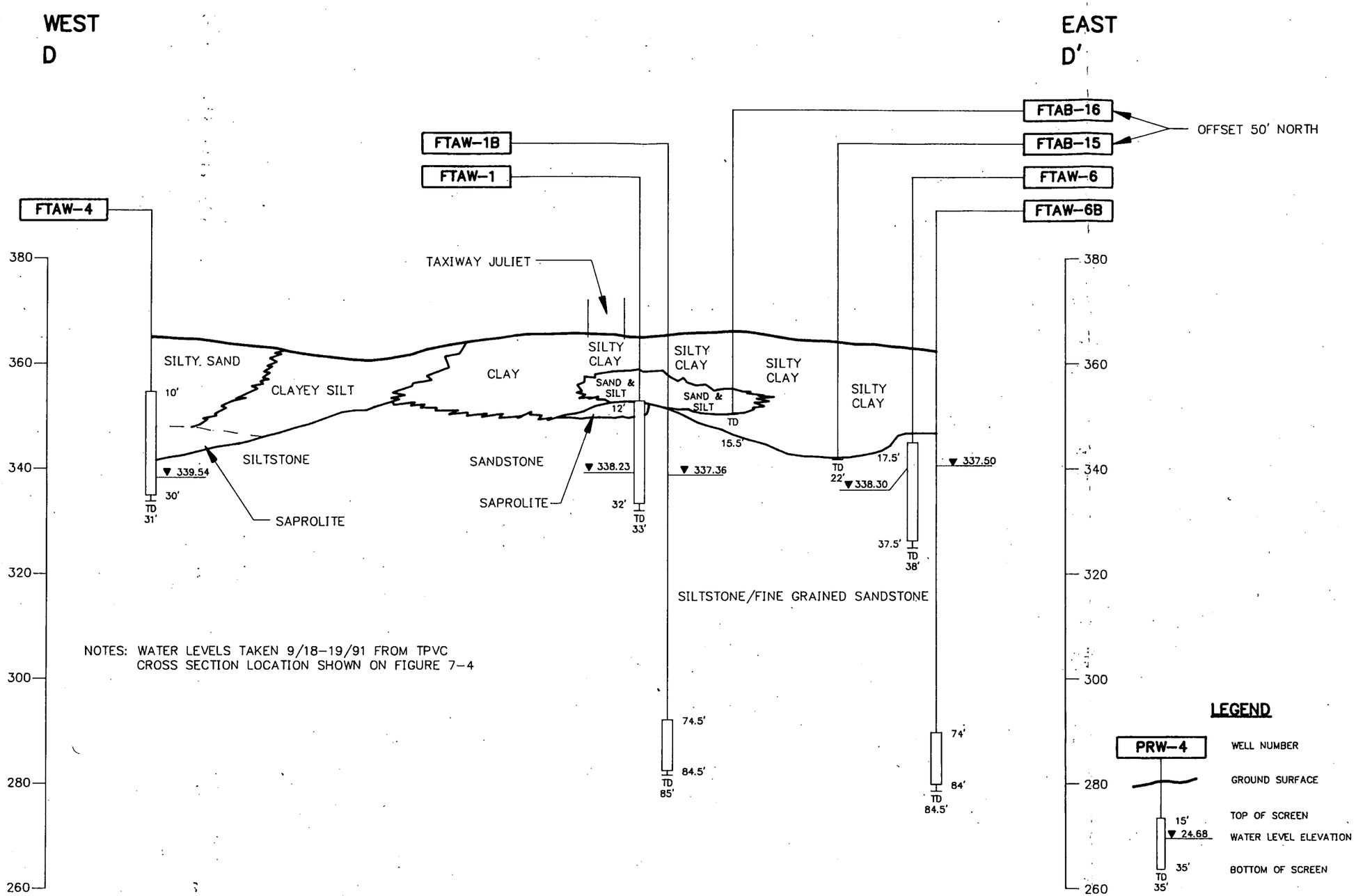
7.4.3 Hydrology

The ground surface in the vicinity of the Fire Training Area slopes toward the south at a grade of approximately 2 percent. Runoff during normal precipitation events should be minimized by the relatively gentle slope and the existence of vegetation, consisting primarily of grasses, which serve to slow runoff velocity and increase infiltration. Two small ponds are located within 100 feet of the site in the downslope direction.

Based on observation of local topography, any runoff from the site area may be expected to flow off base through a small ephemeral drainage that crosses the base boundary approximately 2,000 feet south of the Fire Training Area. This drainage, which also carries runoff from the Antenna Field Landfill Site, flows into Pennypack Creek approximately 3,000 feet from the base property line.

7.4.4 Hydrogeology

The hydrogeology of the Fire Training Area has been interpreted primarily from potentiometric surface measurements at six shallow and three intermediate wells in the vicinity. Groundwater was encountered at depths ranging from approximately 23 to 27 feet below the ground surface. Potentiometric surface maps (Figures 7-4 and 7-5) prepared separately from water levels measured in shallow and intermediate wells, suggest a groundwater flow toward the south-southeast in the shallow wells and a southwest flow direction in the intermediate depth wells. Table 7-2 provides water level measurement data from site wells.



NOTES: WATER LEVELS TAKEN 9/18-19/91 FROM TPVC
CROSS SECTION LOCATION SHOWN ON FIGURE 7-4

0 20 40
VERTICAL SCALE IN FEET

0 100 200
HORIZONTAL SCALE IN FEET

FIGURE 7-3

CROSS SECTION D-D'
NAS SITE 5 - FIRE TRAINING AREA
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

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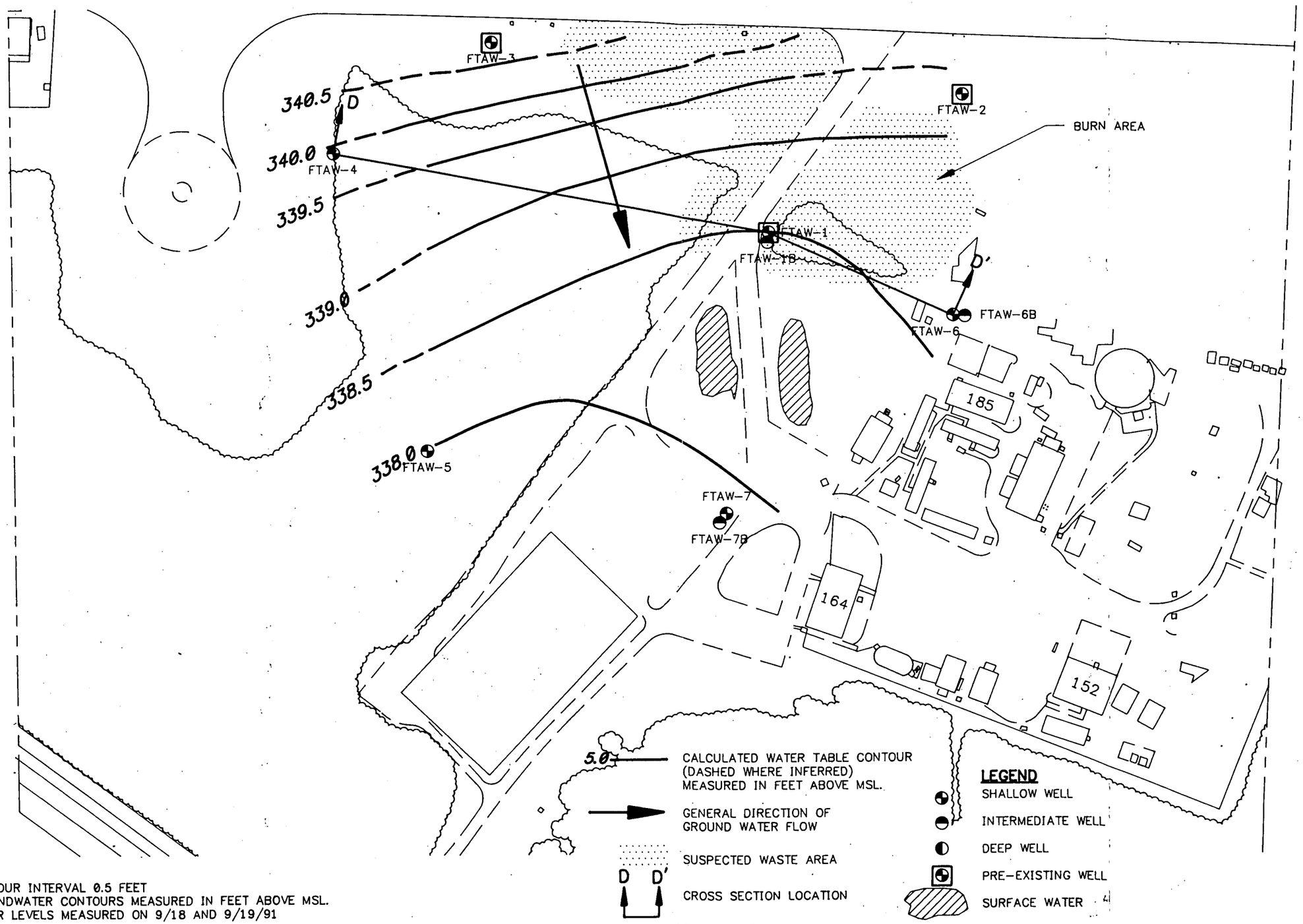

NOTES:

CONTOUR INTERVAL 0.5 FEET
GROUNDWATER CONTOURS MEASURED IN FEET ABOVE MSL.
WATER LEVELS MEASURED ON 9/18 AND 9/19/91

POTENTIOMETRIC SURFACE MAP OF SHALLOW MONITORING WELLS
NAS SITE 5 – FIRE TRAINING AREA
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

FIGURE 7-4

HALLIBURTON NUS
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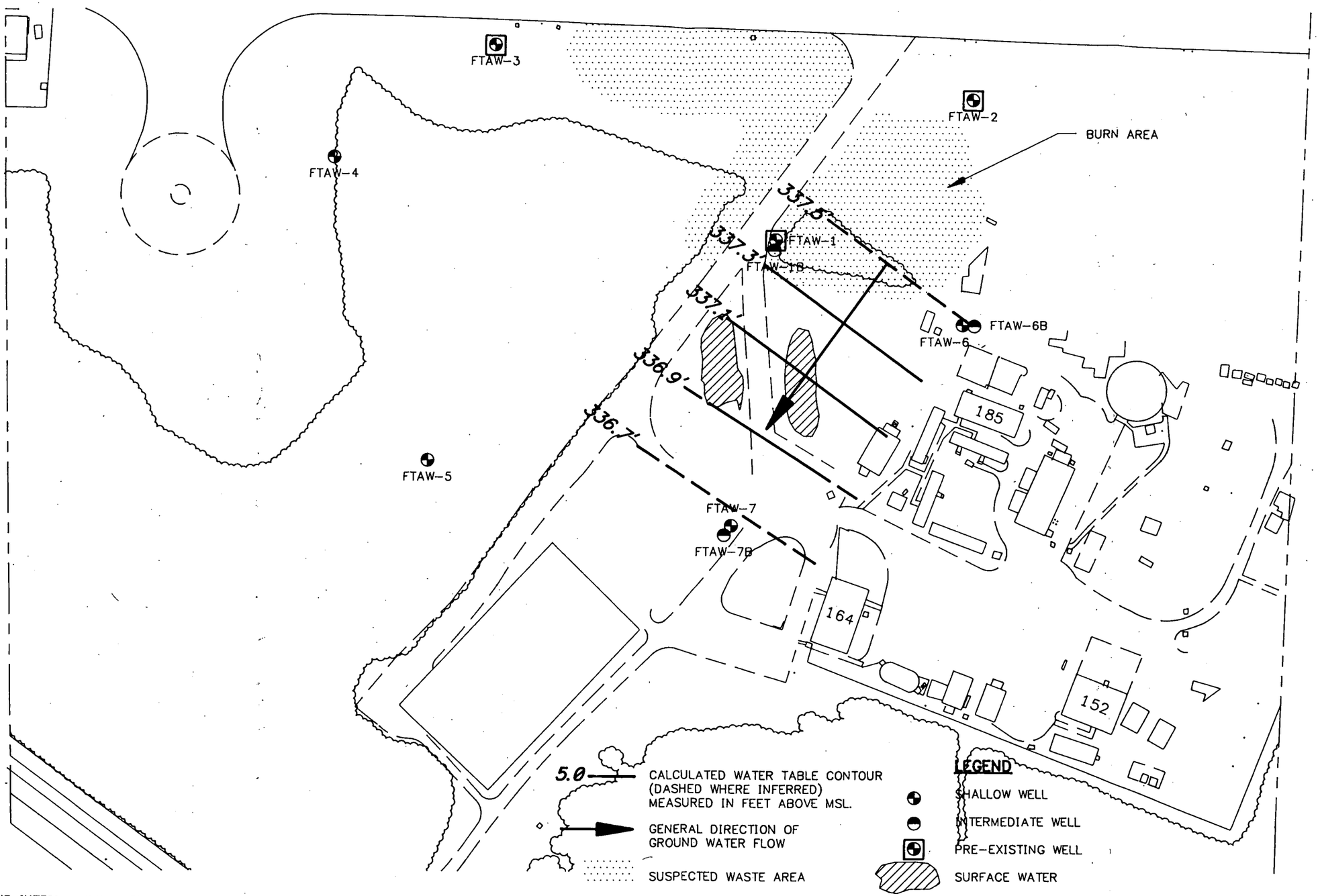

NOTES:

CONTOUR INTERVAL 0.2 FEET
WATER LEVELS MEAURED ON 9/19/91

POTENTIOMETRIC SURFACE MAP OF INTERMEDIATE MONITORING WELLS
NAS SITE 5 – FIRE TRAINING AREA
NAVAL AIR STATION WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

0 100 200
SCALE IN FEET

FIGURE 7-5

HALLIBURTON NUS
Environmental Corporation

TABLE 7-2

WATER LEVEL DATA[1]
FIRE TRAINING AREA
NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Well Number	Top PVC Elevation	Ground Elevation	Water Level[2]	Water Elevation
FTAW-1	365.11	362.92	26.88	338.23
FTAW-1B	364.56	363.40	27.20	337.36
FTAW-2	366.40	364.46	27.55	338.85
FTAW-3	368.13	366.27	27.47	340.66
FTAW-4	366.54	364.72	26.90	339.64
FTAW-5	360.84	358.90	23.40	337.44
FTAW-6	363.30	360.80	25.00	338.30
FTAW-6B	362.00	360.70	24.50	337.50
FTAW-7	361.65	359.70	24.00	337.65
FTAW-7B	361.12	359.60	24.50	336.62

(1) Measurements in feet above MSL, except when noted.
(2) Measurements in feet below top of PVC.

Note: Measurements taken 09/18/91 through 09/19/91.

7.5 NATURE AND EXTENT OF CONTAMINATION

This section contains a media-specific discussion of the nature and extent of soil and groundwater contamination that was observed at the Fire Training Area Site. No surface water or sediment samples were collected at this site. The chemical analytical results are summarized on a series of tables that present only those chemicals that were detected in at least one sample. The complete analytical data base, which contains all analytes and their detection limits, is contained in Appendix A.

During the Site Inspection, four wells were installed on site (FTAW-1 through -4) and soil samples were collected from four soil borings (FTAB-1 through -4), one of which was used for well installation. The samples were analyzed for volatile organics and petroleum hydrocarbons. All the analytical results were presented in the Site Inspection Report (EA, May 1990) and used to develop the scope of work for the RI. The groundwater sample collected from well FTAW-1, which is located slightly cross-gradient from the burn area, contained the highest concentrations of both solvents (e.g., trichloroethene and 1,1,1-trichloroethane) as well as the sole detection of benzene (59 µg/L), which is more typically associated with fuel. The concentrations of solvents reported in well FTAW-1 are as follows:

- Tetrachloroethene - 25.28 to 56 µg/L
- Trichloroethene - 192.71 to 320 µg/L
- 1,1-Dichloroethene - 464.56 to 663.76 µg/L
- 1,2-Dichloroethene - 56.74 to 64.93 µg/L
- 1,1,1-Trichloroethane - 1,322.3 to 1,990.6 µg/L
- 1,1,2-Trichloroethane - 4 µg/L
- 1,1-Dichloroethane - 265.3 to 350 µg/L

1,1,1-Trichloroethane was detected in the other three wells at concentrations between 1 and 22 µg/L during all three sampling rounds. Tetrachloroethene and trichloroethene were also occasionally detected in one or more other wells.

The soil samples collected from the boring for well FTAW-1 (FTAB-1) contained the highest concentrations of and the greatest variety of volatile organic chemicals. For example, 1,1,1-trichloroethane was detected at a concentration of 5,700 µg/kg and trichloroethene was detected at a concentration of 2,000 µg/kg. Sample FTAB-2, which was the sample collected closest to the existing burn barrel, contained much lower concentrations of only a few volatile organics such as acetone (53 µg/kg), toluene (5 µg/kg), and trichloroethene (3 µg/kg). The concentrations of total

petroleum hydrocarbons ranged from 22 mg/kg to 830 mg/kg in the four soil samples, with the maximum concentration found in the sample collected from FTAB-1.

The results of this earlier investigation showed that both the soil and the groundwater in the vicinity of the Fire Training Area (particularly FTAW-1) have been affected by past site activities. Both halogenated aliphatic compounds and monocyclic aromatics were detected in both media. Because these are the major types of contaminants expected at this site, the samples collected during the RI were analyzed for volatile organics only.

7.5.1 Surface and Subsurface Soil

Twelve soil borings were drilled at this site for the purpose of collecting samples for chemical analysis. Depths of up to 18 feet were sampled, which is the approximate depth of the water table surface. All samples were analyzed only for TCL volatile organics. The analytical results are summarized in Table 7-3, and the complete data base is contained in Appendix A.

Very little contamination was observed in these samples, with the primary contaminant classes being the ketones and monocyclic aromatics. Contamination was found sporadically in the soil, and the concentrations were generally low (below 10 µg/kg). In the surface soil (0 to 2 feet deep), toluene was the only analyte detected in the 8 samples collected. It was found at a concentration of 1 µg/kg in the surface sample from boring 15 (FTAB-15-0002). Toluene was detected in only one other soil sample (at a concentration of 5 µg/kg), which was the sample collected from a depth of 2 to 4 feet in boring 13 (FTAB-13-0204). That particular sample also contained 4-methyl-2-pentanone at a concentration of 2 µg/kg. No other volatile organics were detected in any other soil samples collected from depths of 4 feet or less (a total of 14 samples).

Two of the eleven samples collected from depths of 4 to 6 feet were found to contain volatile organic chemicals (benzene, chloromethane, and carbon disulfide). The chemical that was found at the maximum concentration was chloromethane, which was detected at a concentration of 3 µg/kg in boring 6 (FTAB-6-0406).

At the next depth interval sampled (6 to 8 feet), only one of 9 samples contained volatile organics. 2-Hexanone was found in boring 5 (FTAB-5-0608) at a concentration of 1 µg/kg and acetone was found at a concentration of 5 µg/kg in boring 11 (FTAB-11-0608).

Samples were also collected from depths of 8 to 10 feet (4 samples), 10 to 12 feet (10 samples), and 12 to 14 feet (4 samples). Only two chemicals (2-butanone and chloromethane) were found in

TABLE 7-3

DATA SUMMARY TABLE - SOIL
FIRE TRAINING AREA - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	CRDL (µg/kg)	Frequency of Detection	Data Completeness (%)	Range of Sample Quantitation Limits (µg/kg)	Range of Detected Concentrations (µg/kg)	95% UCL[2] (µg/kg)	Mean of All Values[3] (µg/kg)
2-Butanone	10	1/60	100	10-62	9	8	6.6
2-Hexanone	10	1/60	100	10-62	1	1[5]	6.5
4-Methyl-2-pentanone	10	1/60	100	10-62	2	2[5]	6.5
Benzene	10	1/60	100	5-31	1	1[5]	3.3
Carbon Disulfide	10	1/60	100	5-31	1.5[4]	1.5[5]	3.3
Chloromethane	10	2/60	100	10-62	3-6	6[5]	6.5
Toluene	10	2/60	100	5-31	1-5	4	3.3

(1) Contract required detection limit.
(2) Upper 95 percent confidence limit on arithmetic average.
(3) Arithmetic average.
(4) Result reported is the average of duplicate sample results.
(5) UCL exceeds maximum, therefore maximum reported.

these samples. Chloromethane was detected at the 12- to 14-foot depth at a concentration of 6 µg/kg (FTAB-13-1214), and 2-butanone was detected at the 8- to 10-foot depth at a concentration of 9 µg/kg (FTAB-14-0810). No other organic chemicals were detected in the soil samples. Several of these volatile organics such as toluene, acetone, and 2-hexanone could be present as a result of blank contamination, given the concentrations reported in Section 2.5, which were found in one or more nonassociated blanks.

Seven additional soil samples from depths of between 14 and 18 feet were also analyzed for volatile organics. None were detected.

Based on the low concentrations of volatile organics detected in the soil, the soil does not appear to represent a significant residual source of contamination outside the immediate burn area that was sampled in 1989. The soil sample results presented in the SI Report (EA, May 1990) for sample FTAB-1 contained much higher concentrations of the contaminants that were also found in the groundwater than were found during the RI.

7.5.2 Groundwater

Seven shallow wells and three deep wells were sampled at the Fire Training Area Site, and the water was analyzed for Target Compound List volatile organic chemicals only. The analytical results for the shallow wells are summarized in Table 7-4, and the results for the deep wells are summarized in Table 7-5.

Three shallow wells were found to contain volatile organic chemicals. Once again, the sample from well FTAW-1 was the most contaminated. Halogenated aliphatics are by far the most commonly- found chemicals, as during the SI. The contamination in the shallow aquifer is centered around well clusters 1 and 7, which are in the central portion of the study area. The sample collected from well FTAW-1 contained 1,1-dichloroethene (840 µg/L), 1,2-dichloroethenes (180 µg/L), 1,1-dichloroethane (420 µg/L), trichloroethene (590 µg/L), and 1,1,1-trichloroethane (2,800 µg/L). The next downgradient well sample (FTAW-7) in the shallow aquifer contained only 2 µg/L 1,1,1-trichloroethane. The only other shallow well to contain volatile organics was the sample from well FTAW-2, which was found to contain 2 µg/L tetrachloroethene. Hence, the contamination in the shallow aquifer appears to be limited to a narrow area south of the roadway that passes through the center of the site.

The deep wells at cluster locations 1 and 7 (FTAW-1B and -7B) also exhibited contamination with volatile organic chemicals. However, the concentrations were much lower than those reported in the shallow wells. Again, the halogenated aliphatics were the most prevalent chemicals, although benzene

TABLE 7-4

CHEMICALS DETECTED IN SHALLOW GROUNDWATER SAMPLES (μg/L)[1]
FIRE TRAINING AREA SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	FTAW-1	FTAW-2	FTAW-3	FTAW-4	FTAW-5[2]	FTAW-6	FTAW-7
	(353.11'-373.11')[3]	(336.4'-356.4')	(337.13'-357.13')	(336.13'-356.54')	(318.9'-338.9')	(323.3'-343.3')	275.6'-285-6')
Trichloroethene	590	5U	5U	5U	5U/5U	5U	5U
Tetrachloroethene	500U	2J	5U	5U	5U/5U	5U	5U
1,1,1-Trichloroethane	2800U	5U	1BB	3BB	5U/5U	5U	2J(1)
total 1,2-Dichloroethenes	180J	5U	5U	5U	5U/5U	5U	5U
1,1-Dichloroethane	420	5U	5U	5U	5U/5U	5U	1J(1)
1,1-Dichloroethene	840	5U	5U	5U	5U/5U	5U	5U

(1) Complete analytical data base in Appendix A.
(2) Field duplicate sample results for both samples reported.
(3) Screened interval elevation (NGVD 1929).

Qualifiers defined as follows:
U - Not detected at detection limit shown.
J(1) - Value is estimated because the reported concentration is less than the CRQL.
J - Value is estimated by the laboratory because the reported concentration is less than the CRQL.
BB - Value is considered to be a false positive due to blank contamination.

TABLE 7-5

CHEMICALS DETECTED IN DEEP GROUNDWATER SAMPLES (µg/L)[1]
FIRE TRAINING AREA SITE - NAS WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

Chemical	FTAW-1B	FTAW-6B	FTAW-7B
	(279.9'-288.9')[2]	(276.7'-277.7')	(275.6'-285.6')
Benzene	16J(2)	5U	5U
Tetrachloroethene	8	5U	5U
Trichloroethene	69J(2)	5U	2J(1)
1,1,1-Trichloroethane	260	5U	6
total 1,2-Dichloroethenes	11J(1)	5U	5U
1,1-Dichloroethane	84	5U	2J(1)
1,1-Dichloroethene	120J(2)	5U	4J(1)

[1] Complete analytical data base in Appendix A.
[2] Screened interval elevation (NGVD 1929).
Qualifiers defined as follows:
U - Not detected at detection limit shown.
J(1) - Value is estimated because reported concentration is less than CRQL.
J(2) - Value is estimated due to MS/MSD RPDs outside QC limits.

was detected in one sample (FTAW-1B at 16 µg/L). The deep well sample from cluster 1 (FTAW-1B) also contained tetrachloroethene (8 µg/L), trichloroethene (69 µg/L), 1,2-dichloroethenes (11 µg/L), 1,1-dichloroethene (120 µg/L), 1,1,1-trichloroethane (260 µg/L), and 1,1-dichloroethane (84 µg/L).

Like the shallow wells, the deep well from cluster location 7 (FTAW-7B) contained fewer chemicals at lower concentrations. For instance, trichloroethene was found at a concentration of 2 µg/L, 1,1-dichloroethene at 4 µg/L, 1,1,1-trichloroethane at 6 µg/L, and 1,1-dichloroethane at 2 µg/L.

As in the 1989 SI, halogenated solvents were once again the predominant type of groundwater contaminant detected at the Fire Training Area. Benzene was detected only once in 1991, as in 1989. These same chemicals were detected in subsurface soil samples collected from borings in and around the burn area, as described in the SI Report (EA, May 1990).

7.6 CONTAMINANT FATE AND TRANSPORT

The most prevalent contaminant migration route at this site is the downward migration of soluble organic chemicals through the soil where they eventually reach the water table. This pathway is illustrated by the occurrence of organic chemicals at depth in the soil boring samples collected throughout the burn area and the detection of similar compounds in groundwater samples. The types of material used in fire training exercises (e.g., fuels and waste solvents) consist of chemicals with high solubilities and low organic carbon partition coefficients, which are properties that make them susceptible to this form of migration. In addition to the potential bulk movement of some materials into the soil in the years when a burn pan was not used, the use of liquids to extinguish the fires could also drive contamination to depth. Once in the groundwater, these chemicals would continue to migrate downgradient, although they will be subject to some retardation by soil organic carbon.

The Fire Training Area is well vegetated and fairly flat, therefore overland migration of soil from the site will be minimal. However, the lack of soil cover in the immediate burn area could contribute to fugitive dust emissions of fine-grained soil particulates. Surface soil would be most affected by this migration route.

7.7 POTENTIAL HUMAN AND ENVIRONMENTAL RECEPTORS

Because this site is fairly isolated and because access is restricted, the only potential receptors under current land use conditions are those base personnel involved in fire training exercises and site maintenance. These persons could be exposed via direct contact with surface soil, a minor amount of incidental ingestion of soil while on site, and by the inhalation of fugitive dust emissions from surface

soil. However, surface soils contained a minimal amount of contamination, and therefore exposures would also be minimal.

The majority of soil contamination is confined to the subsurface soil, to which no one would be exposed unless land use changes or unless construction activities disturb the soil. As far as construction is concerned, the only receptors would be adults involved in this activity. However, a change in land use (such as base closure and future residential land use) could result in exposure of both adults and children who would then reside in this area.

At the present time, groundwater in the shallow aquifer is not used for potable purposes in the immediate vicinity. However, there are no restrictions on the future installation of a domestic well should land use change. This could also result in exposure of both children and adults via ingestion, inhalation of volatile emissions during showering, and direct dermal contact.

No environmental receptors have been identified at this site, with the exception of transient wildlife that may cross the site when it is not in use.

7.8 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

7.8.1 Field Activities

Twelve test borings were completed and three shallow and three intermediate level monitoring wells were installed during RI work at the Fire Training Area. Five soil samples were collected from each boring location and groundwater samples were obtained from the six wells installed during RI work and from four previously installed wells. All samples were analyzed for TCL volatiles only.

7.8.2 Physical Characteristics

Borings advanced to the top of bedrock in the site area indicate an overburden thickness ranging form 8 to 22 feet. Overburden was described as silty clay to clay material. Bedrock consisted primarily of a fine-grained sandstone with some siltstone and shale encountered near the upper bedrock surface at some locations.

Groundwater levels were measured at depths ranging from 23 to 27 feet below the ground surface. Groundwater flow directions were observed to vary considerably between shallow and intermediate aquifer zones.

7.8.3 Site Contamination

Soil and groundwater samples collected during the SI contained several monocyclic aromatic hydrocarbons and halogenated aliphatics. The samples with the greatest concentrations were found in the immediate vicinity of the burn area, with lower concentrations (or no contaminants detected) in the outlying areas. The primary contamination was centered around well FTAW-1, which contained several volatile organic chemicals at concentrations above drinking water standards.

The RI focused on areas where burning was thought to occur with the expectation of defining other source areas. However, little contamination was observed in these soil samples. With the exception of the initial well located near the burn pit (FTAW-1) and several wells installed adjacent to it (FTAW-1B, FTAW-7, and FTAW-7B), no other wells contained volatile organic chemicals. The sample collected from FTAW-1B contained lower concentrations of volatiles than that collected from FTAW-1. Both the upgradient and downgradient wells contain no volatile organics above detection limits.

The data appear to indicate that the contamination at the Fire Training Area is confined to a relatively small area and has not migrated downgradient. However, the full vertical extent of groundwater contamination has not been defined, nor has the extent of soil contamination been determined.

7.8.4 Recommendations

Based on the lack of information on the vertical extent of groundwater contamination at this site and the fact that the extent of soil contamination has not been defined in the area of known groundwater contamination, additional investigation is recommended. The investigation should focus on the area near well cluster 1 (FTAW-1 and 1B) and analyses can be limited to volatile organics.

Upon definition of the extent of contamination, a quantitative risk assessment and feasibility study should be performed.

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