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REMEDIAL INVESTIGATION REPORT FOR SITE 1 – PRIVET ROAD COMPOUND NASJRB WILLOW GROVE, PENNSYLVANIA

Engineering Field Activity Northeast
Naval Facilities Engineering Command
Contract No. N62472-90-D-1298
Contract Task Order 277

July 2002

TETRA TECH NUS, INC.

REMEDIAL INVESTIGATION REPORT
FOR
SITE 1 – PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE,
PENNSYLVANIA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT

Submitted to:
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Environmental Branch, Code EV
Naval Facilities Engineering Command
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Contract No. N62472-90-D-1298
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EXECUTIVE SUMMARY

Tetra Tech NUS, Inc. (TtNUS) has prepared this Remedial Investigation Summary Report for the Naval Air Station Joint Reserve Base (NASJRB) Willow Grove under Contract N62472-90-D-1298 for the Comprehensive Long-Term Environmental Action Navy (CLEAN). This work is part of the Navy's Installation Restoration Program (IRP), which is designed to identify and characterize contamination of Navy and Marine Corps facilities resulting from past operations and to institute corrective measures as appropriate.

IRP activities are typically performed in four distinct phases. The first phase consists of a preliminary assessment (PA), and the second phase consists of a site inspection (SI). The third phase is a remedial investigation/feasibility study (RI/FS), which is intended to characterize the physical and chemical parameters and risks associated with the facility. The fourth phase, if required, may include remedial action that is designed to control and mitigate contamination.

The following summary provides conclusions and recommendations resulting from the Navy's investigation of conditions at the NASJRB Willow Grove Site 1 - Privet Road Compound Area environmental study site. Background historical and environmental setting information and a discussion of the process used to arrive at these conclusions and recommendations begin on page ES-2.

PURPOSE AND OBJECTIVES

The purpose of this report is to present the methods and results of the Phase II RI activities and subsequent investigations conducted at NASJRB Willow Grove Site 1. IRP Site 1 was previously investigated as part of the PA, SI, and RI processes. Initial Phase II RI field activities for all four sites were conducted from March through July 1997 in accordance with the Phase II RI Work Plan submitted by TtNUS in May 1997. The draft Phase II Report was submitted for review in April 1998. Informal comments from the United States Environmental Protection Agency (EPA) were addressed through a series of additional field investigations conducted from April 1998 through October 2000. This report combines the results from the draft Phase II report and previous findings for Site 1 with the results of the RI activities performed from April 1998 through October 2000.

The RI objective was to characterize the nature and extent of contaminants at Site 1 and gain additional understanding of the physical parameters affecting contaminant fate and transport. The results of the RI were then used to evaluate human health risk and ecological risk screening against current benchmark values and move into the feasibility study and/or remedial action phases of the RI program.

SITE LOCATION AND DESCRIPTION

Naval Air Station Joint Reserve Base, Willow Grove, Pennsylvania (formerly NAS, Willow Grove) is located in Horsham Township, Montgomery County in southeastern Pennsylvania, approximately 15 miles north of the city of Philadelphia (Figure ES-1). The base occupies approximately 1,000 acres of flat to slightly rolling terrain and is generally bounded by State Route 611 to the east, State Route 463 to the southwest, and Keith Valley Road to the north.

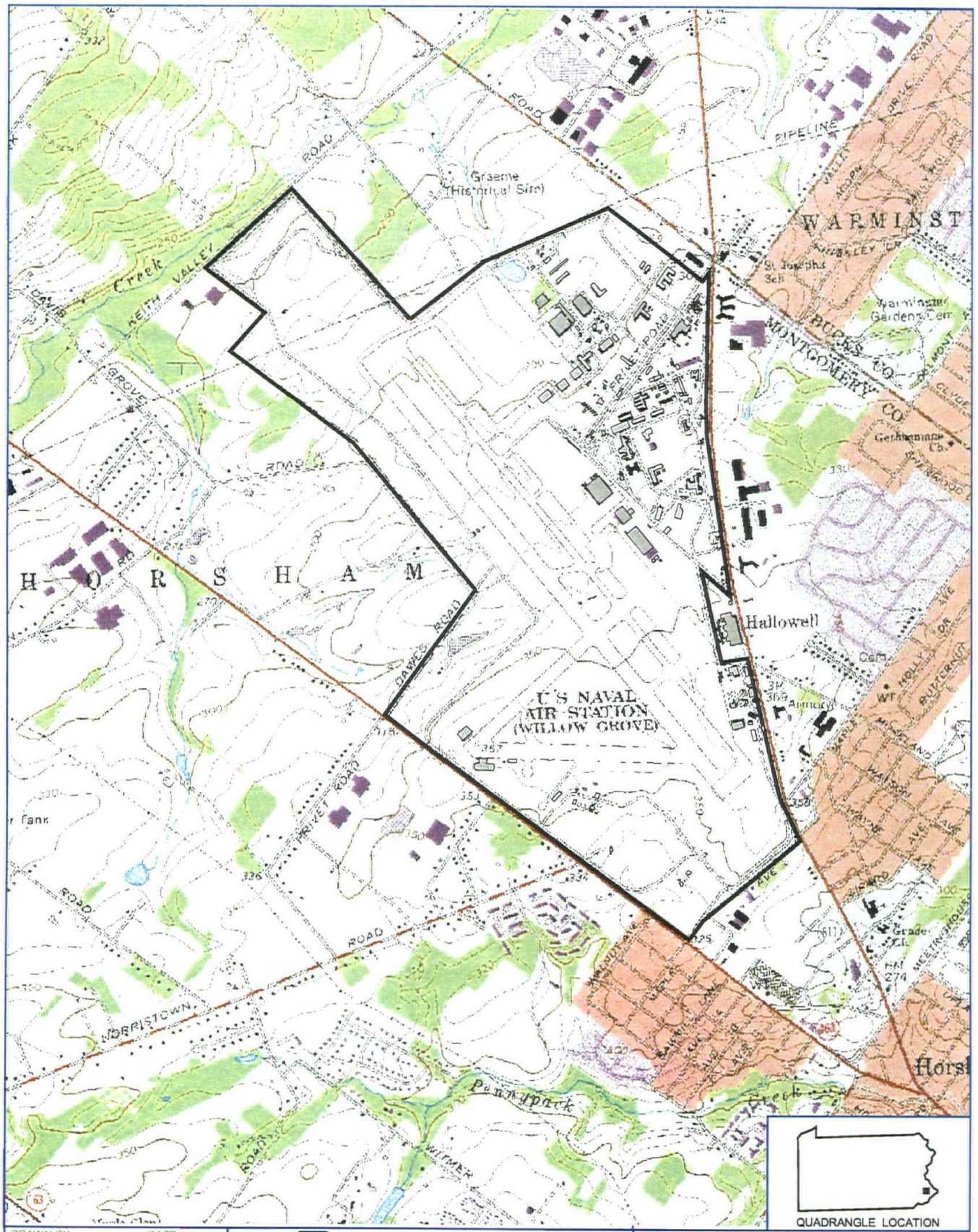
The primary mission of NASJRB Willow Grove is to provide support for operations involving aviation activities and to train Navy reservists. NASJRB Willow Grove supports other tenants such as the Marines, the Air Force, and the Army. The base provides facilities, services, materials, and training in direct support of all assigned units. These units include antisubmarine warfare squadrons, a helicopter squadron, a fleet logistic support squadron, and other Navy and Marine units. The Willow Grove Air Reserve Station (ARS) occupies approximately 162 acres of land in the northeastern section of the NASJRB and shares common facilities with the NASJRB.

Four sites are included within the scope of the IRP: two landfill areas [Antenna Field Landfill (Site 2) and Ninth Street Landfill (Site 3)], a waste transfer station [Privet Road Compound Site (Site 1)], and a former fire protection training area [Fire Training Area (Site 5)]. The relative locations of the sites are shown on Figure ES-2. Activities potentially resulting in site contamination occurred at different time periods between 1942 (the first Fire Training Area exercises) and 1975 (last use of Privet Road Compound).

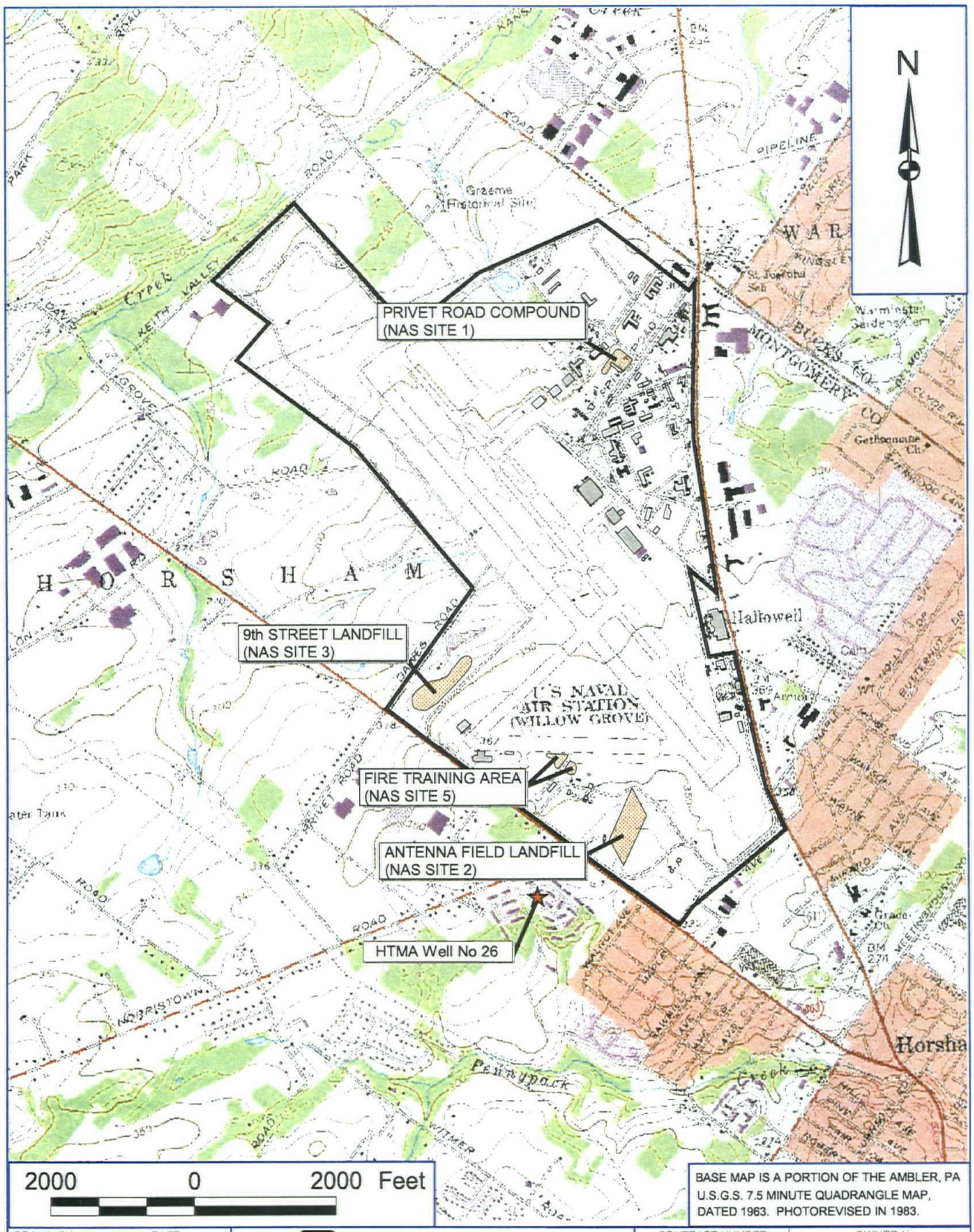
SITE 1 – THE PRIVET ROAD COMPOUND

The Privet Road Compound is a fenced area that is approximately ½ acre in size and is located west of Building No. 6. The compound was constructed to serve as a transfer station for wastes after closure of the Ninth Street Landfill (Site 3) in 1967. The compound operated between 1967 and 1975 and was used as an open disposal area where appreciable quantities of waste were burned and buried. The suspected waste-handling area extends beyond the limits of the fenced compound and covers more than 2 acres, including the present location of a bowling alley and parking area.

The Privet Road Compound lies within a heavily developed section of the NASJRB, adjacent to Privet Road and the Air Reserve and Pennsylvania National Guard facilities. The bowling alley and associated parking area cover a significant portion of the ground surface south of the compound. The compound area contains scattered piles of miscellaneous construction materials. The ground surface slopes at a grade of approximately two percent toward the northwest.



DRAWN BY LDL	DATE 4/26/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207 (RI SITE 1)
CHECKED BY	DATE	LOCATION MAP	DWG INFORMATION: NASJRB Willow Grove.apr Site 1 RI - FIG ES-1 LDL 4/26/02
COST/SCHEDULE-AREA		NASJRB WILLOW GROVE	APPROVED BY RET / DATE
SCALE AS NOTED		WILLOW GROVE, PENNSYLVANIA	DRAWING No. FIGURE ES-1 / REV



BASE MAP IS A PORTION OF THE AMBLER, PA U.S.G.S. 7.5 MINUTE QUADRANGLE MAP, DATED 1963. PHOTOREVISED IN 1983.

DRAWN BY LDL	DATE 4/26/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207
CHECKED BY	DATE	LOCATION OF RI SITES SITE 1 - PRIVET ROAD COMPOUND NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DWG INFORMATION: NASJRB Willow Grove.apr Site 1 RI - FIG ES-2 LDL 4/26/02
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING No. FIGURE ES-2 / REV

Topography and Surfac Water Hydrol gy

Although a significant portion of the ground surface in the area is covered by impermeable paving material, much of the precipitation during normal weather conditions is believed to infiltrate, due to the relatively gentle slope, intermittent vegetated areas, and the rutted and uneven nature of the ground surface in the compound area. Storm drainage swales parallel the northeastern and southeastern sides of the compound and intersect at the northern corner of the site. Runoff is prevented from entering the site from the south by grading and a storm drainage channel located along the southern side of Privet Road. Runoff from the compound that enters the drainage swales discharges to the Air Reserve Station stormwater detention basin. Water flow from the stormwater detention basin follows an unnamed tributary to Park Creek and enters the Little Neshaminy Creek drainage basin.

Groundwater Flow Patterns

The sandstones, shales, and conglomerates of the Triassic Basin are relatively good water-bearing formations. They generally yield abundant supplies to wells (Hall, 1934). The groundwater ranges from soft to hard, and the average hardness is greater than that of most other formations in southeastern Pennsylvania.

The major source of groundwater in the vicinity of NASJRB Willow Grove is the fractured bedrock of the Stockton Formation (Earth Data, Incorporated, 1985). These rocks form a multi-aquifer system of relatively discrete water-bearing zones separated by less permeable zones. Transmissivity and groundwater movement within water-bearing zones are greater parallel to bedding than across bedding. Groundwater can generally be found between 5 and 25 feet below ground surface (bgs).

Soils

Soils observed at the NASJRB Willow Grove during current and previous RI fieldwork ranged from 4 feet to more than 25 feet in thickness. Generally, the soils included brown, yellowish-brown, reddish-brown, and orange mixtures of silt, clay, and sand with finer-grained materials dominant.

The Soil Survey of Montgomery County (United States Department of Agriculture, 1967) indicates that five major soil series are mapped within the boundaries of the four RI sites. The soil series include the Lansdale, Lawrenceville, Chalfont, and Readington silt loams and the Lansdale loam. Minor areas of other soil series, composed chiefly of silt loam materials, are developed in small, low-lying areas. In general, these soils have a moderate to slow permeability that encourages rapid runoff during normal precipitation events.

Most of the soil within the boundaries of the air station has been disturbed. In addition, large areas have been filled with shale and sandstone with mixed earth materials. These soils, known as made land, vary widely in depth and drainage potential.

G logy

The geologic interpretation of the Privet Road Compound is based on the subsurface data (boring logs, geophysical logs, and test pits) obtained during site investigations. These data indicate that the local geology beneath this site is generally consistent with the regional geology.

NASJRB Willow Grove is located within the Triassic Basin of southeastern Pennsylvania. The bedrock underlying the NASJRB consists of the middle arkose member of the Late Triassic age Stockton Formation. The Stockton Formation locally is about 5,000 feet thick and is unconformably underlain by Ordovician to PreCambrian age basement rocks. Current and previous environmental investigations indicate that the top of bedrock at the air station is generally found in the range of 5 feet to 25 feet bgs.

Meteorology

NASJRB Willow Grove is located about 70 miles west of the Atlantic Ocean, which tends to have a moderating effect on temperatures. Normal minimum and maximum daily temperatures range from 24°F in February to 86°F in July. The average annual rainfall is 44.5 inches. The average annual snowfall is 21.5 inches. Precipitation is fairly evenly distributed throughout the year, with an increase in rainfall during the summer months. Average annual and extreme frost penetrations are 20 inches and 30 inches, respectively.

Mean annual relative humidity ranges from 54 percent in the early afternoon to 78 percent before dawn. The mean annual Class A Pan Evaporation is about 42 inches per year. The prevailing wind direction at the base is southwesterly during the summer and northwesterly during the winter. The mean annual wind speed and direction are approximately 9 miles per hour from the west-northwest.

Ec logy

The natural environment at NASJRB Willow Grove has been altered by development ever since the facility was first commissioned in 1942 as an airport. Buildings and paved roadways are concentrated mainly in the eastern portion of the facility. Due to the development on the base, the land has not retained a natural

vegetation cover. The vegetative communities that remain are limited and generally include lawn areas maintained by activity personnel, old field, immature forest, and wetland.

Except for old field scrub/shrub, maintained grassy field is probably the most common vegetative cover at the base. Most of this habitat is located west of the runways. Wooded areas occur mainly along the western boundary of the activity and serve as a buffer between the Air Station and residences along Route 463 and the neighboring golf course and commercial complex. Wetland habitat is rare within the base area. According to the National Wetlands Inventory map of this area (United States Department of Interior, undated), five wetlands exist on the base, but none is located at Site 1.

COMPARISON TO BACKGROUND

Compounds of potential concern (COPCs) are selected based on a series of statistical tests and comparison to background samples. Background samples were collected in and around NASJRB Willow Grove from media similar in characteristics to on-site samples but from areas outside the known or suspected areas of influence of the sites. Site sampling data were compared to background to determine if contaminants are elevated at a site.

COMPARISON TO ARARs and TBCs

All data were evaluated by comparison to Applicable or Relevant and Appropriate Requirements (ARARs) or criteria to be considered (TBCs). The following ARARs and TBCs were used in this evaluation:

- Surface and subsurface soils:
  - Risk-based concentration (RBC) for residential soil ingestion
  - RBC for industrial soil ingestion
  - Pennsylvania Department of Environmental Protection (PADEP) soil residential direct contact medium-specific concentration (MSC)
  - PADEP soil non-residential MSC

- Surface water:
  - Ambient Water Quality Criterion (AWQC) for freshwater aquatic life
  - AWQC for ingestion of water and fish
  - PADEP Water Quality Criteria (WQC); continuous concentrations
  - PADEP WQC; human health criteria

- Sediment:
  - Sediment ecological toxicity threshold values

- Groundwater:
  - Maximum Contaminant Level (MCL)
  - Drinking water health advisory
  - PADEP groundwater MSC
  - RBC for tap water consumption

HUMAN HEALTH RISK ASSESSMENT

The human health risk assessment was performed to estimate the actual or potential risks to human health resulting from the presence of contamination in surface soil, subsurface soil, sediment, groundwater, and surface water and to provide the basis for determining the need for remedial measures.

Three major aspects of chemical contamination must be considered when assessing public health risks: contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; potential exposure points must exist either at the source or via migration pathways if exposure occurs at a remote location other than the source; and human or environmental receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure; without any one of the three factors listed above, there is no risk.

The risk assessment estimated the potential for human health risk attributable to each NASJRB Willow Grove site. The risk assessment process used at NASJRB Willow Grove was in accordance with current EPA risk assessment guidance and was performed according to methods established in the NASJRB Willow Grove RI Work Plan (1997), which was reviewed and approved by EPA Region 3 and PADEP.

Potential Receptors

The receptors chosen for the sites at NASJRB Willow Grove are presented in this section. All the receptors listed below are applicable to every site because all selected media were sampled at each site. A full discussion of the assumptions and procedures used in human health risk assessment can be found in Section 3.1 of this report.

The current xposure scenarios that were applied are as follows:

- Occupational Worker - The full-time on-site worker is an adult who works at NASJRB Willow Grove year round. This receptor is potentially exposed to COPCs in surface soil via ingestion, dermal contact, and inhalation.

- Adolescent and Adult Trespasser - A trespasser is an adult or adolescent who trespasses at NASJRB Willow Grove. These receptors are potentially exposed to COPCs in surface soil via ingestion, dermal contact, and inhalation and to COPCs in surface water via ingestion and dermal contact. Cancer and non-cancer risks were estimated separately for adolescent and adult trespassers.

Future exposure scenarios are as follows:

- Future Excavation Worker - A future excavation worker is an adult who is assumed to work at NASJRB Willow Grove in the future during any type of excavation activity. This receptor is potentially exposed to COPCs in surface and subsurface soil via ingestion, dermal contact, and inhalation. Additionally, this receptor is potentially exposed to VOCs in shallow groundwater via inhalation.

- Future Resident - A future resident is a person who will live in a residence at or near NASJRB Willow Grove in a hypothetical future scenario. This receptor resides at a residence as a child (from age 0 to 6 years) and as an adult (for 24 years exposure duration). This receptor is potentially exposed to COPCs in groundwater via ingestion, dermal contact, and inhalation (adult resident only) and to COPCs in surface soil via ingestion, dermal contact, and inhalation. Non-cancer risks will be estimated separately for child and adult; cancer risks are considered cumulative (risks are summed over child and adult periods of exposure). Potential exposure to subsurface soils following real estate development will be discussed qualitatively.

- Future Child Recreational Receptor - A future recreational receptor is a child who participates in recreational activities at NASJRB Willow Grove in a hypothetical future scenario. This receptor is potentially exposed to surface soil via ingestion, dermal contact, and inhalation and to surface water and sediment via ingestion and dermal contact.

Exp sur Route by Medium

There are five environmental media at NASJRB Willow Grove through which potential receptors (see previous section) can be either directly or indirectly exposed to site-related COPCs: surface soil, subsurface soil, sediment, surface water, and groundwater. Potential exposure routes include ingestion, dermal contact, and inhalation.

ECOLOGICAL RISK ASSESSMENT

Ecological receptors at NASJRB Willow Grove may be at risk from contaminants associated with Site 1. Accordingly, an ecological risk assessment (ERA) was performed to characterize the potential risks from site-related contaminants to ecological receptors that inhabit the installation. The ERA was conducted following guidance recommended by EPA (1977) and the Department of the Navy (DON, 1999) and was based on laboratory analysis of surface water, sediments, and surface soil samples collected at the site. This section provides an outline of the approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment followed a two-step process, as follows:

Step 1: Preliminary Problem Formulation and Ecological Effects Evaluation

- Preliminary Problem Formulation - This first phase of an ERA discusses the goals, breadth, and focus of the assessment. It includes general descriptions of NASJRB Willow Grove sites, with emphasis on the habitats and ecological receptors that are present. This phase also involves characterization of site contaminants, contaminant sources, and migration routes and an evaluation of routes of contaminant exposure. Assessment and measurement endpoints that will be evaluated are also selected. Finally, a conceptual model is developed that describes how contaminants associated with Site 1 may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this component, medium-specific ecological benchmarks for each analyte (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. This step is undertaken concurrently with the exposure assessment, described below.

Step 2: Preliminary Exposure Assessment and Risk Characterization

- Preliminary Exposure Estimate - This portion of the ERA includes identification of contaminant concentration data used to represent ecological exposure in various media and the selection of exposure point concentrations from the data.

- Preliminary Risk Calculation - In this step, exposure point concentrations are compared to screening levels in order to characterize potential risks to ecological receptors of concern. Analytes found to pose potential risk after these comparisons are selected as ecological COPCs.

Due to the potential complexity of ERAs, they are usually conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs). SMDPs are meetings involving the risk managers and risk assessment team and are conducted to evaluate the work up to that point and to ensure that the ecological risk assessment is proceeding in an efficient manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met. The results are then used to identify the data required for the next tier, if necessary. The Tier 1 ERA is also known as a screening risk assessment. The screening risk assessment uses conservative (i.e., stringent) assumptions to evaluate site data and determine whether additional ecological risk assessment or accelerated site cleanup may be warranted or that the site poses negligible ecological risks.

The second tier is a baseline ERA (BERA), which is conducted if the results of the screening-level ERA indicate that additional study is warranted. The BERA comprises Steps 3 through 7 of the eight-step ERA process and is a more focused study of the initial COPCs. The beginning of the BERA also presents a more balanced evaluation of the conservativeness inherent in the first two steps of the ERA process (DON, 1999).

DISCUSSION OF RESULTS AT SITE 1 – THE PRIVET ROAD COMPOUND

Volatile organic compounds (VOCs) were detected in groundwater samples collected from monitoring wells surrounding the Privet Road Compound. The absence of VOC contamination in surface or subsurface soils indicates that the site itself is not a major source of the groundwater contamination at the present time. However, the complex hydrogeology and effect of intermittent pumping of the supply wells on groundwater flow make it difficult to identify the current source of VOC contamination.

Polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides were detected in on-site soils but were not expected to migrate significantly from the contaminated source. The

PCB-contaminated soil was removed by the Navy in 1999, further mitigating the potential for any of these compounds to migrate.

Metals were detected in site soils and in groundwater from monitoring wells surrounding the site. Metals are typically strongly adsorbed to soil materials in the environment, but many may be converted into soluble forms. Leaching of metals from the site to groundwater is a potential transport mechanism.

Consistent with EPA guidelines, the reasonable anticipated future land use exposure scenario is occupational worker. Under the current occupational worker exposure scenario, the human health risk assessment performed for Site 1 indicates cancer risk at the upper end of the EPA's acceptable risk range, largely for potential exposure to PCBs in site soils (now removed). Noncancer risks were below guid lines for the current occupational worker exposure scenario. The human health risk assessment and the ecological screening assessment found that the site does not pose a threat to current or reasonably anticipated future human and ecological receptors. However, several other historical issues or guidelines in law must be considered, as discussed below.

Human Health Risk Assessment

The total cumulative carcinogenic risk for the current occupational worker was equal to EPA's target cancer risk range at Site 1 for the reasonable maximum exposure (RME) scenario and within EPA's target cancer risk range for the central tendency exposure (CTE) scenario before the PCB-contaminated soil was removed in 1999. RME incorporates input parameters into the exposure scenarios that are protective of 90 or 95 percent of the population, and CTE incorporates input parameters that are representative of an average or median exposure scenario. The total cumulative carcinogenic risk for the future residential receptor exceeded EPA's target cancer risk range for the RME and CTE before the PCB-contaminated soil was removed in 1999. Removal of the PCB-contaminated soil at Site 1, the main contributor to cancer risk under these scenarios, virtually eliminated risk from soils to potential receptors.

Groundwater at Site 1 is currently used for human consumption (after VOC stripping tower treatment). The RME and CTE risks for groundwater consumption (untreated groundwater) for a future residential receptor are 4E-04 and 9E-05, respectively, both of which exceed or equal the EPA target cancer risk range of 1E-04 to 1E-06. Beryllium and arsenic are the main contributors to the RME and CTE groundwater carcinogenic risk at Site 1 for the future residential receptor. Iron is the main contributor in surface soils and manganese is the main contributor in groundwater to the RME and CTE noncarcinogenic risk (hazard index (HI) greater than 1.0; an HI is used to represent aggregate noncancer human health risk at a site) at Site 1 for the future residential child receptor. All other noncarcinogenic HIs

for the other potential receptors at Site 1 are less than 1.0. The history of Site 1 use as a waste transfer and handling station and for storage of PCB transformers is consistent with the COPCs found in soil media at the site.

Ecological Risk Assessment

Several inorganic and organic contaminants were present in Site 1 surface water, sediment, and surface soil samples at concentrations in excess of ecological screening levels and were, therefore, retained as preliminary contaminants of potential concern (PCOCs). Several other contaminants in all media assessed in this ERA were retained as PCOCs since no screening levels were available. However, almost all these contaminants were eliminated as COCs in the risk management phase of the assessment for one or more reasons, including low frequency of detection, maximum concentrations comparable to or below background (primarily inorganics), or alternative guidelines and spatial analysis of detections.

PCBs (now removed) were determined to be present at high enough concentrations in soils, with high frequencies of detection, to pose potential risks to terrestrial receptors. Therefore, PCBs were selected as COCs in soils. However, it does not appear that PCBs were migrating from Site 1 since they were not detected in downgradient sediment samples collected in the drainageways that collect runoff from the site. The site is located in a commercial-type area of the base; terrestrial habitat on the site is minimal and of poor quality; therefore, significant use of the site by ecological receptors is unlikely. Due to this combination of mitigating factors and the fact that PCB-contaminated soils have been removed, potential risks to terrestrial receptors from soil PCBs appear to be very low.

CONCLUSIONS

Soils

No further action for site soils is recommended.

The Navy performed a soil removal action for PCB-contaminated soils near the bowling alley located on the Privet Road Compound Area in June 1999. Appendix D contains the PCB soil removal summary report prepared for the Navy by Foster Wheeler Corporation. Potential risks to human and ecological receptors from PCB-contaminated soils at site were virtually eliminated by the Navy's removal action.

S diment and Surface Water

Compounds found in soils at Site 1 do not appear to be migrating from Site 1, since they were not detected in downgradient sediment or surface water samples collected in the drainageways that collect runoff from the site. Removal of PCB-containing soils in 1999 eliminated any possibility of future migration.

Groundwater

Concentrations of chlorinated VOCs were found in excess of the federal water quality standard for drinking water [Maximum Contaminant Levels (MCLs)]. The Navy operates two groundwater pumping w lls near Site 1 that supply air station potable water needs. The potable water supply system includes an air stripper to remove VOCs from the extracted groundwater. In effect, the Navy is performing de facto remediation of the groundwater in the area.

The Privet Road Compound is a probable minor historical contributing source to the VOCs in local groundwater. However, based on the finding of chlorinated VOCs in monitoring wells upgradient of Site 1, it does not appear to be the sole or major source. It is likely that additional historical sources of VOCs to groundwater exist upgradient of the Privet Road Compound, possibly in the vicinity of Building 78 (the current Public Works Building) and other candidate (including off station) source sites. Since the Privet Road Compound is not the sole source or a major contributor to chlorinated VOC contamination in the area (and because no concentrated source of VOCs has been found), further action regarding groundwater at the Site 1 area cannot be supported by known Privet Road Compound Site conditions.

The Navy may consider a plan to identify the other suspected on-station source or sources of chlorinated VOCs in groundwater in the area.

Additional groundwater investigations to further quantify the contribution from historical off-station source areas may be warranted, but would be the responsibility of others under the direction of the appropriate regulatory agency.

1.0 INTRODUCTION

TetraTech NUS, Inc. (TtNUS), formerly Brown & Root Environmental, submits this remedial investigation (RI) report for Installation Restoration Program Site 1 at the Naval Air Station Joint Reserve Base (NASJRB) Willow Grove in response to Contract Task Order No. 277 under Contract N62472-90-D-1298, Comprehensive Long-Term Environmental Action Navy (CLEAN). This work is part of the Navy's Installation Restoration Program (IRP), which is designed to identify and characterize contamination of Navy and Marine Corps facilities resulting from past operations and to institute corrective measures as appropriate.

IRP activities are typically performed in four distinct phases. The first phase consists of a preliminary assessment (PA), and the second phase consists of a site inspection (SI). The third phase is a remedial investigation/feasibility study (RI/FS), which is intended to characterize the physical and chemical parameters and risks associated with the facility. The fourth phase consists of remedial action that is designed to control and mitigate contamination. This report was prepared under Phase III IRP activities (RI/FS).

In addition to meeting the objectives of the Navy's IRP, the purpose of the RI is to meet the requirements of CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act of 1980), as amended by SARA (Superfund Amendments and Reauthorization Act of 1986). The RI investigates the nature and extent of contamination associated with all hazardous substance releases at the facility that are not regulated and are not being investigated under the authority of the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), or other federal statutes.

1.1 PURPOSE AND OBJECTIVES

The purpose of this report is to present the methods and results of the Phase II RI activities and subsequent investigations conducted at NASJRB Willow Grove Site 1. IRP Site 1 was previously investigated as part of the PA, SI, and RI processes. The first phase of RI activities was performed in 1991, and the final report was issued in February 1993. Initial Phase II RI field activities were conducted from March through July 1997 in accordance with the Phase II RI Work Plan submitted by TtNUS in May 1997. The draft Phase II Report, discussing results and analysis for all four IR sites, was submitted for review in April 1998. Informal comments from the United States Environmental Protection Agency (EPA) were addressed through a series of investigations for the four sites conducted from 1998 through 2000. This Site 1 report combines the results from the draft Phase II Report and previous findings for Site 1 with the results of the activities performed from April 1998 through October 2000.

The RI objective was to characterize the nature and extent of contaminants at Site 1 and gain additional understanding of the physical parameters affecting contaminant fate and transport. The results of the final RI report were used to evaluate human health risk and ecological risk screening against current benchmark values and move into the feasibility study and/or remedial action phases of the RI program.

1.2 SITE LOCATION AND DESCRIPTION

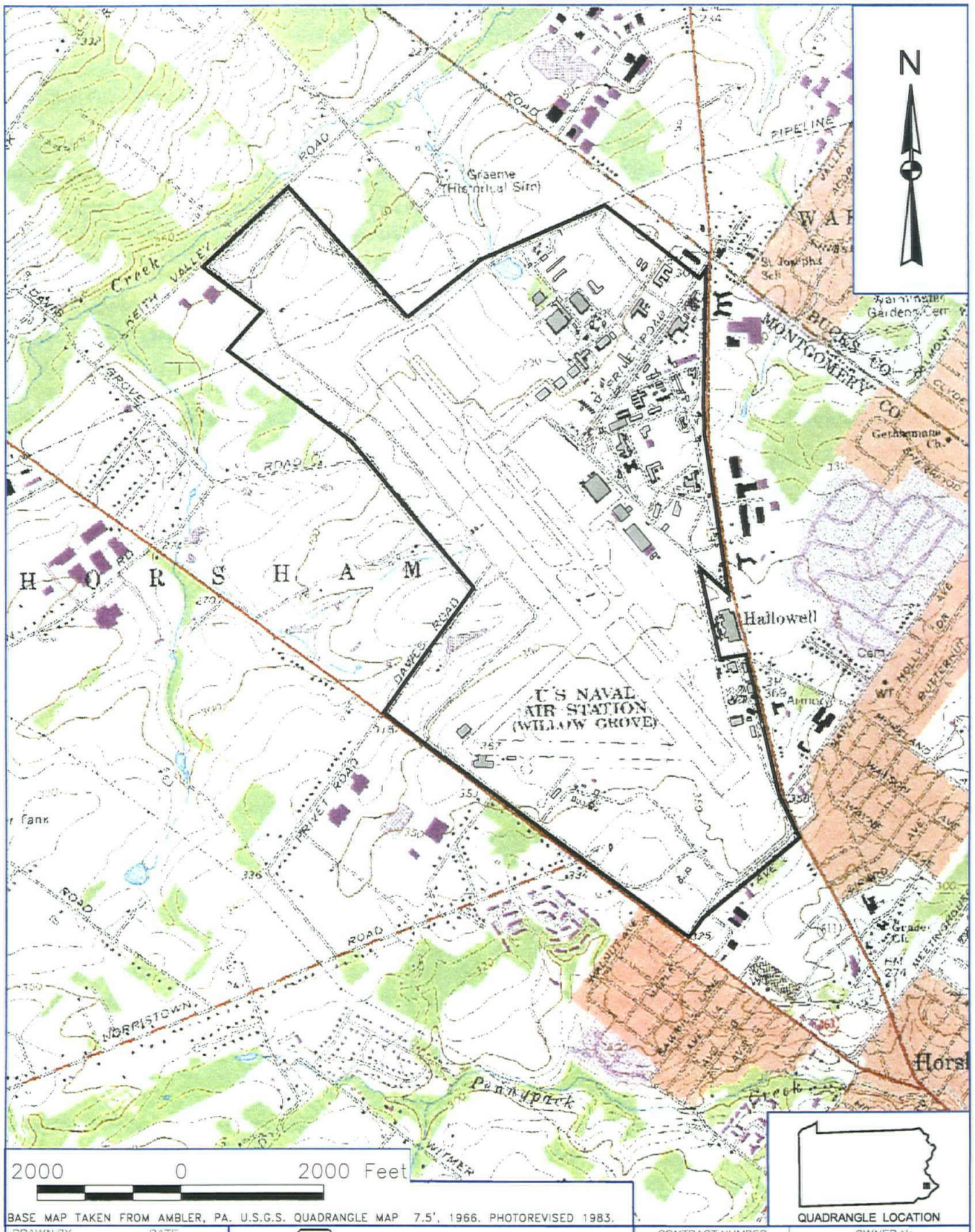
NASJRB Willow Grove, Pennsylvania (formerly NAS, Willow Grove) is located in Horsham Township, Montgomery County in southeastern Pennsylvania, approximately 15 miles north of the city of Philadelphia (Figure 1-1). The base occupies approximately 1,000 acres of flat to slightly rolling terrain and is generally bounded by State Route 611 to the east, State Route 463 to the southwest, and Keith Valley Road to the north.

The primary mission of NASJRB Willow Grove is to provide support for operations involving aviation activities and to train Navy reservists. NASJRB Willow Grove supports other tenants such as the Marines, the Air Force, and the Army. The base provides facilities, services, materials, and training in direct support of all assigned units. These units include antisubmarine warfare squadrons, a helicopter squadron, a fleet logistic support squadron, and other Navy and Marine units. The Willow Grove Air Reserve Station (ARS) occupies approximately 162 acres of land in the northeastern section of the NASJRB and shares common facilities with the NASJRB.

The four sites included within the scope of the IRP are two landfill areas [Antenna Field Landfill (Site 2) and Ninth Street Landfill (Site 3)], a waste transfer station [Privet Road Compound Site (Site 1)], and a former fire protection training area [Fire Training Area (Site 5)]. The relative locations of the sites are shown on Figure 1-2. Activities potentially resulting in site contamination occurred at different time periods between 1942 (the first Fire Training Area exercises) and 1975 (last use of Privet Road Compound). Descriptions of the Privet Road Compound - Site 1 are provided in Section 4.1.

1.3 PREVIOUS INVESTIGATIONS

Previous work at the NASJRB Willow Grove includes the PA, SI, and first phase of the RI. The PA, formerly identified as the Initial Assessment Study, identified 16 sites, seven at the Air Reserve Facility in 1984 and nine at the NAS in 1986. One additional site, the Navy Fuel Farm, was added to the program in 1988. SI work was performed at 12 of the 17 sites, and RI/FS activities have subsequently been completed or are underway at eight sites.



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CHECKED BY RET	DATE	LOCATION MAP NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DWG INFORMATION: NASJRB Willow Grove.apr Site 1 RI - FIG 1-1 LDL 4/30/02
COST/SCHEDULE-AREA			APPROVED BY RET / DATE
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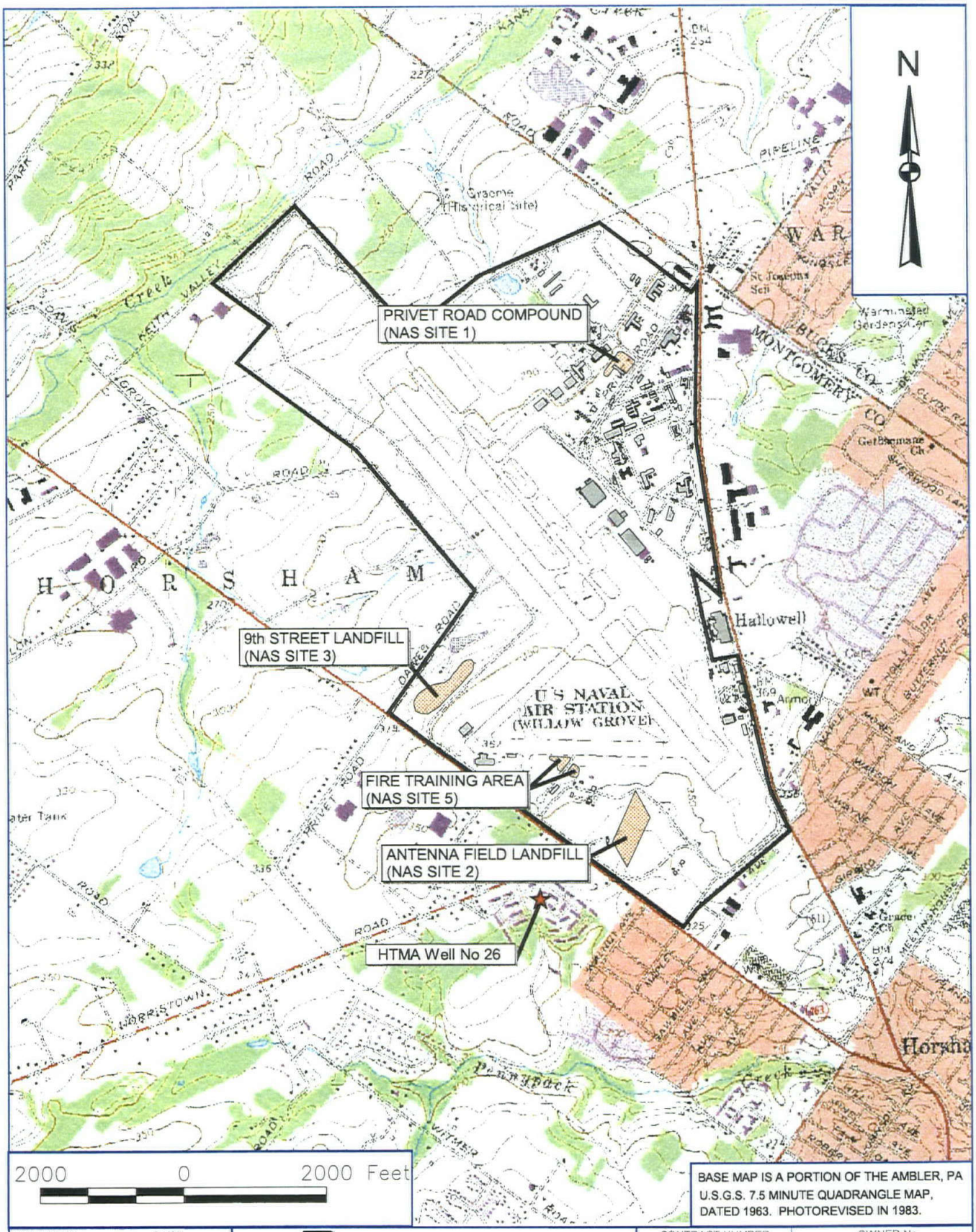


BASE MAP IS A PORTION OF THE AMBLER, PA U.S.G.S. 7.5 MINUTE QUADRANGLE MAP, DATED 1963. PHOTOREVISED IN 1983.

DRAWN BY LDL	DATE 4/26/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207
CHECKED BY	DATE	LOCATION OF RI SITES SITE 1 - PRIVET ROAD COMPOUND NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DWG INFORMATION: NASJRB Willow Grove.apr Site 1 RI - FIG 1-2 LDL 4/26/02
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING No. FIGURE 1-2 / REV

In addition, extended site inspections were performed at two sites, NAS Site 7 (Abandoned Rifle Range No. 2) and ARS Site 4 (Washrack Area). Work at three of the eight RI/FS sites was completed under a program managed by the Air Force. Phase I RI activities were completed for four of the remaining five RI/FS sites, and the results were reported in 1993 (HNUS, 1993). The Phase I RI characterized the physical and chemical nature of these four sites and identified data gaps requiring further study. Recommendations for further investigation included in the Phase I RI were incorporated into subsequent planning discussions for additional work and have led to the Phase II activities that are reported in the Phase II RI report.

After the Phase II RI report was submitted for comment, the Navy performed a soil removal action for polychlorinated biphenyl (PCB) contaminated soils at this site near the bowling alley located on the Privet Road Compound in June 1999. Appendix D contains the PCB soil removal summary report prepared for the Navy by Foster Wheeler Corporation.

1.4 POST-PHASE II RI INVESTIGATIONS

After the Phase II RI was submitted for regulatory review in April 1998, the Navy performed several activities related to remedial investigations at Site 1. Significant post-Phase II RI activities are listed here and are discussed elsewhere (mostly in Section 4) in this RI report for Site 1.

- PCB-contaminated soil removal (summary report in Appendix D).
- Long-term groundwater level measurements and groundwater quality investigations in the Navy production wells were led by the United States Geological Survey (USGS) for the Navy (summary report in Appendix O).
- Responses to comments on the Draft Phase II RI report (Appendix N).

1.5 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

The regional and general physical characteristics of NASJRB Willow Grove are described on the basis of published information, reports of previous site studies, and information obtained and interpreted during the course of the Phase II RI. Site-specific physical characteristics for the Site 1 are discussed in Section 4.

1.5.1 Meteorology

NASJRB Willow Grove is located about 70 miles west of the Atlantic Ocean, which tends to have a moderating effect on temperatures. Normal minimum and maximum daily temperatures range from 24° in February to 86°F in July.

The average annual rainfall is 44.5 inches. The average annual snowfall is 21.5 inches. Precipitation is fairly evenly distributed throughout the year, with an increase in rainfall during the summer months. Average annual and extreme frost penetrations are 20 inches and 30 inches, respectively.

Mean annual relative humidity ranges from 54 percent in the early afternoon to 78 percent before dawn. The mean annual Class A Pan Evaporation is about 42 inches per year.

The prevailing wind direction at the air station is southwesterly during the summer and northwesterly during the winter. The mean annual wind speed and direction are approximately 9 miles per hour from the west-northwest.

1.5.2 Topography and Surface Water Hydrology

NASJRB Willow Grove lies within the Triassic Lowlands Section of the Piedmont Physiographic Province. This section is characterized by rolling topography. Broad northeast-southwest-trending ridges in the area reflect resistant conglomeratic sandstone beds or diabase dikes. The base occupies a relative topographic high, which for the most part precludes surface water flow onto the facility from surrounding areas. Surface elevations range from a high of approximately 370 feet above mean sea level (MSL) in the vicinity of Taxiway Juliet to a low of approximately 240 feet above MSL in the northern portion of the base. Slopes are generally less than three percent. In areas where the land has been regraded, however, the slopes may be steeper.

NASJRB Willow Grove is situated within an upland area that forms a local drainage divide between the Little Neshaminy Creek drainage basin to the north and the Pennypack Creek drainage basin to the south. Both of these local drainage basins lie within the regional drainage basin of the Delaware River. Most of the activity drains toward the north through several unnamed ephemeral, intermittent, and perennial drainageways into Park Creek, which is a tributary of Little Neshaminy Creek. The extreme southern portion of the base, including the Antenna Field Landfill and a portion of the Fire Training Area, lies within the Pennypack Creek drainage basin.

There are reportedly no flowing or perennial streams within the base boundaries. During heavy rainfalls, very local flooding conditions are associated with various swales and man-made drainage ditches.

Runoff from surface areas is primarily channeled through open drainage swales and enclosed storm sewers to one of five primary outfall areas. Three of these outfalls drain to Park Creek. The fourth outfall is an intermittent stream that flows into Pennypack Creek. The fifth outfall is a direct connection to the Northern Storm Sewer System.

The receiving waters for stormwater runoff derived from the base are fished. The Pennsylvania Department of Environmental Protection (PADEP) designates Pennypack Creek as a warm-water fishery. Little Neshaminy Creek is stocked with trout.

1.5.3 Soils

Soils observed at NASJRB Willow Grove during current and previous RI fieldwork ranged from 4 feet to more than 15 feet in thickness. Generally, the soils included brown, yellowish-brown, reddish-brown, and orange mixtures of silt, clay, and sand with finer-grained materials dominant.

The Soil Survey of Montgomery County (United States Department of Agriculture, 1967) indicates that five major soil series are mapped within the boundaries of the four RI sites. The soil series include the Lansdale, Lawrenceville, Chalfont, and Readington silt loams and the Lansdale loam. Minor areas of other soil series, composed chiefly of silt loam materials, are developed in small, low-lying areas. In general, these soils have a moderate to slow permeability that encourages rapid runoff during normal precipitation events.

Most of the soil within the boundaries of the air station has been disturbed. In addition, large areas have been filled with shale and sandstone with mixed earth materials. These soils, known as made land, vary widely in depth and drainage potential.

1.5.4 Regional Geology

NASJRB Willow Grove is located within the Triassic Basin of southeastern Pennsylvania. The bedrock underlying the NASJRB consists of the middle arkose member of the Late Triassic age Stockton Formation. The Stockton Formation locally is about 5,000 feet thick and is unconformably underlain by Ordovician to PreCambrian age basement rocks. Current and previous environmental investigations indicate that the top of bedrock at the air station is generally found in the range of 5 feet to 25 feet below ground surface (bgs).

The Stockton Formation is composed of fine- to coarse-grained arkosic sandstones and conglomerates that are interbedded with finer grained shales and siltstones. These sediments were deposited by a series of coalescing alluvial fans that deposited materials eroded from highlands to the south (Sloto and Davis, 1983). Bedding is very irregular throughout the Stockton Formation, although coarse-grained units commonly overlie 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). Based principally on dominant grain size and lithology, the Stockton Formation is divided into lower, middle, and upper members.

Th middle member of the Stockton Formation is approximately 4,200 feet thick and consists of fine- to medium-grained arkosic sandstone interbedded with shale. Beds of shale and siltstone are common in the upper portion of the member, and coarser grained units are more common in the lower portion of the member. The rocks of the middle member are well sorted and weakly cemented, which creates a relatively high porosity compared to the lower and upper members of the formation (Rima et al., 1962). The middle member of the Stockton Formation typically weathers to a depth of 15 to 35 feet.

The lower member of the Stockton Formation is composed primarily of coarse-grained arkosic sandstone and conglomerate and, to a lesser extent, medium-grained arkosic sandstone. Locally, the lower member is less than 1,500 feet thick.

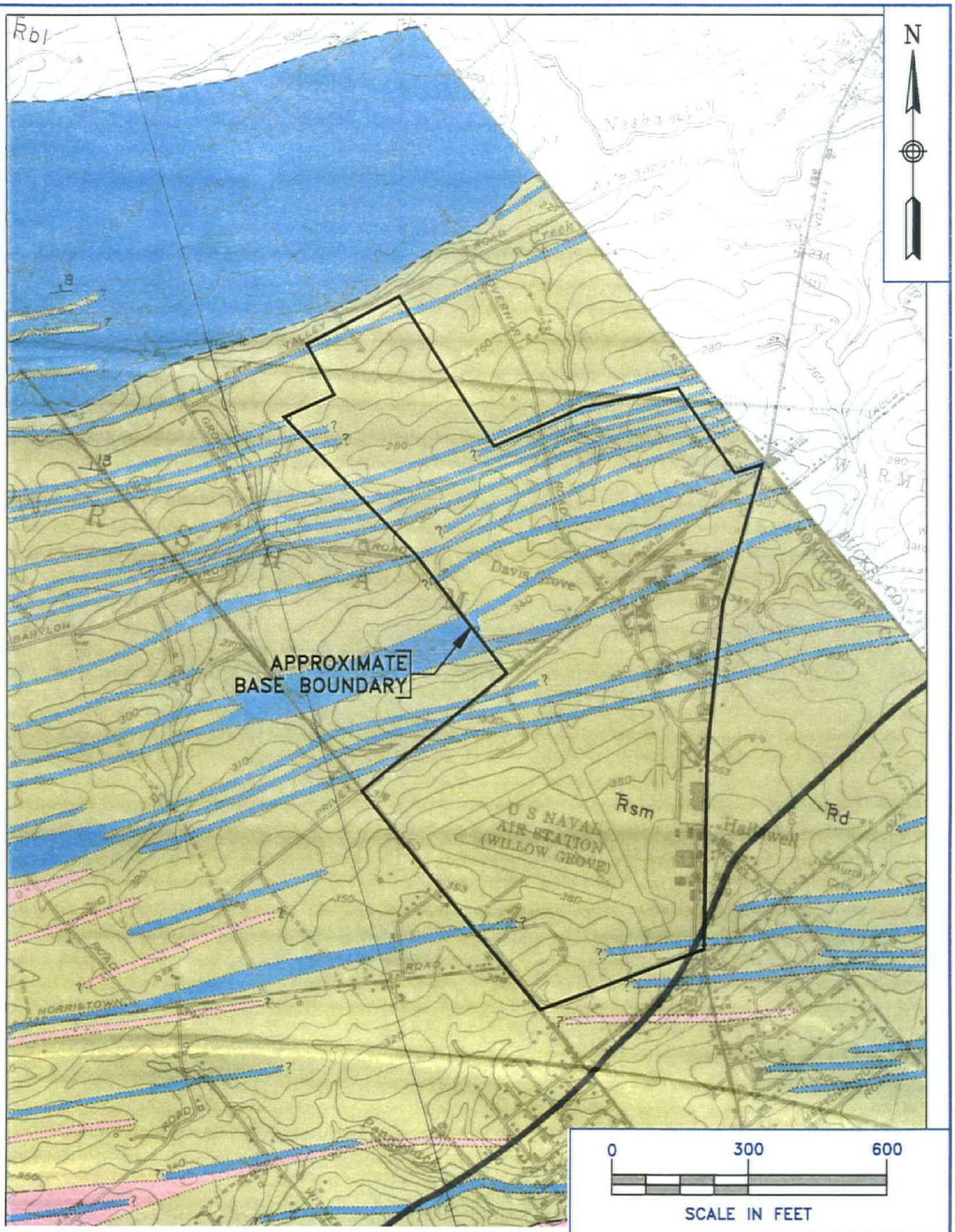
The upper member of the Stockton Formation is not present in the vicinity of NASJRB Willow Grove. The upper member is composed primarily of shale, siltstone, and fine-grained arkosic sandstone. In general, the grain size within this unit decreases in a stratigraphically upward direction, with the fine-grained sandstone occurring most commonly in the lower portion of the unit.

Regionally, the sedimentary beds of the Stockton Formation strike to the northeast and dip at an average rate of 12 degrees to the northwest. Based on subsurface correlations made during this current investigation, the bedrock strike was calculated to be N 76°E and the dip was calculated to be 7° to the northwest. At another government installation located approximately 3 miles northeast of the site, strikes ranging from north 64 degrees east to north 71 degrees east and dips ranging from 5 degrees to 9 degrees to the northwest were calculated from subsurface correlations of geophysical borehole logs for the middle member of the Stockton Formation (HNUS, 1995).

A northeast-southwest-trending, nearly vertical igneous diabase dike bisects the Stockton Formation and passes just south and east of the NASJRB Willow Grove boundary. The thickness of this dike is approximately 90 feet (Rima et al., 1962). Figure 1-3 is a general geological map of the NASJRB Willow Grove vicinity.

1.5.5 Regional Hydrogeology

The sandstones, shales, and conglomerates of the Triassic Basin are relatively good water-bearing formations. They generally yield abundant supplies to wells (Hall, 1934). The groundwater ranges from soft to hard, the average hardness is greater than that of most other formations in southeastern Pennsylvania.



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5466/SITE 1/5466gd101 RI FIG1-3 (Page1).dwg 4/26/02 LDL

5466/SITE 1/5466gd101 RI FIG1-3(Page1).dwg

TRIASSIC

UPPER TRIASSIC

Ŧd

Diabase
Not tapped by wells in this area.

Ŧbl

Brunswick and Lockatong formations, undifferentiated; gray to black, and red shale and sandstone; the water-bearing properties of these formations have not been studied for this report.

Stockton formation

Ŧsu

Upper shale member

Red shale and siltstone, containing beds of fine-grained arkosic sandstone (shown in brown); reported yields from wells in this member range from 10 to 80 gmp; average specific capacity of wells is 0.5 gpm per foot of drawdown.

Ŧsm

Middle arkose member

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

Ŧsl

Lower arkose member

Medium to coarse, coarse, and very coarse-grained arkosic sandstone and arkosic conglomerate, containing beds of fine- and meduim-grained arkosic sandstone (shown in brown) and red shale and siltstone (shown in blue); reported yields from wells in this member range from 10 to 500 gpm and average 110 gom; average specific capacity of wells is 3.0 gpm per foot of drawdown.

O€p€

Rocks of Ordovician to Precambrian age; these rocks have not been studied in this area.

DRAWN BY LDL DATE 4/26/02	Tetra Tech NUS, Inc.	GENERAL GEOLOGICAL MAP LEGEND OF SYMBOLS SITE 1 – PRIVET ROAD COMPOUND NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	CONTRACT NO. 5466
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REVISED BY DATE			APPROVED BY DATE
SCALE NONE			DRAWING NO. FIGURE 1-3 (PAGE 2) REV.

5466/SITE 1/5466gd102 RI FIG1-3(Page2).dwg 4/26/02 LDL

5466/SITE 1/5466gd102 RI FIG1-3(Page2).dwg

The major source of groundwater in the vicinity of NASJRB Willow Grove is the fractured bedrock of the Stockton Formation (Earth Data, Incorporated, 1985). These rocks form a multi-aquifer system of relatively discrete water-bearing zones separated by less permeable zones. Transmissivity and groundwater movement within water-bearing zones are greater parallel to bedding than across bedding. Groundwater can generally be found between 5 and 25 feet bgs.

Groundwater within the Stockton Formation locally occurs under both unconfined and confined conditions. The unconfined conditions generally extend to a subsurface depth of about 75 to 100 feet, depending on the local lithologies. Confined conditions are generally encountered below a depth of about 150 feet. A semi-confined or transitional aquifer lies between the unconfined and confined aquifers. Vertical or nearly vertical fractures that cut across bedding and the weathering of various beds are expected to permit varying degrees of leakage between individual water-bearing zones, particularly at shallower depths.

Although significant amounts of groundwater may be held in storage within the primary porosity of the fine- to medium-grained sandstones, groundwater migration is chiefly through the secondary porosity created by fractures and joints and along bedding-plane partings. The finer grained shale and siltstone beds typically have very low permeabilities. In addition, fractures and joints are typically not as well developed in these finer grained beds. Consequently, the shale and siltstone units often act as confining layers to groundwater flow.

Numerous private (residential) and municipal-type production wells supply water for domestic and commercial uses in the NASJRB Willow Grove vicinity.

1.5.6 Ecology

A detailed evaluation of the NASJRB Willow Grove biological features was conducted during the site investigation phase of the environmental activities for the base (EA, May 1990). Most of the following discussion is excerpted from the resulting report.

1.5.6.1 Ecosystems

The natural environment at NASJRB Willow Grove has been altered by development ever since the facility was first commissioned in 1942 as an airport. Buildings and paved roadways are concentrated mainly in the eastern portion of the facility. Due to the development on the base, the land has not retained a natural vegetation cover. The vegetative communities that remain are limited and generally include lawn areas maintained by activity personnel, old field, immature forest, and wetland.

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

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

Wetland habitat is rare within the base area. According to the National Wetlands Inventory map of this area (United States Department of Interior, undated), five wetlands exist on the base. An excavated pond, classified as a palustrine, open water, intermittently exposed wetland is located near the property boundary in the extreme northern portion of the base. The recreation pond at the picnic area is classified as a palustrine open water, intermittently exposed, impounded wetland. A small palustrine, scrub/shrub emergent wetland is located downstream of the recreational pond. The recreational pond and the nearby emergent wetland are located adjacent to the Ninth Street Landfill site. Two small ponds near the southeastern corner of the base are classified as palustrine, open water, intermittently exposed, excavated wetlands. Two small (man-made) ponds (approximately 80 feet long by 20 feet wide) are present at the central area of Site 5. These small ponds are not mapped as wetlands but have become established with marsh grasses and sedges. A larger (several acres) area of marsh habitat consisting mainly of sedges and bulrush occupies topographically low areas just north of the runway end zone. Many of these wetland grasses were planted by Air Station tenant personnel to attract waterfowl and have not been formally mapped as wetlands. This area is not located near any former waste disposal activities.

Wildlife species occurring at NASJRB Willow Grove are those that commonly occur near urbanized areas. Species observed, or reported to occur, include eastern cottontail (*Sylvilagus floridanus*), muskrat (*Ondatra zibethica*), raccoon (*Procyon lotor*), woodchuck (*Marmota monax*), eastern gray squirrel (*Sciurus carolinensis*), and white-tailed deer (*Odocoileus virginianus*). Pheasants (*Phasianus colchicum*) have been observed in the old field habitat. Canada geese (*Branta canadensis*) apparently nest within the Activity's boundaries. Mallards (*Anas platyrhynchos*) have been observed in the wetlands area downstream from the pond at the picnic area. Other observed bird species include robin (*Turdus migratorius*), starling (*Sturnus vulgaris*), mourning dove (*Zenaidura macroura*), wood thrush (*Hylocichla mustelina*), cardinal (*Cardinalis cardinalis*), mockingbird (*Mimus polyglottos*), sparrows, and numerous others.

Aquatic communities on the base occupy the two man-made impoundments at the recreational pond (near the Ninth Street Landfill) and the Building 114 pond. The aquatic community includes catfish, largemouth bass (*Micropterus salmoides*), and sunfish. Both ponds are reportedly available to base personnel for recreational fishing. The recreational pond has reportedly received contaminated runoff from spills related to aircraft accidents and firefighting. Fish kills have been reported in this pond. Frogs and insects inhabit the two small wet areas at Site 5 if the weather is rainy.

1.5.6.2 Endangered and Threatened Species

The Endangered Species Act of 1973, as amended, provides for the protection of endangered and threatened species. Government agencies are required to submit to the United States Fish and Wildlife Service any proposed actions that may jeopardize the continued existence of any species listed under the act as threatened or endangered. The peregrine falcon (*Falco peregrinus*), which is classified as endangered by the United States Fish and Wildlife Service, has been observed in the area, but it is considered to be a rare seasonal (March to November) transient. No other federally listed plants or animals are known to occur on the base. There are no known threatened or endangered plants or animals, as recognized by the Commonwealth of Pennsylvania under Chapter 147, Title 58, within the boundaries of the base.

1.6 QUALITY ASSURANCE/QUALITY CONTROL

The objective of the quality assurance/quality (QA/QC) process is to evaluate data quality of field quality control blanks, field duplicate precision, laboratory quality control analyses and precision, accuracy, representatives, comparability, and completeness (PARCC). Field sample results usability was determined by the process described below. As a result of this process, all field sample results have been rated as to data quality. The data usability qualifier (e.g., R - rejected or J - estimated) is included as a suffix to the numerical laboratory result in all data summary tables and the qualifier is explained in a footnote on the table.

1.6.1 Field Quality Control Blanks

Field quality control blanks are generally used to measure the success of the program in avoiding extraneous contamination during sample collection, storage, and transport. Field blanks serve to trace possible routes of contamination, including bottleware, sampling equipment, rinsate water, solvent vapors, and items (e.g., gloves) that may contact samples or sample containers. Field blanks were collected at

the frequencies specified in the work plan, following EPA Region 3 guidance. The following types of blanks were collected:

Fi ld Blanks

Field blanks were obtained to estimate incidental or accidental contamination from field sampling techniques and to determine if cross-contamination of samples had occurred. Field blanks were taken separately from each source of equipment decontamination water (potable water and bottled deionized water) and analyzed for the same suite of parameters as the environmental samples, in accordance with Navy Facilities Engineering Service Center (NFESC) guidelines.

Trip Blanks

Trip blanks were used to determine if contamination was introduced during sample storage and transport. Trip blanks remained with the sample containers in the field at all times, were returned unopened at the conclusion of each day's field activities, and were included in each cooler shipment of VOC samples sent to the laboratory. Trip blanks were analyzed for Target Compound List (TCL) VOCs only.

Rinsate Blanks

Equipment rinsate blanks were utilized to determine if contamination had been introduced through contact with the sampling equipment. Equipment rinsate blanks were prepared by running analyte-free water through sample collection equipment (bailer, split-spoon, hand auger bucket, etc.) after decontamination. Rinsate blanks were generated for each type of non-dedicated sampling equipment at the frequencies specified in the work plan. Equipment rinsate blanks were analyzed for the same suite of parameters as the associated environmental samples.

1.6.2 Discussion of Field Quality Control Blank Impact

Table 1-1 summarizes the frequency and concentration of contaminants detected in each type of field quality control blank collected during the 1997 RI. In nearly all cases, blank contamination occurred at very low frequencies and was restricted to concentration ranges near the detection or quantitation limits. During data validation, the concentrations of compounds detected in laboratory and field quality control blanks were compared to concentrations found in the corresponding environmental samples to determine potential impacts on the analytical data. Analytical results from environmental samples were qualified as potential artifacts attributable to blank contamination if the compound was not found at a concentration of

TABLE 1-1

SUMMARY OF FIELD QUALITY CONTROL BLANK RESULTS
NASJRB WILLOW GROVE, PENNSYLVANIA

Analytes	Rinsate Blanks		Field Blanks		Trip Blanks	
	Frequency of Detection	Maximum Concentration (ug/L)	Frequency of Detection	Maximum Concentration (ug/L)	Frequency of Detection	Maximum C ncentration (ug/L)
V latiles						
2-BUTANONE	1 / 25	13	0 / 6		0 / 26	
BROMODICHLOROMETHANE	0 / 25		1 / 6	1	0 / 26	
BROMOFORM	0 / 25		2 / 6	8	0 / 26	
CHLOROFORM	0 / 25		0 / 6		1 / 26	2
DIBROMOCHLOROMETHANE	0 / 25		2 / 6	5	0 / 26	
METHYLENE CHLORIDE	4 / 10	20	1 / 2	16	3 / 9	14
Semivolatiles						
BIS(2-ETHYLHEXYL)PHTHALATE	3 / 23	4	1 / 8	13		N/A
DI-N-BUTYLPHTHALATE	4 / 21	2	1 / 8	1		N/A
DIETHYLPHTHALATE	6 / 23	10	1 / 8	6		N/A
PHENOL	1 / 23	1	0 / 8			N/A
Pesticides/PCBs						
None Detected						N/A
Dioxins/Furans						
1,2,3,4,6,7,8-HPCDD	0 / 3		1 / 2	0.0000807		N/A
1,2,3,4,6,7,8-HPCDF	0 / 3		1 / 2	0.0000416		N/A
1,2,3,6,7,8-HXCDD	0 / 3		1 / 2	0.000006		N/A
1,2,3,7,8,9-HXCDD	0 / 3		1 / 2	0.0000065		N/A
OCDD	0 / 3		1 / 1	0.00111		N/A
OCDF	0 / 3		1 / 1	0.000102		N/A
TCDD TOXICITY EQUIVALENTS		0.00000035	2 / 2	0.00000438		N/A
TOTAL HPCDD	0 / 3		1 / 2	0.0000807		N/A
TOTAL HPCDF	0 / 3		1 / 2	0.000103		N/A
TOTAL HXCDD	0 / 3		1 / 2	0.0000279		N/A
TOTAL HXCDF			1 / 2	0.0000442		N/A
Metals						
ALUMINUM	0 / 19		1 / 5	407		N/A
ARSENIC	0 / 22		2 / 7	2.9		N/A
BARIUM	0 / 22		2 / 7	225		N/A
CADMIUM	1 / 22	6.5	0 / 7			N/A
CALCIUM	6 / 22		2 / 7	77200		
COPPER	0 / 22	739	1 / 7	12.9		N/A
IRON	0 / 22		3 / 7	2900		N/A
LEAD	11 / 22	8.2	4 / 7	9.2		N/A
MAGNESIUM	0 / 22		2 / 7	23600		N/A
MANGANESE	0 / 22		2 / 7	27.1		N/A
POTASSIUM	0 / 22		1 / 7	1910		N/A
SODIUM	0 / 22		2 / 7	15900		N/A
ZINC	7 / 22	20	2 / 6	89.4		N/A
Miscellaneous Parameters						
DIESEL RANGE ORGANICS			0 / 1			N/A
GASOLINE RANGE ORGANICS			0 / 1			N/A

Frequency of detection refers to number of times compound was detected among all samples versus total number of samples. Number of samples may vary based on the number of usable results.

at least five times (10 times for certain common laboratory contaminants) the concentration in the associated blank.

Metals and trihalomethanes detected in the potable water source (local tap water) field blank included aluminum, calcium, iron, magnesium, sodium, zinc, bromoform, bromodichloromethane, and dibromochloromethane, among other compounds. The detected metals are common "hard water" contaminants and the trihalomethanes are common by-products from disinfection water treatment.

Calcium and zinc are elements found naturally in soils and sediments and in the potable water used in the first step of equipment decontamination. Therefore, it cannot be determined whether detection of these elements is associated with the first-step cleaning solution (potable water) or with residual soil materials left after completion of decontamination.

Methylene chloride was detected in several trip blanks and rinsate blanks at concentrations below or near the contract-required quantitation limit (CRQL). This compound is a common laboratory contaminant and was detected more frequently in laboratory blanks than in field quality control blanks. This caused many of the positive field quality control blank results for methylene chloride to be qualified as not detected due to laboratory blank contamination. The positive results in Table 1-1 represent only those compounds remaining after data validation. Methylene chloride was not used in the field; therefore, laboratory sources are likely to be responsible for the sporadic detection of low levels of this compound in field quality control blanks.

1.6.3 Field Duplicate Precision

Field duplicate pairs were analyzed in order to assess the overall precision of the sampling and analysis process. Field duplicate pairs consisted of two field samples of identical media sampled at the same field location using the same sampling process. Duplicate pairs were stored and transported together to the laboratory for analyses. The relative percent differences (RPDs) for the duplicate pairs were calculated and reported by the laboratory and evaluated by the data validator in order to quantitate any imprecision. In general, the majority of the field duplicate results exhibited acceptable precision and there were no consistent trends to indicate improper sampling technique.

1.6.4 Laboratory Quality Control Analyses

Laboratory quality control samples were analyzed as required by each specific analytical protocol and NFESC requirements. Quality control data from organic analyses included laboratory blank results, surrogate, matrix spike, and matrix spike duplicate recoveries, internal standard recoveries, initial

calibration relative standard deviations and minimum response factors, continuing calibration percent differences and response factors, laboratory control spikes, mass spectral tuning ratios, clean-up column recoveries, pesticide performance evaluation recoveries, pesticide analyte degradation percentages, and compound identification criteria (mass ratios, retention time windows, and two-column percent differences). In general, the frequency of analytical problems in each of these areas was very low and indicated overall acceptable method performance for each type of analysis.

Organic analysis laboratory blanks revealed limited contamination, with low concentrations (near or below the CRQL) of common laboratory contaminants such as methylene chloride, acetone, 2-butanone, and selected phthalate esters. Sample-matrix-related interferences caused high percent differences for a few pesticide results, resulting in data qualified as estimated based upon validation protocols. A limited number of volatile and semivolatile results were qualified as estimated based upon calibration relative standard deviations or percent differences. Several semivolatile soil sample results were qualified as estimated due to slightly exceeded holding times [greater than the 7-day allowance per regional data validation guidelines but within Contract Laboratory Program (CLP) method-specified contractual holding times]. In a few cases, sample matrix effects may have caused low or high internal standard, matrix spike, or surrogate recoveries, which led to the qualification of results as estimated or biased low. Where required, such samples were reanalyzed according to the analytical protocol.

Quality control data from inorganic analyses included laboratory blank results, matrix spike recoveries, laboratory duplicate RPDs, serial dilution percent differences, initial calibration, continuing calibration, and CRDL standard percent accuracy, laboratory control sample recoveries, and interference check standard accuracy.

The frequency of analytical problems in each of these areas was low and indicated overall acceptable method performance for each type of analysis. Inorganic analysis laboratory blanks revealed low frequencies of contamination, generally restricted to concentrations below the CRDL, that affect data qualification but do not require sample reanalysis based on EPA protocols. Several matrix spike or post-digestion spike recoveries were below or above quality control (QC) limits and resulted in the qualification of data as biased low or biased high, respectively. These problems are typically attributed to sample matrix interference effects caused by other substances in the sample. A few results were qualified as estimated or biased because of laboratory duplicate imprecision or CRDL standard recoveries above or below control limits. Very few problems occurred in other areas.

1.6.5 Parameters

The quality of the data set is measured by certain characteristics of the data, namely the PARCC parameters. Precision and accuracy are expressed quantitatively, and the others are expressed qualitatively.

Precision

Pr cision characterizes the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for a sample under the same or similar conditions. Precision is expressed as a range (the difference between two measurements of the same parameter) or as an RPD (the range relative to the mean, expressed as a percent). Precision is measured quantitatively. Range and RPD values are calculated as follows:

$$\text{Range} = OR - DR$$

$$RPD = (OR - DR) / [\,(OR + DR) / 2\,] \times 100\%$$

where: OR = original sample result
DR = duplicate sample result

RPD values are calculated for matrix spike duplicates, laboratory duplicates, and field duplicates and are compared to the control limits as a quality assurance (QA) check. Data validation field duplicate results associated with this RI are discussed in Section 1.5.3.

Accuracy

Accuracy is the comparison between experimental and known or calculated values expressed as a percent recovery (%R). Percent recoveries are derived from analysis of standards spiked into deionized water (standard recovery) or into actual samples (matrix spike or surrogate spike. recovery). Recovery is calculated as follows:

For a surrogate spike or laboratory control spike or standard

$$\%R = E / T \times 100\%$$

where: E = experimental result

T = true value (theoretical result)

For a sample matrix spike

$$\%R = (SSR - SR) / SA \times 100\%$$

where: SSR = sample spike result

SR = sample result (unspiked)

SA = spike concentration added

and

SA = (spike aliquot)(spike concentration)/(sample aliquot + spike aliquot)

Accuracy for aqueous and solid samples was evaluated by use of surrogate and matrix spikes at the CLP-required frequencies. CLP acceptance criteria and corrective actions were applied. Out-of-criteria results were reviewed during EPA data validation to determine the need for qualification or rejection.

R presentativeness

All obtained data should be representative of actual conditions at the sampling location. The work plan was designed so that the samples present an accurate representation of actual site conditions. The rationale discussed in the work plan was designed to ensure this. All sampling activities conformed to the protocols specified in the work plan. The use of CLP analytical protocols and data deliverables ensured that analytical procedures were consistently performed to generate results that are considered representative.

The use of low-flow dedicated sampling pumps in conjunction with monitoring of turbidity and other parameters ensured that monitoring well data were as representative of the formation as possible. Despite efforts such as installation of dedicated low-flow bladder pumps and adherence to the low-flow sampling procedure, in a few instances, low turbidity samples could not be collected. Where use of the low-flow purge method did not result in stabilized turbidity readings, filtered samples were also obtained from the same location. In addition, sample filtration was required for all older monitoring wells that did not possess dedicated low-flow sampling pumps. Filtered and unfiltered metals results were then compared to achieve a more accurate perspective of contaminant fate and transport.

Comparability

Comparability is achieved by using standardized sampling and analysis methods and data reporting procedures. The use of standard analytical procedures and sample collection techniques throughout all sampling rounds maximized the comparability of all Willow Grove data. Additionally, consideration was given to field environmental conditions that could influence analytical results.

Completeness

Completeness is a measure of the amount of valid data obtained from the measurement program, compared to the total amount collected. For relatively clean, homogeneous matrices, 100 percent completeness is expected. However, as matrix complexity and heterogeneity increase, completeness may decrease. Where analysis is precluded or where data quality objectives (DQOs) are compromised, effects on the overall investigation must be considered. Whether any particular sample is critical to the investigation is evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

Critical data points were not evaluated until all the analytical results were evaluated. If, in the evaluation of results, it becomes apparent that the data for a specific medium are of insufficient quality (for example, completeness less than 95 percent), either with respect to the number of samples or an individual analysis, resampling of the deficient data point(s) may be necessary. The site- and medium-specific completeness percentages are summarized in Table 1-2. The overall percentages of rejected data points in Table 1-2 were generally low and within acceptable ranges. In the 1997 RI, most of the rejected data were attributed to inductively coupled plasma (ICP) spectral interference (antimony), low CRDL standard recoveries (selenium), or very low surrogate recoveries in one pesticide analysis.

Sample matrix effects may be the cause of the very low pesticide recoveries, which affect the ability of the analysis to successfully detect pesticides in one soil sample. Low CRDL standard recoveries occurred for selenium and triggered the rejection of 14 non-detected soil results in one sample delivery group. The analysis may not have been capable of detecting selenium in these cases.

False positive results may have occurred with 60 sample results for antimony, based on its detection in several associated QC runs in which antimony should have been non-detected [Interference Check Standard (ICS) Mix A]. This problem indicates that the ICP spectrometer was not properly correcting for signal bias with antimony, caused by the spectral overlap from higher concentrations of common minerals, and that samples containing moderate levels of minerals may present results for antimony that appear to be positive but are actually artifacts.

TABLE 1-2

SUMMARY OF REJECTED DATA
NASJRB WILLOW GROVE, PENNSYLVANIA

SITE NUMBER	Monitoring Wells			Subsurface Soil			Surface Soil			Surface Water			Sediment		
	No. of Rejected Results	Total No. of Results	Percent Rejected Data	No. of Rejected Results	Total No. of Results	Percent Rejected Data	No. of Rejected Results	Total No. of Results	Percent Rejected Data	No. of Rejected Results	Total No. of Results	Percent Rejected Data	No. of Rejected Results	Total No. of Results	Percent Rejected Data
01	16	2910	0.55	71	8030	0.88	0	393	0	0	425	0	0	900	0
02	1	1575	0.06	51	6012	0.85	0	2398	0	2	2683	0.08	0	3135	0
03	8	5080	0.16	0	1200	0	28	4110	0.68	0	1047	0	0	1350	0
04	0	3865	0	6	4048	0.15	11	1426	0.77	0	447	0	0	450	0
12	0	760	0	1	894	0.11	0	447	0	-	-	-	-	-	-
Backgr und Areas	-	-	-	-	-	-	10	1508	0.66	0	1341	0	3	1341	0.22

The selenium CRDL recoveries and ICS results for analytes that are supposed to be absent from Mix A are advisory QC criteria that do not require mandatory action according to CLP protocol; however, both problems are related to laboratory performance and not sample matrix effects.

2.0 FIELD INVESTIGATION

The Phase II field investigation consisted of the initial activities completed in 1997 and follow-on activities at Site 1 completed in 1998 through 2000. The initial field investigation activities were performed between March 3 and July 15, 1997. A second round of groundwater-level measurements was performed on August 7, 1997. The follow-on investigation activities were performed between May 1998 and October 2000. The initial Phase II RI field activities and the May 1998 follow-on activities were conducted in accordance with the final Phase II RI Work Plan submitted by TtNUS in May 1997. After the Phase II RI report for all four sites was submitted in April 1998, three initiatives were carried out. The Navy performed a PCB-contaminated soil removal action (Appendix D). The USGS collected aquifer test data, interpreted geophysical logs, and evaluated groundwater quality in the two Navy supply wells through its Interagency Agreement with the Navy (Appendix O). The Navy also performed a variety of investigation tasks suggested by regulatory agency or Restoration Advisory Board (RAB) member comments (Appendix N). The details of these post-Phase II RI investigation tasks that were performed are discussed in Section 4.

2.1 SUMMARY OF ACTIVITIES

The initial field activities performed in 1997 to support the Phase II investigation conducted at Sites 1, 2, 3 and 5 included the following:

- Drilling and installation of 30 monitoring wells. Seven wells each were installed at Site 1 and Site 3, five wells were installed at Site 2, and 11 wells were installed at Site 5 (Section 2.1.7.1).

- Geophysical logging of all newly drilled boreholes and one existing borehole.

- Measurement of static water levels in the new wells and existing wells at each site (Section 2.1.8.4) and a long-term water-level study at Site 1 (Section 2.1.7.3).

- Collection of groundwater samples for laboratory analysis from 67 wells, including 28 of the newly installed monitoring wells (Section 2.1.7.2). Samples from Sites 2, 3, and 5 were analyzed for Target Compound List (TCL) VOCs, TCL semivolatile organic compounds (SVOCs), polychorinated biphenyl (PCB)/pesticides, Target Analyte List (TAL) inorganics, and cyanide. Samples from Site 1 were analyzed for TCL VOCs only. Samples were submitted to Applied Research and Development Laboratory (ARDL) in Mount Vermon, Illinois.

- Sampling and analysis of surface soils from each RI site (88 locations total) and 12 NASJRB background locations away from the investigation sites (Section 2.1.1). Samples were submitted to

ARDL for various TCL and TAL analyses, depending on site data requirements and specific locations. Samples from each site were submitted to Triangle Laboratories, Incorporated, of Durham, North Carolina, for dioxin analysis. Selected surface soil samples from Site 1 and Site 5 were analyzed in the field for PCBs using a field kit immunoassay procedure.

- Sampling and analysis of subsurface soils at 43 locations from Sites 1, 3, and 5 (Section 2.1.2). Samples were submitted to Triangle Laboratories for dioxin and to ARDL for various TCL and TAL analysis. Selected subsurface soil samples from Site 1 and Site 5 were analyzed in the field for PCBs using a field kit immunoassay procedure.

- Excavation of nine test pits at Site 2 (Section 2.1.2.2). Forty subsurface samples of landfill material and/or soil were collected and submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide analysis. Two of these samples were analyzed for dioxin.

- Sampling of surface water at two locations each at Sites 2, 3, and 5 to obtain water-quality data (Section 2.1.4). Nine surface water samples were collected at off-base locations to provide baseline background water-quality data. Samples were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide analysis.

- Sampling of sediments at the same locations as surface water for Sites 2, 3, 5, and off-base background. An additional Site 3 sediment sample was collected upgradient of a Phase I RI sediment location. These samples and one sediment sample from Site 1 were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, cyanide, total organic carbon (TOC), and grain size analysis. Five sediment samples were collected at Site 1 from five of the locations sampled in the Phase I RI and submitted to ARDL for TCL SVOCs, TOC, and grain size analysis.

- Sampling of seep areas at Site 2 (aqueous and solid phases) and submission to ARDL for analysis (Section 2.1.6). Seep water and sediments were analyzed for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide. Sediments were also analyzed for TOC and grain size.

- Repair on three artesian wells at Site 3 to stop groundwater from continually flowing.

- Surveying of the horizontal locations and the vertical elevations of newly installed monitoring wells and at locations of surface soil, subsurface soil, sediment, and seep samples and test pit locations (Section 2.1.8).

- Sampling and disposal of investigation-derived waste (IDW) (Section 2.1.9).

Follow-on activities performed in 1998 through 2000 to support the Phase II investigation at Site 1 or to reply to regulatory agency or other comments are discussed in Section 4 :

- Removal of PCB-contaminated soils near the bowling alley (Appendix D)
- Hydrogeological studies in the Navy supply wells (Appendix O)
- Responses to comments on the Phase II RI report (Appendix N)

2.1.1 Surface Soil Investigation

Surface soil samples were obtained from 88 locations (28 sampling locations at Site 1) during the Phase II RI in 1997. No surface soil samples were obtained during the follow-on field activities in 2000. A summary of the surface soil samples collected during the Phase II RI is presented in Table 2-1. A TtNUS geologist sampled by digging 0 to 6 inches bgs with a stainless-steel trowel and placing soil directly into a laboratory-provided sample jar.

Thirteen background surface soil samples were collected at 12 on-base locations. A minimum of three samples were collected from each of the four major soil series mapped within the base, as specified in the Phase II RI work plan. The background soil samples were collected away from known or suspected waste-handling or waste disposal sites. The approximate locations of the soil samples are presented in Section 2.3. Each background sample was analyzed for TCL SVOCs, PCB/pesticides, TAL inorganics, and cyanide (see Table 2-1).

2.1.2 Subsurface Soil Investigation

2.1.2.1 Soil Borings

Subsurface soil samples were collected at Site 1, Site 3, and Site 5 during the 1997 field activities. No subsurface soil samples were collected during the follow-on activities. Soil borings were drilled by hollow-stem auger at 22 locations (seven soil borings at Site 1) using truck-mounted drilling equipment and at 21 locations (all at Site 1) using hand-auger boring techniques. The subsurface soil sampling program is summarized in Table 2-2.

Soil borings were drilled by Advanced Drilling, Incorporated, of Washington, New Jersey. The proposed locations for drilling were cleared for potential underground obstructions by the Navy and local utility companies before each boring was begun. A GEFCO Stratastar-15 drill rig with 4-1/4-inch inner-diameter (ID) augers was used to drill the borings. Each boring was sampled continuously with a split-spoon sampler

TABLE 2-1

SURFACE SOIL SAMPLING SUMMARY
NASJRB WILLOW GROVE, PENNSYLVANIA

Site	Number of Surface Soil Sample Locations	Number of Environmental Surface Soil Samples[1]	Analytical Parameters
1	28	26	PCBs (Field kit immunoassay)
		4	TCL semivolatiles
		3	Dioxin
		1	TCL PCBs
2	18	20	TAL metals, TCL semivolatiles, TCL pesticides/PCBs, and Cyanide.
		3	Dioxin
3	12	13	TAL metals, TCL semivolatiles, TCL pesticides/PCBs, and Cyanide.
		2	Dioxin
5	18	15	TAL metals, TCL semivolatiles, and Cyanide.
		13	PCBs (Field Kit Immunoassay).
		4	TCL PCBs
		2	Dioxin
Background	12	13	TAL metals, TCL semivolatiles, TCL pesticides/PCBs, and Cyanide.

[1] Includes field duplicates.

in accordance with American Society for the Testing of Materials (ASTM) D 1586-84 from the ground surface to the top of bedrock or split-spoon refusal. The augers were advanced after each sample was taken, and a center plug was used during advancement of the augers. Two of the boreholes (03SB01 and 05SB30) were drilled and sampled using a Stratastar-25 drill rig with 2-1/4-inch ID augers.

All drilling activities and soil sampling activities were supervised, logged, and recorded by a TtNUS field geologist. A lithologic description of each sample was recorded on each boring log in accordance with TtNUS standard operating procedure (SOP) GH-1.5 (Appendix D of the Phase II RI work plan). The boring logs are included in Appendix B of the Phase II RI work plan. Each boring log contains the following information:

- Sample numbers and types
- Sample depths
- Description of soil material
- Standard penetration test data (if applicable)
- Sample recovery and sample interval
- Soil color and moisture

In addition, lithology, depth to water, photoionization detector (PID) readings, and the total depth of each borehole are included on each boring log, where applicable.

Hand auger borings were completed to a maximum depth of 6 feet below ground at 21 locations at Site 1 to obtain subsurface soil samples. After surface samples were collected, a stainless-steel hand bucket auger with an extension bar was used to advance the boring and obtain samples from depth intervals of 6 inches to 2 feet, 2 to 4 feet, and 4 to 6 feet. The sample was removed from the auger bucket with a stainless-steel trowel and transferred directly into the laboratory-supplied sample jar.

Selection criteria for soil samples to be submitted to the laboratory for analysis are presented in the detailed discussion for each site. Soil samples were collected in accordance with TtNUS Environmental SOP GH-1.3 (Appendix D of the Phase II RI Work Plan). Sample identification and chain-of-custody requirements were followed as presented in Section 6 and Section 7 of the Quality Assurance Program Plan (QAPP) (Appendix B of the Phase II RI Work Plan). All pertinent field data were recorded in the field logbook and the appropriate sample log sheet. A sample log sheet was filled out for each soil sample selected for laboratory analysis. Sample log sheets are contained in Appendix C of the Phase II RI work plan. The number of subsurface soil samples collected and the laboratory analytical program for each site are summarized in Table 2-2.

2.1.2.2 T st Pit Investigation

Nine test pits were excavated at the Antenna Field Landfill (Site 2) in order to directly observe and evaluate the subsurface conditions at this location. Test pits were excavated by Advanced Drilling, Incorporated with a backhoe. Each pit was approximately 3 to 4 feet wide and 10 feet long. The depth of each pit was planned to extend to the maximum depth of wastes and/or fill encountered, to the water table, or to the maximum reach of the backhoe, whichever was encountered first. The depths of the test pits ranged from 10 to 14 feet. Two of the test pits (02TP01 and 02TP02) were excavated on April 2, 1997. Ground conditions on that day were very wet, and the backhoe became repeatedly stuck at the landfill. The remaining test pits were excavated on May 14 and May 15, 1997, with relatively dry conditions at the site.

Four samples of landfill material were collected and submitted for laboratory analysis from each of the nine trench locations. Four duplicate samples were collected. Samples for analyses were selected based on visual evidence of potential contamination and/or elevated PID readings. In general, no unusual visual evidence or elevated PID readings were encountered. Therefore, grab samples were collected from near the center of each open pit at approximately 2- to 3-foot depth intervals. Detailed notes and logs describing the subsurface conditions encountered, PID readings, and sample locations were maintained for each pit. Test pit logs are contained in Appendix D of the Phase II RI work plan, and sample log forms are included in Appendix C of the Phase II RI. Subsurface samples of landfill material and/or soil were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide analysis. Two of these samples were analyzed for dioxin. A summary of the test pit samples is presented in Table 2-3.

Material excavated during the test-pitting program was placed back in the test pit in accordance with the Phase II RI work plan.

2.1.3 PCB Field Screening

One hundred soil samples (both surface and subsurface soil) were analyzed in the field for PCBs during the Phase II activities in 1997. PCB screening was performed during the soil removal action follow-on activities at Site 1. TtNUS personnel tested selected soil samples from the Privet Road Compound (Site 1) in the field for PCBs to delineate the extent of a previously identified "hot spot." Soil samples at the Fire Training Area (Site 5) were field tested for PCBs to identify and delineate potential PCB impact to soil at that site.

TABLE 2-2

SUBSURFACE SOIL SAMPLING SUMMARY
NASJRB WILLOW GROVE, PENNSYLVANIA

Site	Number of Subsurface Soil Sample Locations	Number of Environmental Subsurface Soil Samples[1]	Analytical Parameters
1	28	50	PCBs (Field kit immunoassay)
		14	TCL semivolatiles
		6	TCL PCBs
		3	Dioxin
3	1	3	TCL VOC
5	14	17	TCL semivolatiles and TAL metals
		13	TCL VOC
		16	Cyanide
		11	PCBs (field kit immunoassay)
		4	TCL PCBs

[1] Includes field duplicates.

TABLE 2-3

SUBSURFACE SOIL (TEST PIT) SAMPLING SUMMARY
NASJRB WILLOW GROVE, PENNSYLVANIA

Site	Number of Test Pit Trench Locations	Number of Environmental Soil Samples[1]	Analytical Parameters
2	9	40	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and Cyanide
		2	Dioxin

[1] Includes field duplicates.

An immunoassay test was used to screen for the presence of PCBs. In this test, the estimated concentration of PCBs is determined by measuring the absorbance of samples and standards using a differential photometer and then comparing the sample results against a calibration curve. Typically, results are used to report concentration as either greater or less than a predetermined action level (e.g., 10 ppm). Detailed methods and procedures for the immunoassay test are discussed in Appendix L of the Phase II RI. Duplicate soil samples were submitted to ARDL for PCB analysis as confirmation samples for the immunoassay field-tested samples. Duplicate samples were collected at a rate of one per 10 field-tested samples. Surface and subsurface soil samples collected for PCB field screening and confirmation laboratory analysis are summarized in Tables 2-1 and 2-2. Results of the Site 1 field testing are presented in Section 4.

2.1.4 Surface Water Sampling Investigation

Eight surface water samples (six locations) were collected at three sites (Site 2, Site 3, and Site 5) and nine samples were collected at eight designated off-base background locations during the 1997 RI activities. Surface water was sampled at two locations each at Sites 2, 3, and 5 to obtain initial water-quality data. Surface water samples were collected at off-base locations to provide baseline background data. Samples were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, and cyanide analysis. Field measurements were taken for the surface water samples prior to sample collection. The field measurements included pH, temperature, and conductivity and visual estimates of the color and turbidity. All field data were recorded in the field logbook and on the appropriate sample log sheet. Sample log sheets for the surface water sampling program are included in Appendix C of the Phase II RI report. A summary of the surface water samples collected at each site during the Phase II RI is presented in Table 2-4.

2.1.5 Sediment Sampling Investigation

Fourteen sediment samples were collected at 13 locations at Sites 1, 2, 3, and 5, and nine sediment samples were collected from the designated eight off-base background locations during the 1997 RI activities. No sediment samples were obtained during the follow-on activities. Sediments were sampled concurrently from the same locations as surface water for Sites 2, 3, and 5 and off-base background. One Site 3 and one Site 1 sediment sample were collected without corresponding surface water samples. All samples were submitted to ARDL for TCL VOCs, SVOCs, PCB/pesticides, TAL inorganics, cyanide, total organic carbon (TOC), and grain size analysis. In addition, five sediment samples at Site 1 were collected from the same locations sampled for the Phase I RI and submitted to ARDL for TCL SVOCs, TOC, and grain size analysis to fill analytical data gaps identified during the scoping process for the current investigation.

TABLE 2-4

SURFACE WATER SAMPLING SUMMARY
NASJRB WILLOW GROVE, PENNSYLVANIA

Site	Number of Surface Water Sample Locations	Number of Environmental Surface Water Samples[1]	Analytical Parameters
2	2	2	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and cyanide
3	2	3	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and cyanide
5	2	3	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and cyanide
Offsite	8	9	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and cyanide

[1] Includes field duplicates.

Sediment sample log sheets are included in Appendix C of the Phase II RI. A summary of the sediment samples collected during the Phase II RI is presented in Table 2-5.

2.1.6 Seep Sampling Investigation

Seep sampling was proposed in the Phase I RI investigation for the Antenna Field Landfill Site (Site 2) but samples could not be collected due to drought conditions. Seep samples were collected during the initial Phase II RI investigation to fill this data gap. Seep samples were not collected during the follow-on activities. Four groundwater seep samples (02SP01 through 02SP04) were collected. Sediments were also collected from the fine-grained depositional area that receives surface runoff from the seep at these locations. All aqueous seep samples were analyzed for TCL VOC, TCL semivolatile compounds, PCB/pesticides, and TAL metals. Sediment seep samples were analyzed for TCL VOC, TCL semivolatile compounds, PCB/pesticides, TAL metals, TOC, and grain size.

Field measurements of pH, temperature, and conductivity were taken for each aqueous seep sample, along with visual estimations of the color and turbidity. All field data were recorded in the field logbook and the appropriate sample log sheet. Seep water and sediment sample log sheets are included in Appendix C of the Phase II RI. A summary of the seep sampling is presented in Table 2-6.

2.1.7 Groundwater Investigation

2.1.7.1 Monitoring Well Installation – Initial Field Activities

Monitoring wells were installed at each site to obtain the additional groundwater quality and hydraulic head data needed to fill the data gaps identified during the scoping of this investigation and discussed in the Phase II work plan.

A total of 30 monitoring wells were installed within 22 boreholes. The specific locations, numbers, and depths of the wells at each site are presented in the detailed discussion for each. A summary of the Phase II RI monitoring well construction details is provided in Table 2-7.

The target depth for each proposed well was determined by the data needs identified during the scoping process and was based on the local hydrogeology as determined from the previous investigation. For shallow wells, the target depth was from the top of bedrock to a subsurface depth of 75 feet. For the intermediate wells, the target depth was from a subsurface depth of 75 to 150 feet. These target drilling depths were used only as general guidelines. The actual depth of the boreholes varied and was based on

TABLE 2-5

SEDIMENT SAMPLING SUMMARY
NASJRB WILLOW GROVE, PENNSYLVANIA

Site	Number of Sediment Sample Locations	Number of Environmental Sediment Samples[1]	Analytical Parameters
1	6	5	TCL semivolatiles, TOC, and grain size.
		1	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and cyanide, TOC, and grain size
2	2	2	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, cyanide, TOC, and grain size
3	3	3	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, cyanide, TOC, and grain size
5	2	3	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, cyanide, TOC, and grain size
Offsite	8	9	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, cyanide, TOC, and grain size

[1] Includes field duplicates.

TABLE 2-6

SEEP SAMPLING SUMMARY
NASJRB WILLOW GROVE, PENNSYLVANIA

Site	Number of Seep Sample Locations	Number of Environmental Seep (aqueous) Samples[1]	Number of Environmental Seep (sediment) Samples[1]	Analytical Parameters
2	4	4	4	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, cyanide, TOC, and grain size

[1] Includes field duplicates.

TABLE 2-7

INITIAL PHASE II RI MONITORING WELL CONSTRUCTION SUMMARY
NASJRB WILLOW GROVE, PENNSYLVANIA

Fire Training Area Site 05			
Borehole Depth	WELL I.D.	Screen interval (ft)	Screen length
150	05MW01 I	125 - 135	10
170	05MW03 I	118 - 128	10
75	05MW08 S	26 - 36	10
	05MW08 SI	55 - 65	10
150	05MW08 I	89 - 99	10
75	05MW09 S	27 - 32	5
	05MW09 SI	59 - 74	15
150	05MW09 I	96 - 106	10
95	05MW10 S	22 - 32	10
	05MW10 SI	79 - 94	15
130	05MW10 I	116 - 126	10
Ninth Street Landfill Site 03			
Borehole Depth	WELL I.D.	Screen interval (ft)	Screen length
144	03MW02 SI	55 - 65	10
	03MW02 I	134 - 144	10
150	03MW05 I	82 - 92	10
85	03MW06 S	26 - 36	10
	03MW06 SI	75 - 85	10
150	03MW06 I	140 -150	10
75	03MW07 S	34 - 44	10
Antenna Field Landfill Site 02			
Borehole Depth	WELL I.D.	Screen interval (ft)	Screen length
105	02MW01 I	70 -80	10
150	02MW03 SI	40 - 55	15
	02MW03 I	140 - 150	10
75	02MW04 S	34 - 44	10
150	02MW04 I	105 - 115	10
Privet Road Compound Site 01			
Borehole Depth	WELL I.D.	Screen interval (ft)	Screen length
33	01MW01 SO	08 - 18	10
	01MW01 S	23 - 33	10
100	01MW01 I	75 - 85	10
100	01MW03 I	69 - 79	10
34	01MW08 SO	7 - 17	10
	01MW08 S	24 - 34	10
100	01MW08 I	76 - 86	10

the subsurface conditions encountered during the drilling process.

The proposed drilling locations were cleared for potential underground obstructions by the Navy and local utilities before the borings were begun. The boreholes were drilled with a Stratistar-25 air-rotary drilling rig operated by Advanced Drilling, Incorporated. For each bedrock borehole, 10-inch-diameter boreholes were drilled from the ground surface to a depth of at least 5 feet into competent bedrock. Six-inch-diameter steel surface casing was installed and grouted into the bedrock with cement-bentonite grout to hydrogeologically isolate the overburden from the bedrock. This casing also serves as the outer protective casing for the completed well above ground. The grout was allowed to set undisturbed for a minimum of 24 hours. Subsequently, a nominal 6-inch-diameter borehole was drilled in the bedrock until significant water-bearing zones were encountered within the target interval for the respective borehole. A TtNUS field geologist logged subsurface lithology, as determined by the drill cuttings, and recorded all drilling information, such as water entry zones, on the boring logs. The borehole and the cuttings were screened with a PID, and readings were recorded in the site logbook and documented in the boring logs. Boring logs are included in Appendix B of the Phase II RI.

Most of the new boreholes were geophysical logged by the USGS to identify subsurface lithology, fractured intervals, water entry or exit zones, and vertical flow direction and quantity. Caliper, gamma ray, single-point resistivity, fluid temperature, fluid resistivity, and thermal-pulse flowmeter logs were run in each borehole. A down-hole video camera recording system was employed at select locations to obtain a visual record of the inner borehole and potential water entry zones. Two shallow boreholes (01MW01S and 01MW08S) were not geophysical logged. Copies of the geophysical log results are contained in Appendix F of the Phase II RI.

The vertical interval to be screened in each borehole was determined by evaluating the geophysical logs and the well boring logs. In general, the wells were constructed to monitor the most significant (highest yielding) water-bearing zone within the target interval for that particular borehole. Other factors that were considered included stratigraphic and vertical separation of the various water-bearing zones already screened in existing wells (if any) at that well cluster.

At some locations, a nested pair of two monitoring wells was installed within one borehole. Typically, this was done in shallow bedrock boreholes in order to monitor both the minimally productive zones usually found at the water table and a higher yielding, deeper fracture within the target interval for the shallow wells.

Monitoring Well Construction

Monitoring wells were constructed with 2-inch-diameter, flush-joint and threaded polyvinyl chloride (PVC) well casing and 2-inch-diameter, Schedule 40, 0.020-inch slotted well screen fitted with a bottom cap. The space between the bottom of the borehole and the bottom of the screen (if any) was backfilled with bentonite and/or cement-bentonite grout to the bottom of the desired monitoring interval and with No. 2 quartz sand from that depth to the bottom of the screen. The annular space between the well screen and the borehole was packed with No. 2 quartz sand to at least 1 foot above the top of the desired monitoring interval. A minimum 2-foot-thick bentonite pellet seal was installed above the sand pack and allowed to hydrate prior to grout emplacement. The remaining annulus was then backfilled with a cement-bentonite grout mixture to within 1 foot of the ground surface or, when two wells were constructed in one borehole, to a depth 2 to 5 feet below the bottom of the shallow well. The depths of all backfill materials were constantly monitored by a TtNUS geologist during the well installation process to ensure that bridging did not occur and that the correct construction depths were achieved. Monitoring wells were completed with a 2-foot-square concrete pad at ground level around the stickup pipe, keyed 1 foot into the annular space. A standpipe was installed at two Site 1 locations to house well cluster 1MW01S, 01MW01SO and well cluster 01MW08S, 01MW08SO because these wells had no protective surface casing set into bedrock. Steel and concrete bollards were placed at selected monitoring well sites where the risk of damage from vehicular traffic or maintenance activities exists. A monitoring well construction log was completed for each well. Well construction logs are contained in Appendix B of the Phase II RI.

Well Development

Most monitoring wells were developed with a submersible pump. The groundwater temperature, pH, conductivity, and turbidity were monitored during development. The wells were developed until these parameters were measured within 10 percent of one another from three consecutive samples and the groundwater became clear. The amount of water removed, during well development and the field parameters for each well were recorded in the project field notebooks.

One well at Site 3 (03MW06S) was developed by hand bailing with a disposable Teflon bailer for 2-1/2 hours because of low well yield. A total of 60 gallons were removed and the final water had a very light brown color.

Hand bailing was attempted at Site 1 Well 01MW08SO but yielded only 12 ounces of water with no perceptible recharge. This overburden well was installed upgradient of Site 1 within the same borehole as the shallow bedrock well at this location to monitor the groundwater quality in the overburden prior to any

potential impacts from the site. The overburden was dry at the time of monitoring well installation during a very dry summer. It is possible that water samples may be available from this well in the future.

2.1.7.2 Monitoring Well Installation – Field Activities 1998 through 2000

No additional monitoring wells were installed at Site 1 after conclusion of field activities in 1997. Additional groundwater information received from the Air Force and from USGS was used to re-evaluate hydrogeological interpretations for the Site 1 groundwater regime (see Section 4).

2.1.7.3 Groundwater Sampling – Phase II RI Activities

Groundwater samples were obtained from all accessible permanent monitoring wells at the four study sites, including the newly installed wells (Phase II RI) and pre-existing wells. Groundwater samples were also obtained from the two Navy supply wells and four monitoring wells at the Air Reserve Station located adjacent to the Private Road Compound (Site 1). Monitoring wells were sampled a minimum of 14 days after development. The groundwater sampling programs specific to each site are presented in the detailed discussions for each site. Four monitoring wells could not be sampled due to field conditions. Wells 01MW08SO (Site 1) and 02MW01I (Site 2) were dry wells. The pump could not be lowered into wells 02MW03S (Site 2) and 03MW01SI (Site 3). Well 02MW03S has apparently collapsed and was filled with sediment to a depth of approximately 3 feet bgs. Well 03MW01SI was damaged, with the casing disjointed approximately 3 feet bgs.

The groundwater sampling program was conducted in accordance with the low-flow sampling procedure (Appendix M of the Phase II RI Work Plan) based on EPA Region 3 (amended) Groundwater Sampling Procedure Low-Flow Purge and Sampling guidance. Monitoring wells were purged prior to sampling using a low-flow submersible pump and disposable polyethylene tubing. Care was taken to place the pump at the prescribed depth within the well screen and to purge the wells at a rate less than the well yield. Purge rates generally did not exceed 1 liter per minute (L/min) and were typically set to the minimum capability of the pump (0.2 L/min to 0.5 L/min) shortly after flow was established. Groundwater was directed into a flow-through cell with a multi-probe water-quality meter. Each well was purged until the monitored parameters (pH, temperature, conductivity, turbidity, and dissolved oxygen) of three consecutive readings were within 10 percent.

The groundwater samples from the monitoring wells were obtained directly at the discharge point of dedicated, disposable polyethylene tubing. The tubing was detached from the flow-through monitoring cell during sample collection in order to obtain the groundwater directly from the pump and dedicated tubing.

The two Navy production wells at Site 1 (01MWNW1 and 01MWNW2) were sampled during normal pumping conditions by collecting water through existing in-line ball valves at each pumphouse.

Groundwater samples from Sites 2, 3, and 5 were analyzed for TCL VOC, TCL SVOCs, TCL pesticides/PCBs, TAL metals, and cyanide. Groundwater samples from the Privet Road Compound (Site 1) were analyzed for TCL VOCs only. Table 2-8 summarizes the groundwater sampling program. All pertinent field data were recorded in the field logbook and on the appropriate sample log sheet. The groundwater sample log sheets are included in Appendix C. of the Phase II RI.

2.1.7.4 Groundwater Sampling – 1998 through 2000 Field Activities

No additional monitoring wells were installed at Site 1 after conclusion of field activities in 1997. Additional groundwater information received from the Air Force and from USGS was used to reevaluate hydrogeological interpretations for the Site 1 groundwater regime. Packer techniques were used by the USGS to isolate and obtain groundwater quality analysis for the various aquifer components represented in the two Navy supply wells. Section 4 presents an in-depth discussion of the findings.

2.1.7.5 Long-Term Water-Level Study – Phase II RI Field Activities

A long-term water-level study was conducted at the Privet Road Compound from March 4 to April 21, 1997. The results of previous investigations and existing data indicated that the groundwater flow conditions at this site were quite complex due to the presence of both unconfined and confined aquifers and the differing effects from the pumping of the Navy supply wells on each aquifer.

Pressure transducers were installed to monitor the water levels in 13 selected wells. Self-contained units (with stand-alone transducer and data logger) and satellite transducers wired into a common data logger were used to collect the water-level readings, which were obtained at 10-minute intervals from each well. A strip chart recorder was installed in Building 6 (Boiler House) to monitor the on-off cycle of the Navy supply wells (NW-1 & NW-2) in order to relate the water-level data recorded in the Privet Road monitoring wells to the production well pumping cycles. Section 4.5.1 details the field activities for the water-level study, and Section 4.3 presents the hydrogeology for the Privet Road Compound site.

2.1.7.6 Static Water-Level Measurements – Phase II RI Field Activities

Two rounds of groundwater-level measurements were collected at the four RI sites (on July 2, 1997 and August 7, 1997) to provide hydraulic head data for piezometric elevations and groundwater contour maps. Static water levels were measured in all available wells using an electronic water-level indicator and were

TABLE 2-8

INITIAL FIELD ACTIVITIES - GROUND WATER SAMPLING SUMMARY
NASJRB WILLOW GROVE, PENNSYLVANIA

Site	Number of Groundwater Sample Locations (Wells)	Number of Environmental Groundwater Samples[1]	Analytical Parameters
1	23	26	TCL VOC
2	6	7	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and cyanide
3	17	19	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and cyanide
5	21	23	TCL VOC, TCL semivolatiles, TCL pesticides/PCBs, TAL metals, and cyanide

[1] Includes field duplicates.

recorded to the nearest 0.01 foot. Well 02MW02S at the Antenna Field Landfill (Site 2) was not measured on July 2, 1997 because the well could not be located. Groundwater levels at four monitoring wells (01MWWW1, 01MWWW1B, 01MWWW2, and 01 MWWW3) at the Air Reserve Station adjacent to and northwest of the Privet Road Site (part of the Site 1 investigation) were not collected on July 2, 1997.

2.1.7.7 Static Water-Level Measurements – 1998 through 2000 Field Activities

A base-wide round of water-level measurements was performed in October 1998 to assist the USGS in construction of a regional groundwater elevation contour map.

Groundwater-level measurements were recorded at Site 2 on September 11, 2000 to provide hydraulic head data for piezometric elevations and groundwater contour maps. Static water levels were measured in all available wells using an electronic water-level indicator (Herron water level indicator) and were recorded to the nearest 0.01 foot.

2.1.7.8 Water-Level Monitoring Tests – 1998 through 2000 Field Activities

Two major field events, led by USGS for the Navy, were performed at the Privet Road Compound Area after the Phase II RI report was submitted.

A regional water-level measurement and mapping initiative was performed to prepare a regional water-level topographical map. Water levels were recorded at on-base and off-base well locations using direct measurement with water-level probes. On-base data were collected by the TtNUS field geologists. Off-base work was performed by the USGS. The resulting regional map was published by USGS and has been helpful to the Navy in various interpretations of site conditions.

The Navy supply wells were the subject of an investigation led by the USGS in the spring of 2000. This investigation is summarized in Appendix O and is referred to extensively in Section 4.

2.1.8 Review of EPIC Historical Aerial Photographs

In April 1999, EPA provided information to the Navy in a summary of Environmental Photographic Interpretation Center (EPIC) historical aerial photographs that indicated various unidentifiable anomalies at or near each of the IRP sites. EPA considered these anomalies potential environmental concerns and requested that the Navy conduct further investigation to assess the potential concerns. The Navy obtained the EPIC aerial photos and completed further review.

The Navy conducted an independent review of the aerial photos and systematically attempted to ascertain the identity of each anomaly and whether an environmental concern existed. The location of each anomaly was determined in relation to current site conditions. Sample location mapping developed for the RI was reviewed to determine if and to what extent the anomalies were investigated. On-site personnel were interviewed, and a site visit at each location was performed on October 24, 2000. Appendix N contains a summary of these activities.

2.1.9 Site Survey

The newly installed monitoring wells were surveyed for horizontal location and elevation by the Pennsylvania-licensed surveyors GEO-Technical Services, Incorporated, of Harrisburg, Pennsylvania. Class B surveying was performed, allowing for a horizontal closure of 1:10,000 and a high vertical accuracy (at least 0.01 foot). Elevations measured for each well included the ground surface at the well and a designated reference point on the uncapped monitoring well top of inner casing (TOC). Horizontal coordinates are reported to Pennsylvania South Zone-North American Datum of 1983 (NAD 83) and elevations are reported with respect to the North American Vertical Datum of 1988 (NAVD 88). Select existing wells were surveyed to tie in previous survey data and as a check on the new survey data. Vertical elevation data from the previous investigation phases were reported to the National Geodetic Vertical Datum of 1929 (NGVD 29) and were converted to NAVD 88 for the Phase II RI report.

Soil borings, surface soil, surface water and sediment, and seep sampling locations were surveyed for horizontal location and elevation. In addition, other significant site features such as building corners or site boundaries were surveyed for horizontal locations as needed to provide adequate site references for improving the quality and accuracy of the site-specific drawings.

2.1.10 Handling of Investigation-Derived Waste

2.1.10.1 Drill Cuttings

All drill cuttings generated during the soil boring and well installation program were field screened with a PID. Drill cuttings from monitoring well boreholes that did not generate elevated organic vapor readings were spread on the ground around the completed well. The soil boring boreholes were backfilled with drill cuttings generated by the drilling or with a cement grout, depending on the presence or absence of organic vapors. Where no elevated organic vapor readings were detected, the borehole was backfilled with soil cuttings. If elevated readings were detected, then the cuttings were isolated and containerized in Department of Transportation (DOT)-approved (Specification 17-C) 55-gallon drums, and the borehole was backfilled with cement grout. Drill cuttings from the Fire Training Area (Site 5) soil borings 05SB17, 05SB19, 05SB21,

05SB22, 05SB24, and 05SB28 produced elevated PID readings and were therefore containerized. The drums were sealed, labeled, and stored at a designated waste holding location pending further testing and ultimate proper disposal of the cuttings. Drill cuttings from well boring FTAW-1D were also containerized and handled in the same manner. Drill cuttings from all other boring locations did not produce any significant PID readings, so the cuttings were spread around the immediate area of the borehole. Appendix I of the Phase II RI report contains waste disposal records.

2.1.10.2 Development Water

Development water from most of the newly installed monitoring wells was directed away from the wellhead and discharged to the ground surface and allowed to infiltrate the soil. Elevated (above background) PID readings were noted during the drilling at well boring 01MW01S. Therefore, the development water from wells 01MW01S and 01MW01SO was containerized and stored on site pending test results of groundwater from those wells. Appendix I of the Phase II RI report contains waste disposal records.

2.1.10.3 Purge Water

Purge water was directed away from the wellhead and discharged to the ground surface and allowed to infiltrate the soil. Very small quantities of purge water were generated during groundwater sampling due to the low-flow sampling procedure. The quantities of purge water removed from each well are listed on the groundwater sample log sheets, which are located in Appendix C of the Phase II RI report.

2.1.10.4 Decontamination Fluids and Drilling Fluids

Steam wash and rinse liquids from the drill rig, tools, and the backhoe bucket were collected at site-specific collection pads. In most cases, the water in the decontamination pads evaporated or was discharged in a manner consistent with the handling of the solids produced during that activity (e.g., drilling auger rinses were allowed to infiltrate the site soil where the corresponding cuttings had been returned to the hole or were spread on the site surface). Decontamination rinse solutions from Site 5, where cuttings from soil borings displayed elevated PID readings, were containerized, held, and sampled.

Water produced during the air-rotary drilling was temporarily contained at the head of the borehole in a plastic-lined, bermed holding pad. This water was discharged away from the wellhead and to the local ground surface and allowed to reinfiltrate if PID readings from the borehole were not elevated and there was no possibility of the drilling water flowing to a natural surface water body. At several locations, the drilling water was contained where there were nearby storm drain ditches or a nearby surface water impoundment. In these cases, drilling fluids were pumped from the temporary holding pad to a 4,000-gallon-capacity tank

trailer. The tank trailer was emptied, as needed, to two holding tanks (6,000 gallons each) until the water was sampled, analyzed, and approved for discharge to the NASJRB water treatment facility. Drilling locations where water was contained and transferred for disposal include the Privet Road Compound (01MW01I, 01MW03I, and 01MW08I) and the Antenna Field Landfill.

2.1.10.5 Personal Protective Equipment (PPE)

PPE was double bagged and disposed off site. PPE and plastic sheeting from the cuttings at Site 1 were containerized and temporarily held pending testing of the cuttings.

2.1.11 General Sampling Operations

2.1.11.1 Sample Designation

Each collected sample was assigned a unique sample tracking number. The sample tracking number consisted of a three-segment or four-segment alpha (A)-numeric (N) code that identifies the sample medium and location, sample depth (for subsurface soils), and QA designation if required. Any other pertinent information regarding sample identification was recorded in the field logbooks. Additionally, monitoring wells installed during the previous SI and RI were renamed to fit the Phase II RI designations with a code that expresses the site number, monitoring well (initials), location number, and assigned depth designation; for example, 05MW08SI represents Site 5, monitoring well, location 8, shallow-intermediate.

The alpha-numeric coding used in the sample system is explained in the diagram and the subsequent definitions:

NN	AA	NN	NNNN
Site	Medium	Location	Sample depth

Character Type:

A = Alphabetical
N = Numerical

Site Designation:

01 = Site 1 - Privet Road Compound
02 = Site 2 - Antenna Field Landfill

03 = Site 3 - Ninth Street Landfill

05 = Site 5 - Fire Training Area

BG = background Sampling Location

Medium:

MW = Groundwater sample from a monitoring well

SB = Soil boring sample

SS = Surface soil sample

SW = Surface water sample

SD = Sediment sample

SP = Seep sample (additional designation L-liquid, S-sediment at end of tracking number)

Sample Location:

Subsurface soil	=	soil boring number
Surface soil	=	sample location number from map
Groundwater sample	=	well number
Surface water/sediment	=	sample location number from map
Seeps	=	sample location number from map
Background Sample	=	background sample location number

Sample Depth:

- For soil samples, the two-digit start depth followed by the two-digit final depth (i.e., 0204 is beginning at 2 feet and ending at 4 feet).
- Not used for groundwater, surface water, sediment, or seep samples.

QA Sample Designation

DUP	=	Duplicate
RB	=	Equipment Rinsate Blank
FB	=	Field Blank
TP	=	Trip Blank

Field Duplicate Labels

Field duplicates were designated as DUP-01, DUP-02, etc. so they were submitted to the laboratory "blind." The chain-of-custody form and other documentation submitted to the laboratory were filled out in such a way that the laboratory could not match the duplicates to the original sample. The time on the duplicate samples was noted as 00:00. The correct sample location, time, etc. were documented in the field logbook. Alternately, duplicate samples were assigned a fictitious sample location, depth, and time to appear as another environmental sample. The correct sample association for the duplicate was documented in the field notebook.

Quality Control Sample Labels

Quality control samples were taken periodically. These samples were used to document the effectiveness of decontamination, to determine the quality of water used for decontamination, and to identify possible cross-contamination occurring during transit. These blank samples, including trip blanks, field blanks, and equipment rinsate blanks, used the QC sample identification scheme, listed below.

Sample Number

A sequential numeric designation was assigned to each type of blank on a daily basis.

Sample Date

The format MMDDYY (M=Month, D=Day, Y=Year) was used to indicate the day the sample was generated.

Example of the Quality Control Labels

The first field blank sample collected on December 4, 1996 would have had the sample identification label FB-01-120496. Matrix spike and matrix spike duplicate (MS/MSD) samples were designated on the field documentation forms and sample labels.

2.1.12 Sampl Handling

Sample Packaging and Shipping

Samples were packaged and shipped in accordance with TtNUS SOP SA-6.2. The field operations leader (FOL), or designate, was responsible for completing the following forms:

- Sample labels
- Chain-of-custody forms
- Appropriate labels applied to shipping coolers
- Chain-of-custody seals
- Federal Express air bills

Sample Custody

Custody of the samples was maintained and documented in accordance with procedures described in TtNUS SOP SA-6.1. Chain-of-custody began with the collection of the samples in the field.

Equipment Decontamination

Equipment involved in field sampling operations, including drilling rigs, backhoe, down-hole tools, augers, and all sampling equipment, was decontaminated before sampling, between individual samples, and after drilling or sampling activities.

The down-hole drilling equipment and sampling tools were cleaned using a high-pressure steam generator (steam jenny) before beginning work, between sample locations (such as test pits, soil borings, soil gas points, etc.), at the completion of the drilling program, and any time the drilling rig left a site before completing a boring. The NASJRB provided potable water directly from fire hydrants. Additional operations followed during drilling equipment decontamination are found in TtNUS SOP GH-1.6.

The sampling equipment used for collecting samples was decontaminated before the beginning of field sampling and between samples. The decontamination steps were as below:

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse

- Deionized water rinse
- Air dry

Field analytical equipment such as pH, conductivity, and temperature instrument probes were rinsed first with deionized water, then with the sample liquid.

2.2 COMPARISON TO ARARs and TBCs

All data were evaluated by comparison by medium to Applicable or Relevant and Appropriate Requirements (ARARs) or criteria to be considered (TBCs). Exceedences of ARARs and TBCs are detailed in the nature and extent of contamination narratives. The following ARARs and TBCs are applicable in this evaluation:

- Surface and subsurface soils:
  - Risk-based concentration (RBC) for residential soil ingestion
  - RBC for industrial soil ingestion
  - PADEP soil residential direct-contact medium-specific concentration (MSC)
  - PADEP soil non-residential MSC
- Surface water:
  - Ambient Water Quality Criterion (AWQC) freshwater aquatic life
  - AWQC ingestion of water and fish
  - PADEP Water Quality Criteria (WQC); continuous concentrations
  - PADEP WQC; human health criteria
- Sediment
  - Sediment ecological toxicity threshold values
- Groundwater
  - Maximum Contaminant Level (MCL)
  - Drinking water health advisory
  - PADEP groundwater MSC
  - RBC for tap water consumption

Currently, the only enforceable regulatory standards for exposure to groundwater are EPA MCLs. However, MCLs have not been specified for many of the chemicals of potential concern (COPCs). Therefore, other regulatory guidelines may be used for comparative purposes to determine health risks and environmental impacts. Federal relevant regulatory guidelines referenced include MCLGs, AWQCs, and EPA Drinking Water Health Advisories (DWHAs). Pennsylvania relevant regulatory standards referenced include ACT 2 Human Health Standards for soils (residential and non-residential ingestion of soil and soil to groundwater pathway) and groundwater (groundwater aquifer ingestion) and Title 25 Chapter 16 Water Quality Toxics Management Strategy (fish and aquatic life continuous criteria concentration and human health criteria). Federal and state ARARs and TBCs are presented in Table 2-9. These groundwater criteria are discussed briefly below.

Maximum Contaminant Levels (MCLs)

MCLs are enforceable standards promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70 years) of an average adult (weighing 70 kilograms) consuming 2 liters of water per day, but they also reflect technical limits on removing the contaminant from water. These enforceable standards are also based upon the toxicant expected to be absorbed by the gastrointestinal tract.

Maximum Contaminant Level Goals (MCLGs)

MCLGs are generally specified as zero for carcinogenic substances (although exceptions, such as beryllium, do exist) and do not consider the technical or economic feasibility of achieving these goals. MCLGs are nonenforceable guidelines based entirely on health effects. MCLs have been set as close to the MCLGs as technologically and economically feasible.

Drinking Water Health Advisories (DWHAs)

DWHAs are guidelines developed by the EPA Office of Drinking Water for non-regulated contaminants in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (with an assumed body weight of 10 kilograms) who consume 1 liter of water per day and in adults (assumed body weight of 70 kilograms) who consume 2 liters of water per day. Health Advisories are generally available for acute (1-day), subchronic (10-day), and chronic (longer-term or lifetime) exposure

TABLE 2-9

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GROVE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [a]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [a]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [a]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L)	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [a] (ug/L)	Ingestion of Water and Fish [b] (ug/L)	Ingestion of Fish Only [b] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils Ingestion Residential (ug/Kg)	Soils Ingestion Non-Residential (ug/Kg)	Soil to Groundwater Pathway [c] (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
Metals																	
aluminum	-	-	2.00E+02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antimony	6.00E+00	6.00E+00	-	3.00E+00	1.50E+01	1.00E+01	1.00E+01	1.00E+01	-	1.40E+01	4.30E+03	6.00E+00	3.00E+01	4.00E+02	6.00E-01	2.19E+02	1.00E+01
arsenic	5.00E+01	-	-	-	-	-	-	-	1.89E+02	1.80E-02	1.40E-01	5.00E+01	3.00E+00	4.00E+00	5.00E+00	1.90E+02 [12]	5.00E+01
barium	2.00E+03	2.00E+03	-	2.00E+03	-	-	-	-	-	-	-	2.00E+03	5.00E+03	7.00E+04	2.00E+02	4.10E+03	1.00E+03
beryllium	4.00E+00	4.00E+00	-	-	2.00E+04	3.00E+04	3.00E+04	4.00E+03	-	-	-	4.00E+00	1.00E+00	1.30E+00	4.00E-01	0.01 x 96hr LC50	-
cadmium	5.00E+00	5.00E+00	-	5.00E+00	2.00E+01	4.00E+01	4.00E+01	5.00E+00	1.10E+00 [6]	-	-	5.00E+00	2.00E+01	5.00E+02	5.00E-01	1.00E+00 [6,12]	1.00E+01
chromium, total	1.00E+02 [1]	1.00E+02 [1]	-	1.00E+02 [1]	8.00E+02 [1]	1.00E+03 [1]	1.00E+03 [1]	2.00E+02 [1]	2.09E+02 [6]	-	-	1.00E+02	-	-	-	1.00E+01 [12]	-
cobalt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.90E+01	-
copper	1.30E+03 [2]	1.30E+03	1.00E+03	-	-	-	-	-	1.10E+01 [6]	-	-	1.00E+03	7.00E+02	3.70E+04	1.00E+02	1.10E+01 [6,12]	1.00E+03
cyanide	2.00E+02	2.00E+02	-	2.00E+02	8.00E+02	2.00E+02	2.00E+02	2.00E+02	5.20E+00	7.00E+02	2.20E+05	2.00E+02	1.00E+03	2.00E+04	2.00E+01	5.00E+00	7.00E+02
iron	-	-	3.00E+02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
lead	1.50E+01 [3]	0.00E+00	-	-	-	-	-	-	3.20E+00 [6]	-	-	5.00E+00	5.00E+02	1.00E+03	-	2.50E+00 [6,12]	5.00E+01
manganese	-	-	5.00E+01	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mercury	2.00E+00	2.00E+00	-	2.00E+00	2.00E+00	-	-	-	1.20E-02 [b]	1.40E-01	1.50E-01	2.00E+00	2.00E+01	3.00E+02	-	1.20E-02	1.44E-01
nickel	1.00E+02	1.00E+02	-	1.00E+02	1.70E+03	1.00E+03	1.00E+03	5.00E+02	1.60E+02 [6]	6.10E+02	4.60E+03	1.00E+02	2.00E+02	2.00E+04	-	1.60E+02 [6,12]	6.00E+02
selenium	5.00E+01	5.00E+01	-	-	-	-	-	-	5.00E+00	-	-	5.00E+01	6.00E+01	5.00E+03	5.00E+00	4.60E+00 [6,12]	-
silver	-	-	1.00E+02	1.00E+02	2.00E+02	2.00E+02	2.00E+02	2.00E+02	1.90E+00 [12]	-	-	1.00E+02	-	-	-	2.00E-01	2.00E+02
thallium	2.00E+00	5.00E-01	-	5.00E-01	2.00E+01	7.00E+00	7.00E+00	7.00E+00	- [7]	1.70E+00	6.30E+00	2.00E+00	6.00E+00	8.00E+01	2.00E-01	1.30E+01	-
vanadium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.03E+02	2.00E+00
zinc	-	-	5.00E+03	2.00E+03	1.00E+04	6.00E+03	6.00E+03	3.00E+03	1.01E+02 [6]	-	-	-	-	-	-	1.00E+02 [6,12]	5.00E+03
Pesticides/PCBs																	
4,4'-DDD	-	-	-	-	-	-	-	-	-	8.30E-04	8.40E-04	-	2.00E+04	2.40E+04	5.00E+05	1.00E-03	-
4,4'-DDE	-	-	-	-	-	-	-	-	-	5.90E-04	5.90E-04	-	1.00E+04	1.70E+04	5.00E+05	1.00E-03	N.D.
4,4'-DDT	-	-	-	-	-	-	-	-	1.00E-03	5.90E-04	5.90E-04	-	1.00E+04	1.70E+04	5.00E+05	1.00E-03	N.D.
aldrin	-	-	-	-	3.00E-01	3.00E-01	3.00E-01	3.00E-01	-	1.30E-04	1.40E-04	2.00E-03	2.60E+02	3.40E+02	5.00E+05	1.00E-01	1.00E-04
alpha-chlordane	2.00E+00 [4]	0.00E+00 [4]	-	-	-	6.00E+01 [4]	6.00E+01 [4]	-	4.30E-03 [4]	5.70E-04 [4]	5.90E-04 [4]	2.00E+00 [4]	3.00E+03	4.00E+03	5.00E+05	4.30E-03 [4]	5.00E-04 [4]
Aroclor-1254 [8]	5.00E-01	0.00E+00	-	-	-	-	-	-	1.40E-02 [5]	4.40E-05	4.50E-05	5.00E-01	5.00E+03	-	-	1.40E-02	4.00E-05
Aroclor-1260 [8]	5.00E-01	0.00E+00	-	-	-	-	-	-	1.40E-02 [5]	4.40E-05	4.50E-05	5.00E-01	5.00E+03	-	-	1.40E-02	4.00E-05
beta-BHC	-	-	-	-	-	-	-	-	-	1.40E-02	4.60E-02	-	2.00E+03	3.00E+03	4.00E+04	-	2.00E-02
dieldrin	-	-	-	-	2.00E+00	5.00E-01	5.00E-01	5.00E-01	-	-	-	2.00E-03	3.00E+02	4.00E+02	9.00E+04	1.90E-03	1.00E-04
endosulfan I	-	-	-	-	-	-	-	-	5.60E-02	9.30E-01	2.00E+00	-	5.00E+05	6.00E+06	7.00E+04	2.30E-03	9.00E-01
endrin	2.00E+00	2.00E+00	-	2.00E+00	1.00E+01	2.00E+01	2.00E+01	3.00E+00	2.30E-03	7.60E-01	8.10E-01	2.00E+00	2.00E+04	3.00E+05	5.00E+05	5.60E-02	8.00E-01
gamma-chlordane	2.00E+00 [4]	0.00E+00 [4]	-	-	-	6.00E+01 [4]	6.00E+01 [4]	-	4.30E-03 [4]	5.70E-04 [4]	5.90E-04 [4]	2.00E+00 [4]	3.00E+03	4.00E+03	5.00E+05	4.30E-03 [4]	5.00E-04 [4]
heptachlor	4.00E-01	0.00E+00	-	-	5.00E+00	1.00E+01	1.00E+01	5.00E+00	3.80E-03	2.10E-04	2.10E-04	4.00E-01	1.00E+03	1.30E+03	4.00E+05	3.80E-03	6.00E-04
heptachlor epoxide	2.00E-01	0.00E+00	-	-	1.00E-01	1.00E+01	-	1.00E-01	3.80E-03	1.00E-04	1.10E-04	2.00E-01	5.00E+02	6.00E+02	5.00E+05	1.00E-01	N.D.
Dioxins/Furans																	
2,3,7,8-TCDD	3.00E-05	0.00E+00	-	-	4.00E-05	1.00E-03	1.00E-04	1.00E-05	-	-	-	3.00E-05	3.00E-02	4.00E-02	-	-	1.00E-08
Semivolatiles																	
1,2,4-trichlorobenzene	7.00E+01	7.00E+01	-	4.00E+01	5.00E+02	1.00E+02	1.00E+02	1.00E+02	-	-	-	7.00E+01	8.00E+05	1.00E+07	2.00E+04	2.60E+01	7.00E+02
1,2-dichlorobenzene	6.00E+02	6.00E+02	-	3.00E+03	3.00E+04	9.00E+03	9.00E+03	9.00E+03	-	2.70E+03	1.70E+04	6.00E+02	7.00E+06	9.00E+07	6.00E+04	1.64E+02	4.00E+02 [9]
1,4-dichlorobenzene	7.50E+01	7.50E+01	-	7.50E+01	4.00E+04	1.00E+04	1.00E+04	1.00E+04	- [9]	4.00E+02	2.60E+03	7.50E+01	1.00E+05	2.00E+05	8.00E+03	1.46E+02	4.00E+02 [9]
2,4-dinitrotoluene	-	-	-	-	1.00E+03	5.00E+02	5.00E+02	3.00E+02	-	1.10E-01	2.10E+00	5.00E-02	1.56E+05	2.00E+06	1.00E+03	3.18E+02	5.00E-02
2,6-dinitrotoluene	-	-	-	-	1.00E+03	4.00E+02	4.00E+02	4.00E+02	-	-	-	5.00E-02	7.60E+04	1.00E+06	1.00E+03	1.98E+02	5.00E-02
2-chlorophenol	-	-	-	4.00E+01	2.00E+03	5.00E+02	5.00E+02	5.00E+02	-	-	-	4.00E+01	4.00E+05	5.00E+06	4.00E+03	-	-
2-methylnaphthalene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	-	-	-	-	-
2-methylphenol	-	-	-	1.00E+02	7.00E+03	2.00E+03	2.00E+03	2.00E+03	-	-	-	-	-	-	-	-	-
4-nitrophenol	-	-	-	6.00E+01	3.00E+03	8.00E+02	8.00E+02	8.00E+02	-	-	-	6.00E+01	5.00E+06	6.00E+07	6.00E+03	-	-
acenaphthene	-	-	-	-	-	-	-	-	5.20E+02	1.20E+03	2.70E+03	-	5.00E+06	6.00E+07	3.00E+04	1.70E+01	2.00E+01
acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
anthracene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	2.30E+07	3.00E+08	7.00E+04	-	1.00E+04
benzo(a)anthracene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	1.00E-01	3.00E-03
benzo(a)pyrene	2.00E+00	0.00E+00	-	-	-	-	-	-	-	2.80E-03	3.11E-02	2.00E-01	6.00E+02	8.00E+02	5.00E+05	-	3.00E-03

TABLE 2-9

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GROVE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [a]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [c]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [c]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [e] (ug/L)	Ingestion of Water and Fish [b] (ug/L)	Ingestion of Fish Only [b] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils Ingestion Residential (ug/Kg)	Soils Ingestion Non-Residential (ug/Kg)	Soil to Groundwater Pathway [f] (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	-	3.00E-03
benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	-	-	5.00E+05	-	-
benzo(k)fluoranthene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-02	3.11E-02	-	6.00E+04	8.00E+04	5.00E+05	-	3.00E-03
benzoic acid	-	-	-	-	-	-	-	-	-	-	-	-	3.00E+08	1.00E+09	6.00E+02	-	-
bis(2-ethylhexyl)phthalate	-	0.00E+00	-	-	-	-	-	-	3.00E+00	1.80E+00	5.90E+00	6.00E+00	3.00E+05	4.00E+05	4.00E+05	5.40E+01	-
butylbenzylphthalate	-	-	-	-	-	-	-	-	3.00E+00	3.00E+03	5.20E+03	-	1.60E+07	2.00E+08	1.00E+05	3.50E+01	3.00E+02
carbazole	-	-	-	-	-	-	-	-	3.00E+02	-	-	-	-	-	-	-	-
chrysene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+05	8.00E+05	5.00E+05	-	3.00E-03
di-n-butylphthalate	-	-	-	-	-	-	-	-	3.00E+00	2.70E+03	1.20E+04	-	-	-	-	2.10E+01	3.00E+03
di-n-octylphthalate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	6.00E+02	8.00E+02	5.00E+05	-	3.00E-03
dibenzofuran	-	-	-	-	-	-	-	-	3.00E+02	-	-	-	-	-	3.00E+04	-	-
diethylphthalate	-	-	-	5.00E+03	-	-	-	-	3.00E+00	2.30E+04	1.20E+05	5.00E+03	6.00E+07	8.00E+08	5.00E+05	8.00E+02	2.00E+04
fluoranthene	-	-	-	-	-	-	-	-	3.98E+03	4.20E+01	5.40E+01	-	3.00E+06	4.00E+07	4.00E+05	4.00E+01	3.00E+02
fluorene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	3.00E+06	4.00E+07	4.00E+04	-	1.00E+03
indeno(1,2,3-cd)pyrene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	-	3.00E-03
N-nitrosodiphenylamine	-	-	-	2.00E+02	1.00E+03	1.00E+03	1.00E+03	3.00E+02	-	5.00E+00	1.60E+01	-	-	-	1.00E+03	5.90E+01	5.00E+00
naphthalene	-	-	-	2.00E+01	1.00E+03	5.00E+02	5.00E+02	4.00E+02	6.20E+02	-	-	2.00E+01	3.00E+06	4.00E+07	8.00E+03	4.30E+01	1.00E+01
phenanthrene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	-	-	8.00E+04	1.00E+00	-
phenol	-	-	-	4.00E+03	2.00E+04	6.00E+03	6.00E+03	6.00E+03	-	2.10E+04	4.60E+06	4.00E+03	4.00E+07	6.00E+08	4.00E+04	2.00E+01	3.00E+02
pyrene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	2.00E+06	3.00E+07	3.00E+05	-	1.00E+03
Volatiles																	
1,1,1-trichloroethane	2.00E+02	2.00E+02	-	2.00E+02	1.00E+05	1.00E+05	4.00E+04	4.00E+04	3.12E+04	3.10E+03	1.70E+05	2.00E+02	7.00E+06	9.00E+07	2.00E+04	6.05E+02	1.00E+03
1,1,2-trichloroethane	3.00E+00	3.00E+00	-	3.00E+00	1.00E+03	6.00E+02	4.00E+02	4.00E+02	- [7]	6.00E-01	4.20E+01	5.00E+00	3.00E+05	4.00E+06	8.00E+02	6.78E+02	6.00E-01
1,1-dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	7.00E+06	1.00E+08	5.00E+02	-	-
1,1-dichloroethene	7.00E+00	7.00E+00	-	7.00E+00	4.00E+03	2.00E+03	1.00E+03	1.00E+03	1.16E+04	5.70E-02	3.20E+00	-	7.00E+05	9.00E+06	1.00E+03	1.492E+03	6.00E-02
1,2-dichloroethane	5.00E+00	0.00E+00	-	-	2.60E+03	7.00E+02	7.00E+02	7.00E+02	- [7]	3.80E-01	9.90E+01	5.00E+00	5.00E+04	6.00E+04	5.00E+02	3.088E+03	4.00E-01
1,2-dichloroethene (total)	7.00E+01 [5]	7.00E+01 [5]	-	7.00E+01 [5]	6.00E+03 [5]	4.00E+03 [5]	2.00E+03 [5]	2.00E+03 [5]	1.16E+04	-	-	7.00E+01	8.00E+05	1.00E+07	7.00E+03	1.35E+03	7.00E+02
2-butanone	-	-	-	-	-	-	-	-	-	-	-	-	4.00E+07	6.00E+08	5.00E+01	3.22E+04	2.00E+03
2-hexanone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-methyl-2-pentanone	-	-	-	-	-	-	-	-	-	-	-	-	6.00E+06	8.00E+07	2.00E+02	-	-
acetone	-	-	-	-	-	-	-	-	-	-	-	-	8.00E+06	1.00E+08	3.00E+01	8.60E+04	4.00E+03
benzene	5.00E+00	0.00E+00	-	-	-	2.00E+02	2.00E+02	-	5.30E+03	1.20E+00	7.10E+01	5.00E+00	1.00E+05	2.00E+05	8.00E+02	1.28E+02	1.00E+00
bromodichloromethane	1.00E+02 [11]	0.00E+00 [11]	-	-	1.30E+04	6.00E+03	6.00E+03	4.00E+03	-	2.70E-01	2.20E+01	1.00E+02 [11]	7.00E+04	9.00E+04	1.00E+04	-	3.00E-01
bromoform	1.00E+02 [11]	0.00E+00 [11]		-	6.00E+03	5.00E+03	2.00E+03	2.00E+03	-	4.30E+00	3.60E+02	1.00E+02 [11]	5.00E+05	7.00E+05	1.00E+04	3.65E+02	4.00E+00
carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-	7.00E+06	1.00E+08	8.00E+02	-	-
carbon tetrachloride	5.00E+00	0.00E+00	-	-	3.00E+02	4.00E+03	2.00E+02	7.00E+01	-	-	-	5.00E+00	3.40E+04	4.40E+04	2.10E+03	5.56E+02	3.00E-01
chlorobenzene	-	-	-	-	-	-	-	-	-	6.80E+02	2.10E+04	-	1.00E+06	2.00E+07	1.00E+05	2.36E+02	2.00E+01
chloroform	1.00E+02 [11]	0.00E+00 [11]	-	-	4.00E+02	4.00E+03	4.00E+03	1.00E+02	1.24E+03 [7]	5.70E+00	4.70E+02	1.00E+02 [11]	7.00E+05	9.00E+05	1.00E+04	3.89E+02	6.00E+00
chloromethane	-	-	-	3.00E+00	1.00E+03	9.00E+03	4.00E+02	4.00E+02	-	-	-	1.00E+02	-	-	-	-	-
dibromochloromethane	1.00E+02 [11]	6.00E+01 [11]	-	6.00E+01	8.00E+03	6.00E+03	6.00E+03	2.00E+03	-	4.10E-01	3.40E+01	1.00E+02 [11]	-	-	-	-	4.00E-01
ethylbenzene	7.00E+02	7.00E+02	-	7.00E+02	3.00E+03	3.00E+04	3.00E+03	1.00E+03	3.20E+04	3.10E+03	2.90E+04	7.00E+02	7.00E+06	1.00E+08	7.00E+04	5.60E+02	3.00E+03
methyl tert-butyl ether	-	-	-	2.00E+01	1.20E+04	2.40E+04	2.40E+04	3.00E+03	-	-	-	2.00E+01	4.00E+05	5.00E+06	2.00E+03	-	-
methylene chloride	5.00E+00	0.00E+00	-	2.00E+01	-	1.00E+04	2.00E+03	-	-	4.70E+00	1.60E+03	5.00E+00	6.00E+05	8.00E+05	5.00E+02	2.368E+03	5.00E+00
tetrachloroethene	5.00E+00	0.00E+00	-	-	5.00E+03	2.00E+03	2.00E+03	1.00E+03	8.40E+02 [7]	8.00E-01	8.85E+00	5.00E+00	7.00E+05	1.00E+07	2.00E+03	1.39E+02	7.00E-01
toluene	1.00E+03	1.00E+03	-	1.00E+03	7.00E+03	2.00E+04	2.00E+03	2.00E+03	1.75E+04	1.00E+04	3.00E+05	1.00E+03	1.60E+07	2.00E+08	1.00E+05	3.30E+02	7.00E+03
trichloroethene	5.00E+00	0.00E+00	-	-	-	-	-	-	2.19E+04 [7]	2.70E+00	8.10E+01	5.00E+00	4.00E+05	5.00E+05	2.00E+03	4.50E+02	3.00E+00

TABLE 2-9

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GROVE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [b]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [d]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [e]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L)	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [f] (ug/L)	Ingestion of Water and Fish [g] (ug/L)	Ingestion of Fish Only [h] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils: Ingestion: Residential (ug/Kg)	Soils: Ingestion: Non-Residential (ug/Kg)	Soil to Groundwater Pathway (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
xylene (total)	1.00E+04	1.00E+04	-	1.00E+04	1.00E+05	4.00E+04	4.00E+04	4.00E+04	-	-	-	1.00E+04	-	-	5.00E+03	2.11E+02	3.00E+02

[1] Criteria are for total chromium
[2] Action Level is 1,300 ug/L
[3] Action Level is 15 ug/L
[4] Criteria are for chlordane
[5] Where applicable, value(s) represent the more stringent of criteria for cis- and trans- isomers
[6] Hardness dependent criteria (100 mg/L used)
[7] Insufficient data to develop criteria. Value given is for Lowest Observable Effect Level (LOEL)
[8] Value given is for PCBs
[9] Value given is for dichlorobenzene
[10] pH dependent criteria (pH 7.8 used)
[11] Criteria are for total trihalomethanes
[12] Value is for dissolved metal
[a] EPA. Drinking Water Regulations and Health Advisories. October 1996. EPA 822-B-96-002
[b] EPA. Quality Criteria for Water 1986. Updated 1991 and December 22, 1992
[c] EPA. Quality Criteria for Water 1986. Update 2, May 1, 1987 and Updates December 22, 1992 and May 4, 1995
[d] Land Recycling and Environmental Remediation Standards Act. May 19, 1995. (ACT 2)
[e] Title 25 Chapter 16 Water Quality Toxics Management Strategy. May 18, 1996.

Note: MCLs that are promulgated by EPA are automatically incorporated into the Pennsylvania Safe Drinking Water Act.

scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels for known or probable human carcinogens.

Ambient Water Quality Criteria (AWQCs)

AWQCs were developed under the Clean Water Act and are not enforceable federal regulatory guidelines but are of primary utility in assessing the potential for toxic effects in aquatic organisms, as well as human receptors. AWQCs consider acute and chronic human health effects from ingestion of both water (2 liters per day) and aquatic organisms (6.5 grams per day). The AWQC may also be adjusted to consider ingestion of water alone (2 liters per day). The AWQC for protection of human health for carcinogenic substances is based on EPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 100,000 to 10,000,000 persons and is generally based on older toxicological data.

P nnsylvania Regulatory Standards and Guidelines

Pennsylvania Safe Drinking Water Regulations (PA Code, Title 25, Chapter 109) set forth drinking water quality standards at least as stringent as the federal Drinking Water Standards. MCLs that are promulgated by EPA are automatically incorporated in the Pennsylvania SDWA. If an MCL does not exist for a contaminant, the Pennsylvania SDWA requires the maximum allowable concentration to be determined in the following order: the concentration that EPA has proposed to set or is considered setting as a primary MCL for the contaminant; the concentration associated with a lifetime cancer risk of 10^{-6} for carcinogenic contaminants or the lifetime drinking water health advisory concentration for noncarcinogenic contaminants, provided that this concentration is equal to or greater than the practical quantitation level and the level achievable through the use of available treatment technology; or the lowest concentration achievable considering the practical quantitation level and available treatment technology.

Pennsylvania Land Recycling and Environmental Standards Act (ACT 2) is the primary law establishing the land recycling program and provides the foundation for standards, procedures, clean-up liability limits, and funding for environmental studies and cleanups. Persons who propose or are required to respond to the release of a regulated substance at a site and who wish to be eligible for clean-up liability protection must select and attain one or more of the environmental standards in ACT 2. The three types of clean-up standards are background, statewide health, and site-specific standards. Background is the concentration of a regulated substance that is present at a site but is not related to the release of regulated substances at the site. Statewide health standards consist of all numerical residential and non-residential standards adopted by PADEP and the federal government. Groundwater in aquifers intended for drinking or agricultural purposes is required to comply with the MCL or Health Advisory Level established for drinking

water, except where naturally occurring groundwater has concentrations of total dissolved solids greater than 2,500 mg/L. Site-specific standards are developed using specific risk factors. For site remediation managed under ACT 2, a Notice of Intent to Remediate and public notice are required for cleanups planned to achieve background, statewide health, and site-specific standards. In addition, for cleanups to site-specific standards, there is a public comment period and public involvement.

During data evaluation for the draft RI report, interim ACT 2 standards issued by PADEP (revision dated November 1996) were applied for comparison purposes. When available, final promulgated standards will supersede the interim PADEP guidelines.

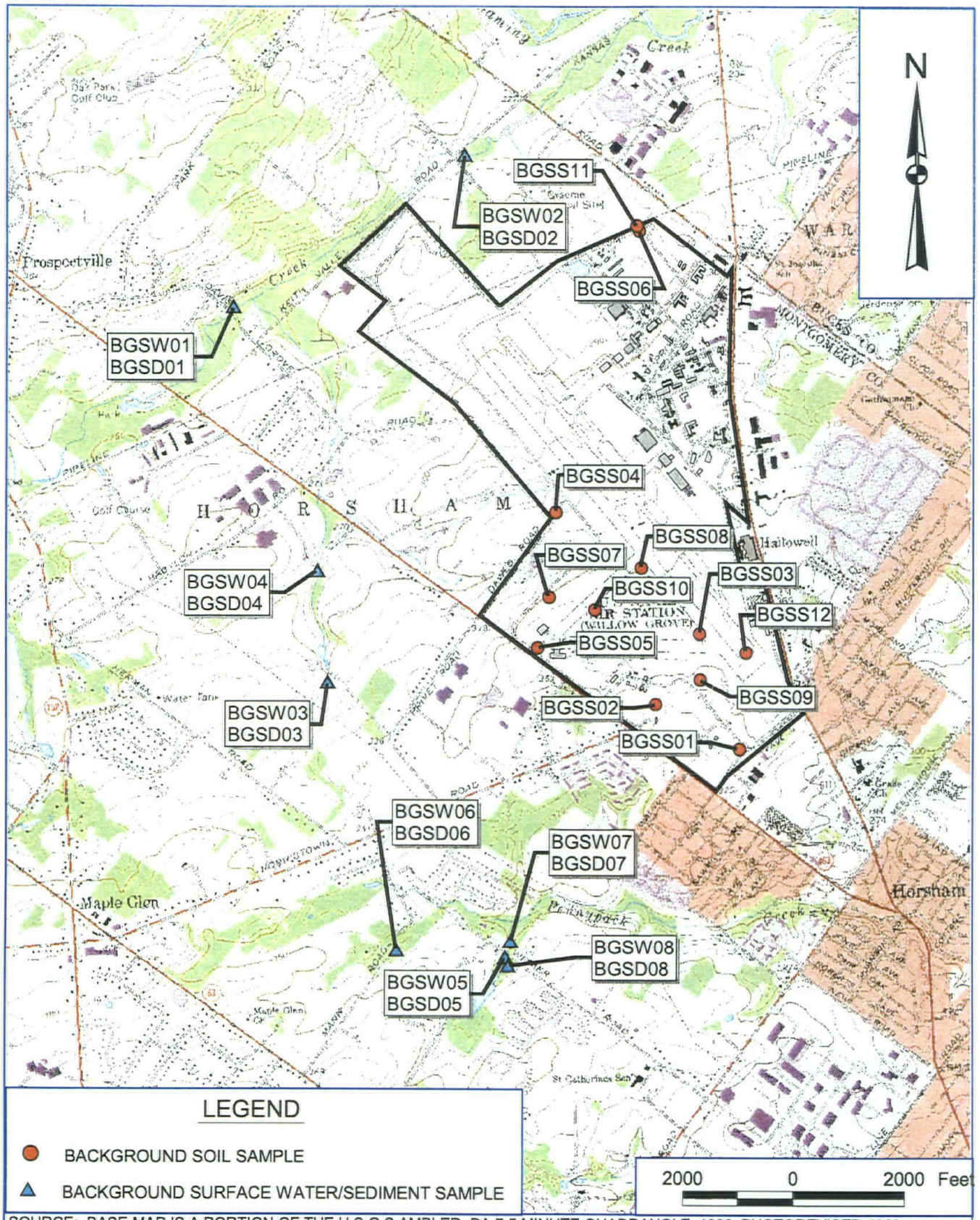
Pennsylvania Water Quality Standards (PA Code, Title 25, Chapter 93) are based upon water uses that are to be protected and considered by PADEP in its regulation of discharges to surface water. The standards may be applicable for actions involving the discharge of pollutants to surface water.

Pennsylvania Water Quality Toxic Management Strategy - Statement of Policy (PA Code, Title 25, Chapter 16) specifies guidelines and procedures for the development of criteria for toxic substances and lists those limits that have been developed to date. The water-quality criteria in Chapter 16 are the numeric limits for stream conditions that need to be maintained or attained to prevent or eliminate pollution and are designed to protect the water uses listed in Chapter 93.

Values of the available regulatory standards and guidelines are presented in Table 2-9. This table presents values for the COPCs that are human, probable human, or possible human carcinogens, for chemicals having only noncarcinogenic effects, and for chemicals having both carcinogenic and noncarcinogenic effects.

2.3 ESTABLISHMENT OF BACKGROUND CONCENTRATIONS

COPCs were selected for use in the RI report to calculate human health and ecological risk resulting from non-naturally occurring compounds at a site. COPC selection is based on a series of statistical tests and comparison to background samples. Background samples were collected in and around NASJRB Willow Grove from media similar in characteristic to on-site samples but from areas outside the known or suspected areas of influence of the sites. Site sampling data are compared to background to determine if contaminants are elevated at a site. During the Phase II sampling, background samples were obtained from surface soils (BGSS01 through BGSS12) and surface water and associated sediments (BGSW01/BGSD01 through BGSW08/BGSD08). Background sample locations may be found in Figure 2-1. Background surface soil samples were also used for comparison to subsurface soil samples. The significance of and occurrence and distribution of background results are discussed in Section 4. Results



LEGEND

- BACKGROUND SOIL SAMPLE
- BACKGROUND SURFACE WATER/SEDIMENT SAMPLE

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

DRAWN BY LDL	DATE 4/30/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 5466 / OWNER No. 2207
CHECKED BY RJT	DATE	BACKGROUND SAMPLE LOCATIONS	DWG INFORMATION: NASJRB Willow Grove.apr Site 1 RI - FIG 2-1 LDL 4/30/02
COST/SCHEDULE-AREA		NASJRB WILLOW GROVE	APROVED BY / DATE
SCALE AS NOTED		WILLOW GROVE, PENNSYLVANIA	DRAWING No. FIGURE 2-1 / REV

TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01	BGSS01-DUP	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
LOCATION:	BGSS01	BGSS01	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
SAMPLE DATE:	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	10500	8570	9090	12300	12800	9240	15000	11900	10500
antimony	5.6 UJ	5.2 UJ	8.4 R	5.8 UJ	7.5 R	7.6 R	9.6 R	8.2 R	5.6 R
arsenic	6.1 J	7	3.7 K	10.6	4.4 K	5.6	5.6 J	7.5	8
barium	95.7	89.9	77.8	108	111	79.5	111	97.9	96.4
beryllium	0.89	0.86	0.75	1.2	1.2	0.79	1.2	0.84	0.98
cadmium	1.4 U	1.3 U	1.3 U	1.4 U	1.3 U	1.4 U	1.3 U	1.3 U	1.3 U
calcium	766	690	1530	914	685	939	1500	763	1010
chromium, total	16.3	14	20.8	15.7	15.9	13.2	17.9	14.5	13.5
cobalt	8.1	8.2	9.3	6.8	7.8	8.3	8.3	8.5	7.1
copper	11.3	10.2	11.9	11.7	8	9.8	10.7	10.7	10.1
cyanide	0.69 U	0.65 U	0.64 U	0.7 U	0.66 U	0.67 U	0.64 U	0.66 U	0.64 U
iron	13200	11500	15700	13200	14100	13900	17600	16900	12800
lead	37.2	29.8	22.9	29.9	64.7	25.2	19.5	18.1	56.7
magn sium	1430	1210	1670	1450	1370	1480	1940	1500	1410
manganese	621	644	514	527	1190	538	684	538	667
mercury	0.14 U	0.13 U	0.13 U	0.14 U	0.13 U	0.14 U	0.13 U	0.13 U	0.13 U
nickel	9	9.2	9.8	10.3	11.2	9.3	10.4	10.4	9.5
potassium	418 U	392 U	627	433 U	402 U	771	750	436	618
selenium	0.28 UL	1.3 UL	1.3 UL	1.4 UL	0.27 UL	1.4 UL	1.3 UL	1.3 UL	1.3 UL
silver	1.4 U	1.3 U	1.3 U	1.4 U	1.3 U	1.4 U	1.3 U	1.3 U	1.3 U
sodium	112 U	104 U	103 U	115 U	107 U	109 U	103 U	105 U	106 U
thallium	0.28 U	0.26 U	0.26 U	0.3	0.27 U	0.27 U	0.28	0.34	0 27 U
vanadium	25.4	22.1	28.2	24.4	24.9	23.8	28.2	25.3	23
zinc	53.1	42.9	49.4	54.2	597	38.7	47.2	31.7	53

NOTES:

- J – Value is considered estimated due to exceedance of technical quality control criteria or because result is less than the Contract Required Quantitation Limit (CRQL).
- U – Value is a non-detected result as reported by the laboratory.
- UJ – Non-detected result is considered estimated due to exceedance of technical quality control criteria.
- UL – Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR – Non-det ct d result is considered unusable due to exceedance of technical quality control criteria.
- L – Positive result is considered biased low due to exce dance of technical quality control criteria.
- K – Positive result is considered biased high due to exceedance of technical quality control criteria.
- B – Positive result is considered to be an artifact of blank contamination, and should not be considered pres nt.
- R – Positiv result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01	BGSS01-DUP	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
LOCATION:	BGSS01	BGSS01	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
SAMPLE DATE:	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97
SEMIVOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
1,2,4-trichlorobenzene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
1,2-dichlorobenzene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
1,3-dichlorobenzene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
1,4-dichlorobenzene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2,2'-oxybis(1-chloropropane)	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2,4,5-trichlorophenol	1200 U	1100 U	1100 U	1200 U	1100 U	1100 U	1100 UJ	1100 UJ	1100 U
2,4,6-trichlorophenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2,4-dichlorophenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2,4-dimethylphenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2,4-dinitrophenol	1200 U	1100 U	1100 U	1200 U	1100 U	1100 U	1100 UJ	1100 UJ	1100 U
2,4-dinitrotoluene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2,6-dinitrotoluene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2-chloronaphthalene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2-chlorophenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2-methylnaphthalene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2-methylphenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
2-nitroaniline	1200 U	1100 U	1100 U	1200 U	1100 U	1100 U	1100 UJ	1100 UJ	1100 U
2-nitrophenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
3,3'-dichlorobenzidine	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
3-nitroaniline	1200 U	1100 U	1100 U	1200 U	1100 U	1100 U	1100 UJ	1100 UJ	1100 U
4,6-dinitro-2-methylphenol	1200 U	1100 U	1100 U	1200 U	1100 U	1100 U	1100 UJ	1100 UJ	1100 U
4-bromophenyl-phenylether	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
4-chloro-3-methylphenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
4-chloroanilin	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U

NOTES:

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- U – Value is a non-detected result as reported by the laboratory.
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- UL – Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR – Non-detected result is considered unusable due to exceedance of technical quality control criteria.
- L – Positiv result is considered biased low due to exceedance of technical quality control criteria.
- K – Positive result is considered biased high due to exceedance of technical quality control crit ria.
- B – Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R – Positive r sult is considered unusable due to exceedance of technical quality contr l criteria.

TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Backgr und

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01		BGSS01-DUP		BGSS02		BGSS03		BGSS04		BGSS05		BGSS06		BGSS07		BGSS08	
LOCATION:	BGSS01		BGSS01		BGSS02		BGSS03		BGSS04		BGSS05		BGSS06		BGSS07		BGSS08	
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil		Surface Soil	
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97		04/07/97	
SEMIVOLATILES	ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg	
4-chlorophenyl-phenylether	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
4-methylphenol	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
4-nitroaniline	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
4-nitrophenol	1200	U	1100	U	1100	U	1200	U	1100	U	1100	U	1100	UJ	1100	UJ	1100	U
N-nitroso-di-n-propylamine	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
N-nitrosodiphenylamine (1)	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
acenaphthene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
acenaphthylene	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	61	J
anthracene	460	U	430	U	420	U	46	J	440	U	68	J	420	UJ	65	J	110	J
benzo(a)anthracen	460	U	430	U	96	J	220	J	100	J	310	J	33	J	270	J	480	
benzo(a)pyren	460	U	430	U	110	J	350	J	110	J	400	J	420	UJ	270	J	720	
benzo(b)fluoranthene	460	U	430	U	160	J	540		160	J	550		420	UJ	340	J	990	
benzo(g,h,i)perylene	460	U	430	U	52	J	180	J	440	U	180	J	420	UJ	110	J	300	J
benzo(k)fluoranthene	460	U	430	U	420	U	310	J	98	J	310	J	420	UJ	270	J	660	
bis(2-chloroethoxy)methane	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
bis(2-chloroethyl) ther	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
bis(2-ethylhexyl)phthalate	67	B	130	B	100	B	480	B	60	B	130	B	160	B	150	B	240	B
butylbenzylphthalate	460	U	430	U	280	J	480	U	180	J	83	J	420	UJ	430	UJ	440	U
carbazole	460	U	430	U	420	U	140	J	440	U	80	J	420	UJ	430	UJ	270	J
chrysene	460	U	430	U	130	J	470	J	130	J	460		43	J	320	J	790	
di-n-butylphthalate	820	B	790	B	400	B	840	B	1100	B	1100	B	420	UJ	430	UJ	81	B
di-n-octylphthalat	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U
dibenz(a,h)anthracene	460	U	430	U	420	U	52	J	440	U	52	J	420	UJ	430	UJ	83	J
dibenzofuran	460	U	430	U	420	U	51	J	440	U	450	U	420	UJ	430	UJ	120	J
diethylphthalate	460	U	430	U	420	U	480	U	440	U	450	U	420	UJ	430	UJ	440	U

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- UL -- Non-detect d result is considered biased low due to exceedance f technical quality control criteria.
- UR -- Non-detected result is considered unusable due to exce dance of technical quality control criteria.
- L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
- K -- Positiv result is consid red biased high due to exceedance of technical quality control criteria.
- B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R -- Positiv result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01	BGSS01-DUP	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
LOCATION:	BGSS01	BGSS01	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
SAMPLE DATE:	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97
SEMIVOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
dimethylphthalate	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
fluoranthene	62 J	51 J	270 J	1200	270 J	1000	49 J	670 J	2000
fluorene	460 U	430 U	420 U	59 J	440 U	450 U	420 UJ	430 UJ	160 J
h xachlorobenz ne	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
hexachlorobutadiene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
hexachlorocyclop ntadiene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
hexachloroethane	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
indeno(1,2,3-cd)pyrene	460 U	430 U	62 J	240 J	49 J	220 J	420 UJ	140 J	400 J
isophorone	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
naphthalene	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
nitrobenz n	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
pentachlorophenol	1200 U	1100 U	1100 U	1200 U	1100 U	1100 U	1100 UJ	1100 UJ	1100 U
phenanthrene	460 U	430 U	120 J	990	110 J	650	420 UJ	490 J	1500
phenol	460 U	430 U	420 U	480 U	440 U	450 U	420 UJ	430 UJ	440 U
pyrene	51 J	46 J	220 J	870	250 J	810	56 J	610 J	1600
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
4,4'-DDD	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
4,4'-DDE	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
4,4'-DDT	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	6.2 J
Aroclor-1016	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
Aroclor-1221	93 U	88 U	86 U	97 U	89 U	91 U	86 U	88 U	89 U
Aroclor-1232	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
Aroclor-1242	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
Aroclor-1248	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
Aroclor-1254	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U

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- UL -- Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR -- Non-detected result is consider d unusable due to exceedance f technical quality control criteria.
- L -- Positive r sult is considered biased low due to exceedance of technical quality control criteria.
- K -- Positive result is considered bias d high due to exceedance of technical quality control criteria.
- B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R -- Positive result is considered unusable due to xceedance of technical quality control criteria.

TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS01	BGSS01-DUP	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
LOCATION:	BGSS01	BGSS01	BGSS02	BGSS03	BGSS04	BGSS05	BGSS06	BGSS07	BGSS08
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
SAMPLE DATE:	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97	04/07/97
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Aroclor-1260	46 U	43 U	42 U	48 U	44 U	45 U	42 U	43 U	44 U
aldrin	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
alpha-BHC	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
alpha-chlordane	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
beta-BHC	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
delta-BHC	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
dieldrin	13	14	4.2 U	760	13 J	220	14	86	420
endosulfan I	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
endosulfan II	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
endosulfan sulfat	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
endrin	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
endrin aldehyde	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
endrin ketone	4.6 U	4.3 U	4.2 U	4.8 U	4.4 U	4.5 U	4.2 U	4.3 U	4.4 U
gamma-BHC (Lindane)	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
gamma-chlordane	2.4 U	2.2 U	2.2 U	10 J	2.3 U	2.3 U	2.2 U	2.2 U	34
heptachlor	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	2.3 U
heptachlor epoxide	2.4 U	2.2 U	2.2 U	2.5 U	2.3 U	2.3 U	2.2 U	2.2 U	33
methoxychlor	24 U	22 U	22 U	25 U	23 U	23 U	22 U	22 U	23 U
toxaph n	240 U	220 U	220 U	250 U	230 U	230 U	220 U	220 U	230 U

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TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE S IL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil						
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97						
INORGANICS	mg/kg		mg/kg		mg/kg		mg/kg						
aluminum	12000		10700		11900		10300						
antimony	8.7	R	6.4	R	8.1	R	8.8	R					
arsenic	6.1	J	7.4		8		6.3						
barium	89.7		90		111		83.7						
beryllium	0.79		1		1.3		0.92						
cadmium	1.2	U	1.3	U	1.3	U	1.3	U					
calcium	614		762		1160		1600						
chromium, total	12.4		13.8		15.3		16						
cobalt	8.2		6.9		8.5		7						
copper	13.4		9.3		9.3		12.7						
cyanid	3.8		0.7		0.64	U	0.66	U					
iron	15700		13300		16700		15500						
lead	16.3		29	K	20.5		31.4						
magn sium	1530		1300		1480		1550						
mangan se	429		667		844		477						
mercury	0.12	U	0.13	U	0.13	U	0.13	U					
nick l	10.4		7.4		9.6		10.1						
potassium	460		531		388	U	396	U					
selenium	1.2	UL	1.3	UL	1.3	UL	1.3	UL					
silver	1.2	U	1.3	U	1.3	U	1.3	U					
sodium	120		106	U	103	U	112						
thallium	0.25		0.3		0.29		0.28						
vanadium	20.9		23.7		26.2		26.5						
zinc	21.7		44.6		49.4		45.8						

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- UL – Non-detected result is considered biased low due to xceedance of technical quality control criteria.
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- L – Positive result is considered biased low due to exceedance of technical quality control criteria.
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TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil						
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97						
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**						
1,2,4-trichlorobenzene	390	U	440	U	430	U	440	U					
1,2-dichlorobenz ne	390	U	440	U	430	U	440	U					
1,3-dichlorobenzene	390	U	440	U	430	U	440	U					
1,4-dichlorobenzene	390	U	440	U	430	U	440	U					
2,2'-oxybis(1-chloropropane)	390	U	440	U	430	U	440	U					
2,4,5-trichlorophenol	990	U	1100	U	1100	U	1100	U					
2,4,6-trichlorophenol	390	U	440	U	430	U	440	U					
2,4-dichlorophenol	390	U	440	U	430	U	440	U					
2,4-dimethylphenol	390	U	440	U	430	U	440	U					
2,4-dinitrophenol	990	U	1100	U	1100	U	1100	U					
2,4-dinitrotoluene	390	U	440	U	430	U	440	U					
2,6-dinitrotoluene	390	U	440	U	430	U	440	U					
2-chloronaphthalene	390	U	440	U	430	U	440	U					
2-chlorophen l	390	U	440	U	430	U	440	U					
2-m thylnaphthalene	390	U	440	U	430	U	440	U					
2-m thylph n l	390	U	440	U	430	U	440	U					
2-nitroaniline	990	U	1100	U	1100	U	1100	U					
2-nitrophenol	390	U	440	U	430	U	440	U					
3,3'-dichlorobenzidine	390	U	440	U	430	U	440	U					
3-nitroaniline	990	U	1100	U	1100	U	1100	U					
4,6-dinitro-2-methylphenol	990	U	1100	U	1100	U	1100	U					
4-bromophenyl-phenylether	390	U	440	U	430	U	440	U					
4-chloro-3-methylphenol	390	U	440	U	430	U	440	U					
4-chloroanilin	390	U	440	U	430	U	440	U					

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- UJ – Non-detect d r sult is considered estimated due t exceedance of t chnical quality control criteria.
- UL – Non-detected result is considered biased low due to exceedance of t chnical quality control criteria.
- UR – Non-detected result is considered unusable due to exceedance of t chnical quality control criteria.
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TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---		---		---		---		---	
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---		---		---		---		---	
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil											
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97											
SEMIVOLATILES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**											
4-chlorophenyl-phenylether	390	U	440	U	430	U	440	U										
4-m thylphenol	390	U	440	U	430	U	440	U										
4-nitroaniline	990	U	1100	U	1100	U	1100	U										
4-nitrophenol	990	U	1100	U	1100	U	1100	U										
N-nitroso-di-n-propylamine	390	U	440	U	430	U	440	U										
N-nitrosodiphenylamine (1)	390	U	440	U	430	U	440	U										
acenaphthene	390	U	64	J	430	U	55	J										
acenaphthylen	390	U	54	J	430	U	62	J										
anthracene	390	U	130	J	430	U	160	J										
benzo(a)anthracene	390	U	590		430	U	940											
benzo(a)pyrene	390	U	830		430	U	1100											
benzo(b)fluoranthene	390	U	1000		430	U	1500											
benz (g,h,i)perylene	390	U	320	J	430	U	490											
benzo(k)fluoranthene	390	U	820		430	U	920											
bis(2-chloroethoxy)methane	390	U	440	U	430	U	440	U										
bis(2-chloro thyl)ether	390	U	440	U	430	U	440	U										
bis(2-ethylhexyl)phthalate	92	B	110	B	110	B	130	B										
butylbenzylphthalate	390	U	440	U	430	U	440	U										
carbazole	390	U	310	J	430	U	260	J										
chrysene	390	U	860		430	U	1200											
di-n-butylphthalate	460	B	1000	B	740	B	660	B										
di-n-octylphthalate	390	U	440	U	430	U	440	U										
dibenz(a,h)anthracene	390	U	96	J	430	U	160	J										
dibenzofuran	390	U	120	J	430	U	61	J										
diethylphthalat	390	U	440	U	430	U	440	U										

NOTES:

- J – Value is considered estimated due to exceedance of technical quality control criteria or because result is less than the Contract Required Quantitation Limit (CRQL).
- U – Value is a non-detected result as reported by the laboratory.
- UJ – Non-det cted result is considered estimated due to xceedance of technical quality control criteria.
- UL – Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR – Non-det cted r sult is considered unusable due to exceedance of technical quality control criteria.
- L – Positiv result is consid red biased low due to exceedance of technical quality control criteria.
- K – Positiv result is considered biased high due to exceedance of t chnical quality control criteria.
- B – Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R – Positive result is consid red unusabl due to exceedance of technical quality control criteria.

TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Backgr und

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---	---	---	---	---
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil						
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97						
SEMIVOLATILES	ug/kg		ug/kg		ug/kg		ug/kg						
dimethylphthalate	390	U	440	U	430	U	440	U					
flu ranthene	390	U	2300		430	U	2600						
fluoren	390	U	160	J	430	U	120	J					
hexachlorobenzene	390	U	440	U	430	U	440	U					
hexachlorobutadi ne	390	U	440	U	430	U	440	U					
hexachlorocyclopentadiene	390	U	440	U	430	U	440	U					
hexachloroethane	390	U	440	U	430	U	440	U					
indeno(1,2,3-cd)pyrene	390	U	420	J	430	U	640						
isophoron	390	U	440	U	430	U	440	U					
naphthalene	390	U	440	U	430	U	440	U					
nitrobenz ne	390	U	440	U	430	U	440	U					
pentachlorophenol	990	U	1100	U	1100	U	1100	U					
phenanthrene	390	U	1600		430	U	1700						
ph nol	390	U	440	U	430	U	440	U					
pyrene	390	U	1700		430	U	2100						
PESTICIDES	ug/kg		ug/kg		ug/kg		ug/kg						
4,4'-DDD	3.9	U	4.3	U	4.3	U	4.3	U					
4,4'-DDE	3.9	U	4.3	U	4.3	U	4.3	U					
4,4'-DDT	3.9	U	8.3	J	4.3	U	4.3	U					
Aroclor-1016	39	U	43	U	43	U	43	U					
Aroclor-1221	80	U	88	U	87	U	88	U					
Aroclor-1232	39	U	43	U	43	U	43	U					
Aroclor-1242	39	U	43	U	43	U	43	U					
Aroclor-1248	39	U	43	U	43	U	43	U					
Aroclor-1254	39	U	43	U	43	U	43	U					

NOTES:

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U -- Value is a non-d tect d result as reported by the laboratory.
UJ -- Non-detected result is considered estimat d due to exceedance of technical quality control criteria.
UL -- Non-detected r sult is considered biased low due to exceedance f technical quality control criteria.
UR -- Non-detected result is considered unusable due to exceedance of technical quality control criteria.
L -- P sitive result is consid r d biased low due to exceedance of technical quality control criteria.
K -- Positive result is considered biased high due to exceedance of technical quality control criteria.
B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
R -- Positiv r sult is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-10

ANALYTICAL RESULTS FOR SURFACE SOIL - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSS09		BGSS10		BGSS11		BGSS12		---		---		---		---		---	
LOCATION:	BGSS09		BGSS10		BGSS11		BGSS12		---		---		---		---		---	
DATA SOURCE:	Surface Soil		Surface Soil		Surface Soil		Surface Soil											
SAMPLE DATE:	04/07/97		04/07/97		04/07/97		04/07/97											
PESTICIDES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**											
Aroclor-1260	39	U	43	U	43	U	43	U										
aldrin	2	U	2.2	U	2.2	U	2.2	U										
alpha-BHC	2	U	2.2	U	2.2	U	2.2	U										
alpha-chlordane	2	U	2.2	U	2.2	U	2.2	U										
beta-BHC	2	U	2.2	U	2.2	U	2.2	U										
delta-BHC	2	U	2.2	U	2.2	U	2.2	U										
dieldrin	3.9	U	550		4.3	U	63	J										
endosulfan I	2	U	2.2	U	2.2	U	2.2	U										
endosulfan II	3.9	U	4.3	U	4.3	U	4.3	U										
endosulfan sulfate	3.9	U	4.3	U	4.3	U	4.3	U										
ndrin	3.9	U	4.3	U	4.3	U	4.3	U										
ndrin aldehyde	3.9	U	4.3	U	4.3	U	4.3	U										
endrin ketone	3.9	U	4.3	U	4.3	U	4.3	U										
gamma-BHC (Lindane)	2	U	2.2	U	2.2	U	2.2	U										
gamma-chlordane	2	U	48	J	2.2	U	3.2											
heptachlor	2	U	2.2	U	2.2	U	2.2	U										
heptachlor epoxide	2	U	47		2.2	U	3.4	J										
methoxychlor	20	U	22	U	22	U	22	U										
toxaphene	200	U	220	U	220	U	220	U										

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- UJ – Non-detected result is considered estimated due to exceedance of technical quality control criteria.
- UL – Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR – Non-detected result is considered unusable due to exceedance of technical quality control criteria.
- L – Positive result is considered biased low due to exceedance of technical quality control criteria.
- K – Positive result is consider d biased high due to exceedance of technical quality control criteria.
- B – Positive r sult is considered to be an artifact of blank contamination, and should not be considered present.
- R – Positive result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Backgr und

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
INORGANICS	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
aluminum	226	B	247	B	284	B	561		267	B	236	B	163	B	177	B	301	B
antimony	20	U	20	U	20	U	20	U	20	U	20	U	20	U	20	U	20	U
arsenic	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
barium	93		95.9		93.6		97.2		105		112		87.3		110		109	
beryllium	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
cadmium	5	UL	5	UL	5	UL	5	UL	5	UL	5	UL	5	UL	5	UL	5	UL
calcium	34900		34400		26800		27700		28000		15800		22400		18500		15800	
chromium, total	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
cobalt	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
copper	10	U	10	U	10	U	16.6		10	U	10	U	10	U	10	U	10	U
cyanide	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
iron	222		351		519		751		366		273		85.3		311		326	
lead	1	U	1	U	1	U	1.1		1	U	1	U	1	U	1	U	1	U
magn sium	12100		11800		9740		10100		9750		6290		8260		6940		6250	
manganese	75.7		92		98.5		122		65.8		56.7		26.7		45.1		64.2	
mercury	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U
nickel	20	U	20	U	20	U	31.4		20	U	20	U	20	U	20	U	20	U
potassium	2860		2570		1930		1950		2110		1870		1750		1500	U	1500	U
selenium	1	UL	1	UL	5	U	1	U	1	UL	5	U	5	U	5	U	5	U
silver	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
sodium	34000		36200		22500		17400		23300		10700		13200		12700		10800	
thallium	1	UL	1	UL	1	UL	1	UL	1	UL	1	UL	1	UL	1	UL	1	UL
vanadium	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U	5	U
zinc	5	U	7.8		6.8		18.9		9.1		5	U	5	U	5	U	5	U

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- UL -- Non-detected result is considered biased low due to exceedance of t chnical quality control criteria.
- UR -- Non-detected result is considered unusable due to exceedance of technical quality control criteria.
- L -- Positiv result is considered biased low due to exceedance of technical quality control criteria.
- K -- Positiv result is consid red biased high due to exce dance of technical quality control criteria.
- B -- Positiv result is consid red to b an artifact of blank contamination, and should not b considered present.
- R -- Positive result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
SEMIVOLATILES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
1,2,4-trichlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
1,2-dichlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
1,3-dichlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
1,4-dichlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,2'-oxybis(1-chloropropane)	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,4,5-trichloroph nol	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
2,4,6-trichlorophenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,4-dichlorophenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,4-dimethylphenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,4-dinitrophenol	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
2,4-dinitrotoluene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2,6-dinitrotoluene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-chloronaphthal ne	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-chlorophenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-methylnaphthalene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-m thylphenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
2-nitroaniline	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
2-nitrophenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
3,3'-dichlorobenzidine	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
3-nitroaniline	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
4,6-dinitro-2-methylphenol	25	U	25	U	25	U	25	U	25	U	25	U	25	U	250	U	25	U
4-bromophenyl-phenylether	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
4-chloro-3-methylphenol	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U
4-chloroaniline	10	U	10	U	10	U	10	U	10	U	10	U	10	U	100	U	10	U

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- UL -- Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR -- Non-det cted result is consid red unusable due to exceedance of technical quality control criteria.
- L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
- K -- Positive result is considered biased high due to exceedance of technical quality control criteria.
- B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R -- Positive result is consid red unusable due to exceedance of technical quality control criteria.

TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01	BGSW02	BGSW03	BGSW03-DUP	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
LOCATION:	BGSW01	BGSW02	BGSW03	BGSW03	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
DATA SOURCE:	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
SEMIVOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
4-chlorophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
4-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
4-nitroaniline	25 U	25 U	25 U	25 U	25 U	25 U	25 U	250 U	25 U
4-nitrophenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	250 U	25 U
N-nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
N-nitrosodiphenylamine (1)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
acenaphthen	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benzo(a)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benz (b)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benz (g,h,i)p rylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
benzo(k)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
bis(2-chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
carbazole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
di-n-butylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
di-n-octylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
dibenz(a,h)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
diethylphthalat	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U

NOTES:

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- UL – Non-detected result is consid red biased low due to exceedance of technical quality control criteria.
- UR – Non-detected result is consid red unusable due to exceedance of technical quality control criteria.
- L – Positive result is considered biased low due to exceedance of technical quality control criteria.
- K – P sitiv result is considered biased high due to exce dance of technical quality control criteria.
- B – Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R – *Positive result is considered unusable due to exceedance of technical quality control criteria.*

TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Backgr und

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01	BGSW02	BGSW03	BGSW03-DUP	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
LOCATION:	BGSW01	BGSW02	BGSW03	BGSW03	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
DATA SOURCE:	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
h xachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
isophoron	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
nitrobenzen	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
pentachlorophenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	250 U	25 U
phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
phenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-tetrachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-dichloroethan	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-dichloroethene (total)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-dichloropropane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-butanon	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

NOTES:

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- UL – Non-d t cted result is considered biased low due to exceedance of technical quality control criteria.
- UR – Non-detected result is considered unusable due to xceedance of technical quality control criteria.
- L – Positive result is consid red biased low due to exceedance of technical quality control crit ria.
- K – Positive result is considered biased high due to exceedance of technical quality control criteria.
- B – P sitive result is considered to be an artifact of blank contamination, and should not be considered present.
- R – Positiv result is consider d unusable due to exceedance of technical quality control criteria.

TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Backgr und

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
VOLATILES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
2-hexanone	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
4-methyl-2-pentanone	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
acetone	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
benzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
bromodichloromethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
bromoform	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
bromomethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
carbon disulfide	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
carbon tetrachloride	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
chlorobenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
chloroethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
chl roform	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
chloromethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
cis-1,3-dichloropropene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
dibromochloromethane	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
ethylbenzene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
methylene chloride	10	U	10	U	20	B	13	B	16	B	11	B	23	B	7	B	15	B
styrene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
tetrachloroethene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
toluene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
trans-1,3-dichloropropene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
trichloroethene	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
vinyl chloride	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U
xylene (total)	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U	10	U

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TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01		BGSW02		BGSW03		BGSW03-DUP		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
LOCATION:	BGSW01		BGSW02		BGSW03		BGSW03		BGSW04		BGSW05		BGSW06		BGSW07		BGSW08	
DATA SOURCE:	Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water		Surface Water	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
PESTICIDES	ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L		ug/L	
4,4'-DDD	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
4,4'-DDE	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
4,4'-DDT	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Aroclor-1016	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1221	2	U	2	U	2	U	2	U	2	U	2	U	2	U	2	U	2	U
Aroclor-1232	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1242	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1248	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1254	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Aroclor-1260	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
aldrin	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
alpha-BHC	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
alpha-chlordane	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
beta-BHC	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
d lta-BHC	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
dieldrin	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endosulfan I	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
ndosulfan II	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endosulfan sulfate	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endrin	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endrin aldehyde	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
endrin ketone	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
gamma-BHC (Lindane)	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
gamma-chlordane	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U

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- UR – Non-detected result is considered unusable due to exceedance of technical quality control criteria.
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- K – Positive result is considered biased high due to exceedance of technical quality control criteria.
- B – Positive result is consid red to be an artifact of blank contamination, and should not be considered present.
- R – *Positive result is considered unusable due to exceedance of technical quality control criteria.*

TABLE 2-11

ANALYTICAL RESULTS FOR SURFACE WATER - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSW01	BGSW02	BGSW03	BGSW03-DUP	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
LOCATION:	BGSW01	BGSW02	BGSW03	BGSW03	BGSW04	BGSW05	BGSW06	BGSW07	BGSW08
DATA SOURCE:	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
PESTICIDES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
heptachlor	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
heptachlor epoxid	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
methoxychlor	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
t xaphene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U

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TABLE 2-12

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01		BGSD02		BGSD03		BGSD03-DUP		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
LOCATION:	BGSD01		BGSD02		BGSD03		BGSD03		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
DATA SOURCE:	Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
INORGANICS	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	
aluminum	8950		7330		5750		10900		6000		3610		8510		4690		5580	
antimony	12.6	R	5.5	UJ	7.8	UJ	7.8	UJ	6.2	UJ	4.6	UJ	11.1	R	5.1	UJ	5.5	R
arsenic	7.2		3.7		5		5.6		4.1		3.2		4		4.9		4	
barium	105		54.6		142		179		106		76.2		81.2		82.4		120	
beryllium	1.2		0.52		1.1		1.3		0.81		0.6		1.1		0.61		0.98	
cadmium	1.2	UL	1.4	UL	2	UL	1.9	UL	1.6	UL	1.1	UL	1.2	UL	1.3	UL	1.4	UL
calcium	14800		744		1850		2070		1060		878		18200		1080		1130	
chromium, total	34.5		9.7		10.9		16.5		13.5		6.8		29.3		8.7		9.2	
cobalt	12.4		5.8		5.5		7.7		6.8		4.5		9.8		4.9		6.9	
copper	27.8		11.3		11.9		13.7		10.9		5.8		22.1		7.4		8.8	
cyanid	0.61	U	0.68	U	0.97	U	0.96	U	0.77	U	0.56	U	0.58	U	0.62	U	0.67	U
iron	35400		10500		11400		15000		13700		9540		25400		9660		14300	
lead	18.7		20.4		26.8		28.4		19.6		6.4		8.6		10.6		10.4	
magnesium	9100		1000		1130		1670		999		1350		10600		1450		1600	
manganese	759		384		416		551		573		376		529		388		618	
mercury	0.12	U	0.14	U	0.2	U	0.19	U	0.16	U	0.11	U	0.12	U	0.13	U	0.14	U
nickel	22.7		6.8	K	12.5		16.1		9.1		7.8	K	19.1		10.1		9.7	
potassium	2330		514		586	U	825		467	U	775		2330		721		921	
selenium	0.24	UJ	0.27	UJ	0.44	J	0.51	J	0.36	J	0.23	UJ	0.23	UJ	0.25	UJ	0.27	UJ
silver	1.2	U	1.4	U	2	U	1.9	U	1.6	U	1.1	U	1.2	U	1.3	U	1.4	U
sodium	560		109	U	156	U	155	U	125	U	91.7	U	240		101	U	109	U
thallium	0.24	U	0.27	U	0.39	U	0.39	U	0.31	U	0.23	U	0.23	U	0.25	U	0.27	U
vanadium	52.6		12.2		20.3		25.8		18.8		7.9		42.8		11.9		11.9	
zinc	97.6		39.5		43.9		60		51.3		25.4		80.4		28.2		35	

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TABLE 2-12

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01	BGSD02	BGSD03	BGSD03-DUP	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
LOCATION:	BGSD01	BGSD02	BGSD03	BGSD03	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,2,4-trichlorobenzene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
1,2-dichlorobenz ne	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
1,3-dichlorobenz ne	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
1,4-dichlorobenz ne	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2,2'-oxybis(1-chloropropane)	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2,4,5-trichlorophenol	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
2,4,6-trichlorophenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2,4-dichlorophenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2,4-dimethylphenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2,4-dinitrophenol	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
2,4-dinitrotoluene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2,6-dinitrot luene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2-chloronaphthalene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2-chlorophenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2-methylnaphthalene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2-methylphenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
2-nitroaniline	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
2-nitrophenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
3,3'-dichlorobenzidine	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
3-nitroaniline	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
4,6-dinitro-2-methylphenol	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
4-bromophenyl-ph nylether	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
4-chloro-3-methylphenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
4-chloroanilin	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U

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TABLE 2-12

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01	BGSD02	BGSD03	BGSD03-DUP	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
LOCATION:	BGSD01	BGSD02	BGSD03	BGSD03	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
4-chlorophenyl-phenylether	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
4-methylphenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
4-nitroaniline	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
4-nitrophenol	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
N-nitroso-di-n-propylamine	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
N-nitrosodiphenylamine (1)	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
acenaphth ne	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
acenaphthylene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
anthracen	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
benzo(a)anthracene	580	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
benzo(a)pyrene	530 J	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
benzo(b)fluoranthene	670 J	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
benzo(g,h,i)perylene	400 UJ	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
benzo(k)fluoranthene	300 J	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
bis(2-chloroethoxy)methane	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
bis(2-chloroethyl)ether	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
bis(2-ethylhexyl)phthalate	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
butylbenzylphthalate	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
carbazole	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
chrysene	640	450 U	130 J	90 J	110 J	380 U	380 U	420 U	450 U
di-n-butylphthalate	400 UJ	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
di-n-octylphthalate	400 UJ	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
dibenz(a,h)anthracene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
dibenzofuran	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
diethylphthalate	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U

NOTES:

- J – Value is considered estimated due to exceedance of technical quality control criteria or because result is less than the Contract Required Quantitation Limit (CRQL).
- U – Value is a n n-d t cted result as reported by the laboratory.
- UJ – Non-detected result is consid red stimated due to xceedance of technical quality control criteria.
- UL – Non-detected result is considered biased low due to exceedance of technical quality control criteria.
- UR – Non-detected result is considered unusable due to exceedance of technical quality control criteria.
- L – Positive result is considered biased low due to exceedance of technical quality control criteria.
- K – Positive result is considered biased high due to exceedance of technical quality control criteria.
- B – *Positive result is considered to be an artifact of blank contamination, and should not be considered present.*
- R – [illegible]tive result is considered unusable due to exceedance of technical quality control [illegible]ia.

TABLE 2-12

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01	BGSD02	BGSD03	BGSD03-DUP	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
LOCATION:	BGSD01	BGSD02	BGSD03	BGSD03	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
SEMIVOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
dimethylphthalate	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
fluoranth ne	510	100 J	210 J	140 J	170 J	380 U	380 U	420 U	450 U
fluoren	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
hexachlorobenzene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
hexachlorobutadiene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
hexachlorocyclopentadiene	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
hexachloroethan	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
indeno(1,2,3-cd)pyrene	400 UJ	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
isophorone	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
naphthal ne	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
nitrobenzen	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
pentachloroph nol	1000 U	1100 U	1600 U	1600 U	1300 U	950 U	960 U	1100 U	1100 U
phenanthrene	260 J	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
phenol	400 U	450 U	650 U	640 U	510 U	380 U	380 U	420 U	450 U
pyrene	1300	100 J	190 J	120 J	150 J	380 U	380 U	420 U	450 U
VOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
1,1,1-trichloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,1,2,2-tetrachloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,1,2-trichloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,1-dichloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,1-dichloroethene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,2-dichloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,2-dichloroethene (total)	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
1,2-dichloropropane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
2-butanone	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U

NOTES:

- J -- Value is consid red stimated due to exceedance of t chnical quality control criteria or because result is less than the Contract R quired Quantitation Limit (CRQL).
- U -- Value is a non-detected result as reported by the laboratory.
- UJ -- Non-detected result is considered estimated due to exceedance of technical quality control criteria.
- UL -- Non-det cted result is considered biased low due to exceedance of technical quality control criteria.
- UR -- Non-detected result is considered unusable due to exce dance of technical quality control crit ria.
- L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
- K -- Positive result is consid red biased high due to exceedance of technical quality control criteria.
- B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R -- Positive result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-12

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01	BGSD02	BGSD03	BGSD03-DUP	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
LOCATION:	BGSD01	BGSD02	BGSD03	BGSD03	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
VOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
2-hexanone	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
4-methyl-2-pentanone	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
acetone	38 B	51 B	20 U	19 U	91 B	12 U	12 U	13 U	14 U
benz ne	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
bromodichloromethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
bromoform	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
bromom thane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
carbon disulfide	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
carbon tetrachloride	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
chlorobenzene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
chloroethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
chloroform	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
chloromethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
cis-1,3-dichloropropene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
dibromochloromethane	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
ethylbenz ne	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
methylene chlorid	8 B	9 B	20 U	19 U	11 B	12 U	12 U	13 U	14 U
styrene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
tetrachloroethene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
toluene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
trans-1,3-dichloropropene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
trichloroethene	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
vinyl chloride	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U
xylene (total)	12 U	14 U	20 U	19 U	16 U	12 U	12 U	13 U	14 U

NOTES:

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U – Value is a non-detected result as reported by the laboratory.
UJ – Non-detected r sult is considered stimated du to exceedance of technical quality control criteria.
UL – Non-detected result is considered biased low due to exceedance of technical quality control criteria.
UR – Non-detected result is considered unusable due to exceedance of technical quality control criteria.
L – Positive result is considered biased low due to exceedance of technical quality control criteria.
K – Positive result is considered biased high due to exceedance of technical quality control criteria.
B – Positive result is consider d to be an artifact of blank contamination, and should not be considered present.
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TABLE 2-12

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01		BGSD02		BGSD03		BGSD03-DUP		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
LOCATION:	BGSD01		BGSD02		BGSD03		BGSD03		BGSD04		BGSD05		BGSD06		BGSD07		BGSD08	
DATA SOURCE:	Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment		Sediment	
SAMPLE DATE:	03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97		03/13/97	
PESTICIDES	ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg		ug/kg	
4,4'-DDD	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
4,4'-DDE	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
4,4'-DDT	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
Aroclor-1016	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1221	82	U	91	U	130	U	130	U	100	U	77	U	78	U	85	U	91	U
Aroclor-1232	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1242	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1248	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1254	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
Aroclor-1260	40	U	45	U	65	U	64	U	51	U	38	U	38	U	42	U	45	U
aldrin	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
alpha-BHC	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
alpha-chlordane	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
beta-BHC	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
delta-BHC	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
dieldrin	4	U	4.5	U	3.1	J	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endosulfan I	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
endosulfan II	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endosulfan sulfat	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endrin	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endrin aldehyd	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
endrin ketone	4	U	4.5	U	6.4	U	6.4	U	5.1	U	3.8	U	3.8	U	4.2	U	4.5	U
gamma-BHC (Lindane)	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U
gamma-chlordane	2.1	U	2.3	U	3.3	U	3.3	U	2.6	U	1.9	U	2	U	2.1	U	2.3	U

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- L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
- K -- Positive result is considered biased high due to exceedance of technical quality control criteria.
- B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
- R -- *Positive result is considered unusable due to exceedance of technical quality control criteria.*

TABLE 2-12

ANALYTICAL RESULTS FOR SEDIMENT - SITE Background

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	BGSD01	BGSD02	BGSD03	BGSD03-DUP	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
LOCATION:	BGSD01	BGSD02	BGSD03	BGSD03	BGSD04	BGSD05	BGSD06	BGSD07	BGSD08
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
SAMPLE DATE:	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97	03/13/97
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
heptachlor	2.1 U	2.3 U	3.3 U	3.3 U	2.6 U	1.9 U	2 U	2.1 U	2.3 U
heptachlor poxid	2.1 U	2.3 U	3.3 U	3.3 U	2.6 U	1.9 U	2 U	2.1 U	2.3 U
methoxychlor	21 U	23 U	33 U	33 U	27 U	20 U	20 U	22 U	23 U
toxaphene	210 U	230 U	330 U	330 U	270 U	200 U	200 U	220 U	230 U

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- U -- Value is a non-detected result as reported by the laboratory.
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- UL -- Non-detected result is considered biased low due to exceedance f t chnical quality control criteria.
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- L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
- K -- Positive result is considered biased high due to exceedance of technical quality control criteria.
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- R -- Positive result is considered unusable due to exceedance of technical quality control criteria.

TABLE 2-13
Background Statistics - Soil Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Max.	Mean of All Data	Sampling Round and Location of Maximum	95% Upper Tolerance Limit (UTL) Back. Mean[a]	Std.Dev. Back.[a]	t Value	LN Q	Back. UTL
aluminum	12/12	9090 -	15000	11300	BGSS06 04/07/97	9.32	0.149	1.7959	L	14700
antimony	0/2	-			NA					
arsenic	12/12	3.7 -	10.6	6.65	BGSS03 04/07/97	1.86	0.283	1.7959	L	10.9
barium	12/12	77.8 -	111	95.7	BGSS04 04/07/97	4.55	0.13	1.7959	L	121
beryllium	12/12	0.75 -	1.3	0.987	BGSS11 04/07/97	-0.0301	0.192	1.7959	L	1.39
cadmium	0/12	-			NA					
calcium	12/12	614 -	1600	1020	BGSS12 04/07/97	6.87	0.332	1.7959	L	1800
chromium	12/12	12.4 -	20.8	15.3	BGSS02 04/07/97	2.72	0.141	1.7959	L	19.8
cobalt	12/12	6.8 -	9.3	7.9	BGSS02 04/07/97	7.9	0.788	1.7959	N	9.38
copper	12/12	8 -	13.4	10.7	BGSS09 04/07/97	10.7	1.54	1.7959	N	13.6
cyanide	2/12	0.7 -	3.8	0.649	BGSS09 04/07/97	0.649				
iron	12/12	12350 -	17600	14800	BGSS06 04/07/97	9.6	0.119	1.7959	L	18400
lead	12/12	16.3 -	64.7	30.6	BGSS04 04/07/97	3.33	0.428	1.7959	L	62.2
magnesium	12/12	1300 -	1940	1500	BGSS06 04/07/97	7.31	0.108	1.7959	L	1830
manganese	12/12	429 -	1190	642	BGSS04 04/07/97	6.43	0.277	1.7959	L	1040
mercury	0/12	-			NA					
nickel	12/12	7.4 -	11.2	9.79	BGSS04 04/07/97	9.79	0.954	1.7959	N	11.6
potassium	7/12	436 -	771	434	BGSS05 04/07/97	434				
selenium	0/12	-			NA					
silver	0/12	-			NA					
sodium	2/12	112 -	120	63.7	BGSS09 04/07/97	63.7				
thallium	7/12	0.25 -	0.34	0.226	BGSS07 04/07/97	0.226				
vanadium	12/12	20.9 -	28.2	24.9	BGSS02 04/07/97	24.9	2.13	1.7959	N	28.9
zinc	12/12	21.7 -	597	90.1	BGSS04 04/07/97	90.1				
4,4'-DDD	0/12	-			NA					
4,4'-DDE	0/12	-			NA					
4,4'-DDT	2/12	6.2 -	8.3	3.01	BGSS10 04/07/97	3.01				

TABLE 2-13

Background Statistics - Soil Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	95% Upper Tolerance Limit (UTL) Back. Mean[@]	Std.Dev. Back.[@]	t Value	LN Q	Back. UTL
Aroclor-1254	0/12	-			NA					
Aroclor-1260	0/12	-			NA					
beta-BHC	0/12	-			NA					
dieldrin	9/12	13	760	179	BGSS03 04/07/97	179				
endosulfan I	0/12	-			NA					
endrin	0/12	-			NA					
heptachlor	0/12	-			NA					
heptachlor epoxide	3/12	3.4	47	7.79	BGSS10 04/07/97	7.79				
1,2,4-trichlorobenzene	0/12	-			NA					
1,2-dichlorobenzene	0/12	-			NA					
1,4-dichlorobenzene	0/12	-			NA					
2-methylnaphthalene	0/12	-			NA					
2-methylphenol	0/12	-			NA					
acenaphthene	3/12	55	64	178	BGSS10 04/07/97	178				
acenaphthylene	3/12	54	62	177	BGSS12 04/07/97	177				
anthracene	6/12	46	160	154	BGSS12 04/07/97	154				
benz(a)anthracene	9/12	33	940	306	BGSS12 04/07/97	306				
benzo(a)pyrene	8/12	110	1100	394	BGSS12 04/07/97	394				
benzo(b)fluoranthene	8/12	160	1500	507	BGSS12 04/07/97	507				
benzo(g,h,i)perylene	7/12	52	490	225	BGSS12 04/07/97	225				
benzo(k)fluoranthene	7/12	98	920	370	BGSS12 04/07/97	370				
butylbenzylphthalate	3/12	83	280	208	BGSS02 04/07/97	208				
carbazole	5/12	80	310	212	BGSS10 04/07/97	212				
chrysene	9/12	43	1200	420	BGSS12 04/07/97	420				
di-n-butylphthalate	0/2	-			NA					
dibenz(a,h)anthracene	5/12	52	160	161	BGSS12 04/07/97	161				
dibenzofuran	4/12	51	120	172	BGSS08 04/07/97	172				

TABLE 2-13

Background Statistics - Soil Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL
fluoranthene	10/12	49	2600	902	BGSS12 04/07/97	902				
fluorene	4/12	59	160	184	BGSS08 04/07/97	184				
indeno(1,2,3-cd)pyrene	8/12	49	640	251	BGSS12 04/07/97	251				
N-nitrosodiphenylamine (1)	0/12	-			NA					
naphthalene	0/12	-			NA					
phenanthrene	8/12	110	1700	667	BGSS12 04/07/97	667				
pyrene	10/12	48.5	2100	723	BGSS12 04/07/97	723				

Notes: Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

Abbreviations:

L, N, or Q — UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.

@ — Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test and background distribution matches lognormal.

TABLE 2-14
Background Statistics - Sediment Data
NASJRB Will w Grov , Penn ylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean[a]	Std.Dev. Back.[a]	t Value	L,N Q	Back. UTL
aluminum	8/8	3610	8950	6620	BGSD01 03/13/97	6620	1950	1.8946	N	10500
antimony	0/5	-			NA					
arsenic	8/8	3.2	7.2	4.55	BGSD01 03/13/97	1.49	0.252	1.8946	L	7.33
barium	8/8	54.6	160.5	98.2	BGSD03 03/13/97	4.54	0.327	1.8946	L	181
beryllium	8/8	0.52	1.2	0.878	BGSD01 03/13/97	0.878	0.28	1.8946	N	1.44
cadmium	0/8	-			NA					
calcium	8/8	744	18200	4980	BGSD06 03/13/97	4980				
chromium	8/8	6.8	34.5	15.7	BGSD01 03/13/97	2.59	0.585	1.8946	L	43.2
cobalt	8/8	4.5	12.4	7.21	BGSD01 03/13/97	1.92	0.338	1.8946	L	13.5
copper	8/8	5.8	27.8	13.4	BGSD01 03/13/97	2.46	0.528	1.8946	L	34
cyanide	0/8	-			NA					
iron	8/8	9540	35400	16500	BGSD01 03/13/97	9.6	0.473	1.8946	L	38200
lead	8/8	6.4	27.6	15.3	BGSD03 03/13/97	2.62	0.509	1.8946	L	38.1
magnesium	8/8	999	10600	3440	BGSD06 03/13/97	3440				
manganese	8/8	376	759	514	BGSD01 03/13/97	6.21	0.256	1.8946	L	834
mercury	0/8	-			NA					
nickel	8/8	6.8	22.7	12.5	BGSD01 03/13/97	2.44	0.43	1.8946	L	27.1
potassium	7/8	514	2330	1050	BGSD01 03/13/97	6.7	0.771	1.8946	L	3820
selenium	2/8	0.36	0.475	0.198	BGSD03 03/13/97	0.198				
sodium	2/8	240	560	143	BGSD01 03/13/97	143				
thallium	0/8	-			NA					
vanadium	8/8	7.9	52.6	22.6	BGSD01 03/13/97	2.91	0.669	1.8946	L	70.7
zinc	8/8	25.4	97.6	51.2	BGSD01 03/13/97	3.83	0.477	1.8946	L	121
aldrin	0/8	-			NA					
alpha-chlordane	0/8	-			NA					
Aroclor-1260	0/8	-			NA					
dieldrin	1/8	3.1	3.1	2.26	BGSD03 03/13/97	2.26				

TABLE 2-14

Background Statistics - Sediment Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL
endosulfan I	0/8	-			NA					
gamma-chlordane	0/8	-			NA					
2,4-dinitrotoluene	0/8	-			NA					
2,6-dinitrotoluene	0/8	-			NA					
2-methylnaphthalene	0/8	-			NA					
acenaphthene	0/8	-			NA					
acenaphthylene	0/8	-			NA					
anthracene	0/8	-			NA					
benz(a)anthracene	1/8	580 -	580	275	BGSD01 03/13/97	275				
benzo(a)pyrene	1/8	530 -	530	268	BGSD01 03/13/97	268				
benzo(b)fluoranthene	1/8	670 -	670	286	BGSD01 03/13/97	286				
benzo(g,h,i)perylene	0/8	-			NA					
benzo(k)fluoranthene	1/8	300 -	300	240	BGSD01 03/13/97	240				
bis(2-ethylhexyl)phthalate	0/8	-			NA					
butylbenzylphthalate	0/8	-			NA					
carbazole	0/8	-			NA					
chrysene	3/8	110 -	640	238	BGSD01 03/13/97	238				
dibenz(a,h)anthracene	0/8	-			NA					
dibenzofuran	0/8	-			NA					
fluoranthene	4/8	100 -	510	221	BGSD01 03/13/97	221				
fluorene	0/8	-			NA					
indeno(1,2,3-cd)pyrene	0/8	-			NA					
N-nitrosodiphenylamine (1)	0/8	-			NA					
naphthalene	0/8	-			NA					
phenanthrene	1/8	260 -	260	235	BGSD01 03/13/97	235				
pyrene	4/8	100 -	1300	315	BGSD01 03/13/97	315				
2-butanone	0/8	-			NA					

TABLE 2-14

Background Statistic - Sediment Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL)				
		Min.	Max.			Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL
acetone	0/5	-			NA					
ethylbenzene	0/8	-			NA					
toluene	0/8	-			NA					

Notes: Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

Abbreviations:

L, N, or Q — UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.

@ — Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test and background distribution matches lognormal.

TABLE 2-15
Background Statistics - Surface Water Data
NASJRB Willow Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection Min.	Max.	Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL) Back. Mean[a]	Std.Dev. Back.[a]	t Value	L,N Q	Back. UTL
aluminum	1/1	561	561	561	BGSW03 03/13/97	561				
antimony	0/8	-			NA					
arsenic	0/8	-			NA					
barium	8/8	87.3	112	101	BGSW05 03/13/97	4.61	0.0919	1.8946	L	121
beryllium	0/8	-			NA					
calcium	8/8	15800	34900	24600	BGSW01 03/13/97	24600	7720	1.8946	N	40200
chromium	0/8	-			NA					
cobalt	0/8	-			NA					
copper	1/8	10.8	10.8	5.73	BGSW03 03/13/97	5.73				
cyanide	0/8	-			NA					
iron	8/8	85.3	635	321	BGSW03 03/13/97	321	156	1.8946	N	634
lead	1/8	0.8	0.8	0.538	BGSW03 03/13/97	0.538				
magnesium	8/8	6250	12100	8910	BGSW01 03/13/97	8910	2350	1.8946	N	13600
manganese	8/8	26.7	110.25	67.1	BGSW03 03/13/97	67.1	26.2	1.8946	N	120
nickel	1/8	20.7	20.7	11.3	BGSW03 03/13/97	11.3				
potassium	6/8	1750	2860	1830	BGSW01 03/13/97	1830				
sodium	8/8	10700	36200	20100	BGSW02 03/13/97	9.8	0.496	1.8946	L	48800
vanadium	0/8	-			NA					
zinc	3/8	7.8	12.85	5.28	BGSW03 03/13/97	5.28				
dieldrin	0/8	-			NA					
bis(2-ethylhexyl)phthalate	0/8	-			NA					
di-n-butylphthalate	0/8	-			NA					
4-methyl-2-pentanone	0/8	-			NA					
acetone	0/8	-			NA					

Notes: Units are ug/L.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are

TABLE 2-15

Background Statistics - Surface Water Data
NASJRB Will w Grove, Pennsylvania

Substance	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	95 % Upper Tolerance Limit (UTL)				
		Min.	Max.			Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL

consolidated into one result.

Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.

Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.

Number of samples may vary based on the number of usable results.

UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

Abbreviations:

L, N, or Q — UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.

@ — Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test and background distribution matches lognormal.

Background C mparison T sts

To determine if results of samples from each site were elevated relative to background sample results, an array of statistical tests was performed. The name of each test, the statistical question answered by the test, the assumptions required to run the test, and the criterion used by each test to judge whether site data are greater than background are delineated in the headings and footnotes to the background comparison table presented in Section 4. These statistical procedures include three quantitative tests that look for overall differences between the entire populations of site and background data values, four quantitative tests that essentially look for hot spots, and two qualitative tests that examine only the frequency of detection (proportion of detected versus non-detected values in site versus background) but not the magnitude of values.

Each statistical test was run using a decision-making probability level (P-level) of 0.05, which means that, in situations where the test conclusion states that site-related results are greater than background, the chance of the test yielding a false conclusion caused by random variations in the data set is five percent or less. The overall conclusion (whether site results are greater than background) was assumed to be "yes" if any one of the quantitative tests concluded that site data are elevated above background. If no conclusion could be reached for any of the quantitative tests (e.g., if the assumptions necessary to run each of the various tests were not valid), then the overall decision was based on the conclusions of the qualitative tests alone. Further information regarding each statistical test is presented below:

- The means of the two data sets were compared if both site and background matched the same type of distribution (normal or lognormal). If the site and background data exhibited equal standard deviations (based upon Bartlett's test for equal variances), then the student's t-test was applied; otherwise, Satterthwaite's t-test was performed to see if the site mean is greater than the background mean. The t-test is valid only if at least 85 percent of site data and 85 percent of background data are positive detects, there are at least three sampling points in each data set, and the pooled standard deviation is not zero.

- Non-parametric statistical tests, which do not require underlying assumptions regarding equal data distributions, were also applied in each case. The Mann-Whitney U-test was used to determine whether the site and background data are from populations with identical medians and rank distributions. The Mann-Whitney test involves combining the two data sets, ranking results from smallest to largest, and evaluating whether the two sites have a similar distribution of data within the range of low to high ranks. If more than 40 percent non-detected results are present in either the site or the background data set or when multiple levels of detection limits are present, a different statistically valid test, Gehan's test, was substituted because recent guidance (EPA, 1992c)

indicates that the Mann- Whitney test is not valid in the aforementioned situations. (Gehan's test is statistically equivalent to the Mann-Whitney Test if all results are positive.) For either of these tests to work, not all data points can be tied and there must be at least two background data points. The Mann-Whitney U test and the Gehan test statistics were computed using appropriate score adjustments for tied values and a normal approximation when sufficient data points were available; an exact computation of probabilities was used in the situations where there were very few (for example, less than eight) data points.

- A 95 percent upper tolerance limit (UTL) test was applied to determine whether the maximum concentration detected in an area of interest was a hot spot of a magnitude exceeding 95 percent of the background population. The 95 percent UTL is defined as the calculated upper limit that, on the average, is expected to include 95 percent of the background population. If the background data were determined to match the shape of a normal or lognormal population, then the limit was calculated using the t-distribution and the appropriate normal or log-transformed mean and standard deviation from the background data set. For this test to be valid, the background data set was required to comprise at least 85 percent detects and at least three data points.

- A substitute procedure for the 95 percent UTL, called the 95 percent quantile test, was employed to test for hot spots if the background data were not in the shape of a lognormal or a normal population. For the quantile test to be valid, at least 19 background data points were required, no detection limit could be greater than the UTL, and at least 10 percent of the data points must be detects in the background data set.

- The upper ranks test (EPA, 1992c, 1996d) is another hot spot test. This test combines the site and background data into one set and determines whether the major portion of a subset of the largest detected results comprise chiefly site data rather than an equal mixture of site and background. In this procedure, the probability is calculated that k or more samples from the largest r data points in the combined data set comprise site data, assuming that the site and background populations are equal. In the event that there is less than a five percent chance that this could happen if the populations are indeed the same, then the test concludes that there is a hot spot comprising k samples from the area of interest.

- In the event that none of the above quantitative statistical tests yielded a definite "yes" or "no" decision, a test of proportions was used to determine if the percentage of positively detected results was greater in the site data versus the background data. When only a very small portion of results are detected (less than 10 percent), this test is recommended (EPA, 1996d, 1989b). The test is routinely applied using a normal distribution approximation to the probability that site is above

background but is not considered valid when fewer than five samples are detected in either site or background. To reach a confident decision regarding VOCs in surface water, a generalized version of the test of proportions, called the Fisher Exact Test, was required (Brownlee, 1965). This test can be applied to all situations because it calculates the exact probability for all combinations of possible outcomes and gives a probability level for the condition where the observed frequency of site detects is greater than background, given the number of samples involved.

- As recommended (EPA, 1996d, 1992b, 1989b), quantitative statistical tests were preceded by data analysis to evaluate the distributional shape for both positive and nondetected data, of which quantile plots or tables are one recommended (and efficient) approach. This data analysis is required because multiple detection limits bias or invalidate the conclusions of common statistical tests. For each chemical in each risk group, a quantile (percentile) range evaluation was required to compare the number and magnitude of site and background nondetects. In particular, some of the above tests do not tolerate any non-detects above a certain magnitude or portion of the total. In the case of the Mann-Whitney test, careful quantitative evaluation was used to determine if the site and background populations exhibited the same distributional spread of non-detected results and whether to instead use the more robust Gehan test. For the Gehan test to be valid, the only requirement was that the method of data censoring could not be significantly different for site versus background, a condition that rendered somewhat unreliable the usability of background tests for the combined routine and low detection limit mercury data comparisons due to different proportions of low detection limit data among the site and background populations.

3.0 RISK ASSESSMENT APPROACHES

3.1 METHODS FOR THE HUMAN HEALTH RISK ASSESSMENT APPROACH

This section provides a description of the human health risk assessment (HHRA) methods used to evaluate the NASJRB Willow Grove data collected at Site 1 (Privet Road Compound). The objectives of the risk assessment were to estimate the actual or potential risks to human health resulting from the presence of contamination in surface soil, subsurface soil, sediment, groundwater, and surface water and to provide the basis for determining the need for remedial measures for these media in the feasibility study.

Three major aspects of chemical contamination must be considered when assessing public health risks: Contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; potential exposure points must exist either at the source or via migration pathways if exposure occurs at a remote location other than the source; and human or environmental receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure; without any one of the three factors listed above, there is no risk.

The risk assessment estimated the potential for human health risk attributable to each NASJRB Willow Grove site including Site 1. Information regarding the toxicity of the compounds detected in the various media, the distribution of contamination, potential migration pathways, and a site-specific estimate of chemical intake via assumed exposure routes was combined to estimate potential risks for each NASJRB Willow Grove site. The risk assessment processes used at NASJRB Willow Grove were in accordance with current EPA risk assessment guidance and were performed according to methods established in the NASJRB Willow Grove Work Plan (1997), which was reviewed and approved by EPA Region 3 and the PADEP.

The HHRA consists of five sections: Data Evaluation, Toxicity Assessment, Exposure Assessment, Risk Characterization, and Uncertainty Analysis. Each section is briefly discussed below.

Data Evaluation (Section 3.1.1) was primarily concerned with distributional analysis of the data, background comparison tests, identification of chemicals of potential concern (COPCs), and representative concentrations. COPCs selected in this section are representative of the type expected for potential human health exposure. Distributional analysis of the data, contaminant concentrations relative to background levels, contaminant release and environmental transport mechanisms, exposure routes, and toxicity were all considered in order to develop a list of COPCs used to define the site-associated risks.

The Toxicity Assessment (Section 3.1.2) presents available reference doses, cancer slope factors, EPA weight of evidence, adjustment of the dose-response parameters, relative potencies for polycyclic aromatic hydrocarbons (PAHs), and relative potencies for dioxins/furans. Quantitative toxicity indices, where available, are presented in this section, including any applicable regulatory standards and criteria.

The Exposure Assessment (Section 3.1.3) identifies potential human health exposure including a characterization of the site setting, selection of potential receptors, selection of exposure routes by medium, a presentation of a site-conceptual model, derivation of exposure estimates for each pathway, and a special explanation of the blood lead modeling. This section identifies potential pathways of COPC migration, selected potential receptors, and the estimated intakes of COPCs for the identified receptors.

Risk Characterization (Section 3.1.4) presents the approaches for determining carcinogenic risks, noncarcinogenic risks, and lead risks. The risk characterization evaluates the potential for adverse health effects from exposure to COPC concentrations in environmental media by integrating information developed during the toxicity and exposure assessments. Reasonable maximum exposure (RME) and central tendency (CT) risks, as defined by EPA guidance, have been calculated. Carcinogenic human health risk is reported as a numerical result based on the exposure that would result in one additional cancer event in a population of 10,000 persons (1E-04) to one additional cancer event in a population of 1,000,000 persons (1E-06). Noncarcinogenic human health risk is reported as a decimal equivalent of a fraction, a Hazard Quotient (HQ), resulting from the ratio of the concentration of a noncancer causing compound found in a particular site medium (e.g., soil or groundwater) divided by the concentration of that compound suspected to cause adverse health affects. HQs greater than 1 indicate that the corresponding noncancer-causing compound is found in site media at a concentration greater than the concentration of that compound thought to be associated with adverse health affects. A Hazard Index (HI) is a sum of HQs and is used to represent aggregate noncancer human health risk at a site.

The Uncertainty Analysis (Section 3.1.5) is a discussion of the uncertainties associated with the HHRA.

3.1.1 Data Evaluation

This section presents the approaches for distributional analysis of the data, background comparison tests, identification of COPCs, representative concentrations, and special notes concerning chromium concentrations, filtered groundwater samples, use of 1991 groundwater data at Site 1 for inorganics, and PCB analysis at Site 1.

3.1.1.1 Distributional Analysis f th Data

Statistical analyses discussed in this section adhere to the guidance referenced in several EPA and related publications (1989a, 1989b, 1992a, 1992b, and 1996a). Section 4.1.5 discusses the general limitations and uncertainties of statistical procedures, particularly with regards to confidence and decision-making power when limited numbers of samples are involved. Before representative concentrations (Section 4.1.4) could be estimated for each site, the underlying statistical distribution of data was determined for each chemical in each medium. Either the Shapiro-Wilk W test or the Shapiro-Francia Test (EPA, 1992a) was performed to determine if the data set of chemical concentrations matches the shape of a normal or lognormal distribution. [The latter test is required if there are more than 50 samples (EPA, 1992a, 1996a).] Normally distributed data exhibit a characteristic "bell-shape" curve that is symmetrical, and lognormal data have a skewed shape (more results at the high-concentration tail). For each chemical in each medium at a site, the W test was performed once using the original data and once after data were converted to their logarithms. A five percent level of significance was used to determine if the data deviate from either hypothesized distribution. If the W test indicated a normal distribution, then the estimation of the reasonable maximum exposure point concentration (using the upper 95th percentile, as discussed in the next section) was based upon a normal distribution and standard deviation. If taking the logarithms of the data provided a better match to the data than a normal distribution, a lognormal transformation of data was used before the upper 95th percentile concentrations were computed. In most cases, the distribution of data fit one of the above two categories. If neither distribution matched well, the default assumption of an underlying lognormal distribution was followed (EPA, 1989a).

3.1.1.2 Background Comparison Tests

To determine if results of samples from each site were elevated relative to background sample results, an array of statistical tests was performed. Section 2.3 presents a discussion of the statistical analyses performed on background analytical data.

3.1.1.3 Identification of Chemicals of Potential Concern (COPCs)

COPC selection is based on various aspects of chemical concentration, distribution, and toxicity. Chemicals are selected to represent site contamination and will provide the framework for the quantitative risk assessment.

Inorganic and organic samples were collected from the NASJRB Willow Grove Sites in groundwater, spring water, surface soil, sediment (seeps, creeks, and ponds), surface water (seeps, creeks, and ponds), and fish media. The positively detected chemicals for each site are compared to background

levels and presented in occurrence and distribution and background tables in Section 4. COPC selection is based on these tables and the following rules (EPA, 1993):

- Screen COPCs against RBC criteria (EPA, 1993). Developed by Region 3 EPA, RBCs are chemical-specific benchmark criteria that represent the calculated concentration for a given contaminant that might produce a cancer risk of 1E-06 or a noncarcinogenic HI of 1.0, given exposure to soil or groundwater by residential receptors and assuming the EPA default values for upper range (RME) intake (e.g., 2 liters groundwater consumption per day for a residential adult or 200 mg soil ingestion per day for a residential child). Using the RBC screening approach, a chemical was eliminated from consideration as a COPC at a site if the maximum detected concentration was less than the RBC screening value or if site concentrations were not significantly greater than background (inorganics only). The COPC selection process differed slightly for each sampling medium, as explained below:

Surface Soil Exposure COPC Selection

Inorganics - Compare the maximum concentration detected in surface soil to the residential soil RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1 and compare site concentration to background concentration in order to determine if the area of interest is significantly greater than background. If both criteria are met, the chemical is selected as a COPC.

Organics - Compare the maximum concentration detected in surface soil to the residential soil RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1. All chemicals exceeding RBCs were selected as COPCs.

Residential RBCs were used as comparison criteria because they are expected to be protective of all receptors exposed to surface soil.

Subsurface Soil Exposure COPC Selection

Inorganics - Compare the maximum concentration detected in subsurface soil to the industrial soil RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1 and compare site concentration to background concentration in order to determine if the area of interest is significantly greater than background. If both criteria are met, the chemical is selected as a COPC.

Organics - Compare the maximum concentration detected in subsurface soil to the industrial soil RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1. All chemicals exceeding RBCs were selected as COPCs.

Industrial RBCs were used as comparison criteria because, generally, only industrial receptors are expected to be exposed to subsurface soils during excavation or construction activities.

Sediment Exposure COPC Selection

Inorganics - Compare the maximum concentration detected in sediment to the residential soil RBC determined at a risk level of 1×10^{-5} or an HQ of 1.0 and compare site concentrations to background concentrations in order to determine if the concentrations in the area of interest are significantly greater than background. This comparison is conservative in that it assumes that exposure intakes for sediment are one-tenth as great as the exposure pathway based on the RBC soil ingestion value. If both criteria are met, the chemical is selected as a COPC.

Organics - Compare the maximum concentration detected in sediment to the residential soil RBC determined at a risk level of 1×10^{-5} or an HQ of 1.0. This comparison is conservative in that it assumes that exposure intakes for sediment are one-tenth as great as the exposure pathway based on the RBC soil ingestion value (whereas exposure to surface water in this HHRA is expected to be even significantly lower than one-tenth of the exposure to surface soil). All chemicals exceeding RBCs were selected as COPCs.

Surface Water Exposure COPC Selection

Inorganics - Compare the maximum concentration detected in surface water to the tap water RBC determined at a risk level of 1×10^{-5} or an HQ of 1.0 and compare site concentrations to background concentrations in order to determine if the concentrations at the site are significantly greater than background. This comparison is conservative in that it assumes that exposure intakes for surface water are one-tenth as great as the exposure pathway based on the RBC tap water value, whereas exposure to surface water in this HHRA is expected to be even lower than one-tenth of the exposure to tap water. If both criteria are met, the chemical is selected as a COPC.

Organics - Compare the maximum concentration detected in surface water to the tap water RBC determined at a risk level of 1×10^{-5} or an HQ of 1.0. This comparison is conservative in that it assumes that exposure intakes for surface water are one-tenth as great as the exposure pathway based on the

RBC tap water value, whereas exposure to surface water in this HHRA is expected to be even lower than one-tenth of the exposure to tap water. All chemicals exceeding RBCs were selected as COPCs.

Future Groundwater Exposure COPC Selection

Inorganics (Monitoring Wells) - Compare the maximum concentration detected in monitoring wells to the tap water RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1 and compare site concentrations to background monitoring well concentrations in order to determine if the concentration at a site is significantly greater than background. If both criteria are met, the chemical is selected as a COPC. Additionally, the maximum concentration detected in groundwater will be compared to applicable MCLs and those chemicals exceeding MCLs will be identified and considered candidate COPCs.

Organics (Monitoring Wells) - Compare the maximum concentration detected in groundwater to the tap water RBC determined at a risk level of 1×10^{-6} or an HQ of 0.1. All organic chemicals exceeding RBCs were selected as COPCs. Additionally, the maximum concentration detected in groundwater will be compared to applicable MCLs and those chemicals exceeding MCLs will be identified and considered candidate COPCs.

- The essential nutrients, including calcium, chlorine, iodine, magnesium, phosphorus, potassium, and sodium, were eliminated as COPCs if they were not present at high concentrations at the site (EPA, 1989a).

- Previously eliminated chemicals were evaluated to determine whether any fell within the following two classifications and, therefore, must be retained as COPCs:

    - If the chemical was a break-down product of a COPC, it was included as a COPC for that medium.

    - If a chemical was a member of the same class of chemicals that were selected as COPCs, that chemical was included as a COPC for that medium (e.g., carcinogenic PAHs, dioxins/furans, and PCBs.

- Lead will be evaluated as a COPC based on derived screening levels for tap water and residential soil. In accordance with EPA Region 3 directive, a value of 400 mg/kg [Office of Solid Waste and Emergency Response (OSWER) Directive, EPA, 1994a] will be used as the residential soil screening RBC and a value of 15 ug/L (Drinking Water Action Level, EPA, 1996b) will be used as the residential tap water RBC.

3.1.1.4 R pr sentative C ncentrati ns

The risk assessment for NASJRB Willow Grove was performed using a representative concentration for each COPC in each medium identified at Site 1. Current and historic concentrations of detected chemicals at each site medium will be evaluated. Usability of results is discussed below. The representative concentration was calculated using the latest risk assessment guidance from EPA (EPA, 1989a).

The validated data will be used to calculate representative concentrations. The data will include 1997 RI data and 1991 RI data. For chemicals with at least one positive detection, the corresponding non-detects will be assumed to be one-half the detection limit (sample quantitation limit). Rejected values (R) and blank qualified results (B) will be eliminated from further consideration. Estimated and biased values (J, K, L) will be used as the reported value.

Duplicate samples will be averaged together and considered as one result. For duplicates, where one result is positive and the other result is a non-detect, the problem of calculating an average result arises whenever one-half the detection limit exceeds the positive result. In these situations, the positive result will be used to represent the non-detect.

The calculation of the representative concentration is a two-step process. First, the distribution of the data must be determined as discussed in the preceding section. Then, based on the distribution of the data, a representative concentration is either calculated or selected.

Several important points are associated with distribution of the data:

- The distribution of a data set is determined using a Shapiro-Wilk test.
- The distributions are classified as either lognormal, normal, or unknown.
- Environmental data are usually determined to be lognormally distributed (default).
- If the data are not determined to be either a lognormal or normal distribution, they are classified as an unknown distribution and a lognormal distribution is assumed.

For data that are considered to be lognormally distributed, the standard deviation of the log-transformed sample set must be determined, as follows:

$$S = \sqrt{\Sigma\left(\frac{\left(X_i - \mu\right)^2}{n-1}\right)}$$

where:

S	=	Standard deviation of the log-transformed data
X_i	=	Individual sample value (log-transformed)
μ	=	Arithmetic mean of the log-transformed n samples
n	=	Number of samples

Calculation of the one-sided upper 95 percent confidence limit (UCL_{LOG}) is shown below.

$$UCL_{LOG} = e^{\left[\mu + 0.5s^2 + \left(\frac{sH}{\sqrt{n-1}}\right)\right]}$$

where:

e	=	Constant (base of the natural log, equal to 2.718)
μ	=	Arithmetic mean of the log-transformed data
H	=	H-statistic (e.g., from table published in Gilbert, 1987)
S	=	Standard deviation of the log-transformed data
n	=	Number of samples

If the data are determined to be normally distributed, then the standard deviation of the sample set is used to calculate the one-sided 95 percent UCL, as follows:

First, the standard deviation of the sample set must be determined:

$$S = \sqrt{\sum\left(\frac{(X_i - \mu)^2}{n-1}\right)}$$

where:

S	=	Standard deviation of the data
X_i	=	Individual sample value
μ	=	Arithmetic mean of the n samples
n	=	Number of samples

The one-sided upper 95 percent confidence limit (UCL_{NOR}) is then calculated as follows:

$$UCL_{NOR} = \mu + \frac{(t * S)}{\sqrt{n}}$$

where:

S	=	Standard deviation of the data
t	=	One-sided t distribution factor
μ	=	Arithmetic mean of the n samples
n	=	Number of samples

For small sample sets or sample sets in which all positive results equal less than one-half the detection limit, the UCL can exceed the maximum detected concentration. In these cases, the maximum concentration will be selected as the representative concentration. The maximum positive value is frequently the default choice when a lognormal distribution (having a higher upper confidence limit from the distributional shape) is used.

3.1.1.5 Special Note Concerning Chromium Concentrations

Chromium data were considered to be the hexavalent chromium (VI) form as opposed to the trivalent form (chromium III) because no speciation data were available. Hexavalent chromium is considered the more toxic form; therefore, assuming that all chromium is hexavalent is a conservative approach.

3.1.1.6 Special Note Concerning Filtered Groundwater Samples

Some monitoring well samples were collected using dedicated low-flow pumps to minimize the occurrence of suspended solids associated with conventional purging and sampling techniques. Filtered samples were collected from older monitoring wells that did not have these pumps.

When samples were collected as both filtered and unfiltered aliquots, EPA technical guidance was applied to pick the most representative data to use for risk assessment. If suspended solids were strongly suggested in the unfiltered analysis, then filtered results were considered more representative of the metals available from transport in the aquifer. Elevated aluminum, iron, and manganese levels in the unfiltered sample relative to the filtered sample were used as evidence that filtered results should be used. Otherwise, unfiltered results were used if there was not a clear indication of elevated metals in association with suspended solids.

3.1.1.7 Special Note Concerning Analysis of PCBs at Site 1

Two types of PCBs data were collected at NASJRB Willow Grove. Aroclor-specific PCB data were collected based on routine methods for off-site laboratory analysis. At known areas of soil contamination at Site 1, "total PCBs" data were collected using field screening by immunoassay. Aroclor-specific data will be summed to calculate a "total PCBs" result at each location so that these data can be combined with the "total PCBs" immunoassay data from different locations. Split sample locations (where analysis was performed by both methods) will be evaluated using only the off-site laboratory data, which are generally considered to be more accurate.

3.1.2 T xicity Ass ssment

The purpose of this section is to identify the potential health hazards associated with exposure to each of the COPCs. A toxicological evaluation characterizes the inherent toxicity of a compound. The literature indicates that the COPCs have the potential to cause carcinogenic and/or noncarcinogenic health effects in humans. Although the COPCs may cause adverse health effects, dose-response relationships and the potential for exposure must be evaluated before the risks to receptors can be determined. Dose-response relationships correlate the magnitude of the intake with the probability of toxic effects, as discussed below. Toxicity information for the COPCs at all sites at NASJRB Willow Grove is presented in Table 3-1 and Appendix J of the Phase II RI report in the form of toxicological profiles.

An important component of the risk assessment process is the relationship between the intake of a compound (the amount of a chemical that is absorbed by a receptor) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts can be quantified. The published information of doses and responses is used in conjunction with information on the nature and magnitude of human exposure to develop an estimate of potential health risks.

Reference doses (RfDs) and slope factors (SFs) have been developed by EPA (1997a, 1995a) and other sources for many organics and inorganics. This section provides a brief description of these parameters.

3.1.2.1 Reference Doses (RfDs)

The RfD is developed by EPA for chronic and/or subchronic human exposure to hazardous chemicals and is based solely on the noncarcinogenic effects of chemical substances. The RfD is usually expressed as a dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-adverse-effect level (NOAEL) or a lowest-observed-adverse-effect level (LOAEL) by an appropriate uncertainty factor. NOAELs, etc. are determined from laboratory animal or epidemiological toxicity studies. The uncertainty factor is based on the extent and applicability of toxicity data to human exposure.

Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the available data. A factor of 10 is used to account for variations in the general population (to protect sensitive subpopulations), extrapolation of test results from animals to humans (to account for interspecies variability), derivation of a NOAEL from a subchronic study (instead of a chronic study) for developing the RfD, and use of a LOAEL instead of a NOAEL. In addition, EPA reserves the use of a modifying factor of up to 10 for professional judgment of uncertainties in the database not already

accounted for. The default value of the modifying factor is 1. The RfD incorporates the r liability of the evidence for chronic human health effects. Even if applicable human data exist, the RfD (as reduced by the uncertainty factor) still maintains a margin of safety so that chronic human health effects are not underestimated. Thus, the RfD is an acceptable guideline for evaluation of noncarcinogenic risk, although the associated uncertainties preclude its use for precise risk quantitation. RfDs for NASJRB Willow Grove site contaminants are provided in Table 3-1.

Noncarcinogenic risks for lead were not quantified and compared to RfDs because EPA has implemented an approach to evaluating lead risks that goes beyond providing a single-point estimate output. Instead, expected blood-lead increases were estimated; a discussion of these results is presented in Section 3.1.5.9.

3.1.2.2 Cancer Slope Factors (SFs)

SFs are applicable for estimating the lifetime probability (assumed 70-year lifespan) of human receptors developing cancer as a result of exposure to known or potential carcinogens. This factor is generally reported in units of 1/(mg/kg/day) and is derived through an assumed low-dosage linear relationship of extrapolation from high to low dose responses determined from animal studies. The value used in reporting the slope factor is the upper 95 percent confidence limit. SFs for NASJRB Willow Grove site contaminants are provided in Table 3-1.

Carcinogenic risks for lead were not quantified because no EPA consensus currently exists with respect to an inorganic lead SF. Instead, potential lead exposures were calculated using a biokinetic model to estimate expected blood-lead increases; a discussion of these results is presented in Section 3.1.3.6.

3.1.2.3 EPA Weight-of-Evidence

The weight-of-evidence designations indicate the preponderance of evidence regarding carcinogenic effects in humans and animals. The categories are defined in Table 3-2 (EPA, 1992d).

TABLE 3-1

DOSE-RESPONSE PARAMETERS - CHEMICALS OF POTENTIAL CONCERN
NASJRB WILLOW GROVE

Chemical of Concern	Fraction of COPC Absorbed in the Gastrointestinal Tract (unitless)**	Toxicity Values						
		RfD*			SF			W ight of Evidence
		Oral* (mg/kg)/day	Dermal (mg/kg)/day	Inhalation* (mg/kg)/day	Oral* 1/(mg/kg)/day	Dermal 1/(mg/kg)/day	Inhalation* 1/(mg/kg)/day	
Volatiles								
1,1,1-trichloroethane	1.0	3.5E-02 E	3.5E-02	2.86E-01 W				D
1,1,2-trichloroethane	1.0	4.0E-03	4.0E-03		5.7E-02	5.7E-02	5.6E-02	C
1,1-dichloroethane	1.0	1.0E-01	1.0E-01	1.43E-01 A				
1,1-dichloroethene	1.0	9.0E-03	9.0E-03		6.0E-01	6.0E-01	1.75E-01	C
1,2-dichloroethane	1.0			2.86E-03 E	9.1E-02	9.1E-02	9.1E-02	B2
benzene	1.0			1.71E-03 E	2.9E-02	2.9E-02	2.9E-02	A
tetrachloroethene	1.0	1.0E-02	1.0E-02		5.2E-02 E	5.2E-02	2.03E-03 E	B2
trichloroethene	1.0	6.0E-03 E	6.0E-03		1.1E-02 W	1.1E-02	6.0E-03 E	B2
Semivolatiles								
benz(a)anthracene	1.0				7.3E-01 E		6.1E-01 E	B2
benzo(a)pyrene	1.0				7.3E+00 I		6.1E+00 W	B2
benzo(b)flouranthene	1.0				7.3E-01 E		6.1E-01 E	B2
benzo(k)fluoranthene	1.0				7.3E-02 E		6.1E-02 E	B2
chrysene	1.0				7.3E-03 E		6.1E-03 E	B2
dibenz(a,h)anthracene	1.0				7.3E+00 E		6.1E+00 E	B2
indeno(1,2,3-cd)pyrene	1.0				7.3E-01 E		6.1E-01 E	B2
bis(2-ethylhexyl)phthalate	0.55	2.0E-02	3.64E-02		1.4E-02	7.7E-03		B2
Pesticides/PCBs								
Polychlorinated biphenyls	1.0				2.0E+00 I	1.78E+00		B2
Aroclor-1260	1.0				2.0E+00 I	1.78E+00		B2
dieldrin	0.5	5.0E-05	1.0E-04		1.6E+01	8.0E+00	1.61E+01	B2
Metals								
aluminum	0.27	1.0E+00 E	3.7E+00					
arsenic	0.95	3.0E-04	3.16E-04		1.5E+00	1.43E+00	1.51E+01	A
barium	1.0	7.0E-02	7.0E-02	1.43E-04 A				D
beryllium	0.01	5.0E-03	5.0E-01		4.3E+00	4.3E-02	8.4E+00	B2
cadmium	0.05	5.0E-04 I	1.0E-02	5.710E-05 W			6.3E+00 I	
chromium	0.01	5.0E-03	5.0E-01				4.2E+01	D
iron	1.0	3.0E-01 E	3.0E-01					
lead	1.0							B2
manganese (water)	1.0	2.3E-02 I	2.3E-02	1.43E-05 I				
manganese (food)	1.0	1.4E-01	1.4E-01	1.43E-05				
thallium	1.0	6.5E-05	6.50E-05					
vanadium	0.0	7.0E-03 H	3.50E-01					
zinc	1.0	3.0E-01	3.00E-01					D
Dioxins/Furans								
1,2,3,4,6,7,8-HPCDD	0.5				1.560E+03	7.800E+02	1.160E+03	B2

TABLE 3-1

DOSE-RESPONSE PARAMETERS - CHEMICALS OF POTENTIAL CONCERN
NASJRB WILLOW GROVE

Chemical of Concern	Fraction of COPC Absorbed in the Gastrointestinal Tract (unitless)**	Toxicity Values						
		RfD*			SF			Weight of Evidence
		Oral* (mg/kg)/day	Dermal (mg/kg)/day	Inhalation* (mg/kg)/day	Oral* 1/(mg/kg)/day	Dermal 1/(mg/kg)/day	Inhalation* 1/(mg/kg)/day	
1,2,3,4,6,7,8-HPCDF	0.5				1.560E+03	7.800E+02	1.160E+03	B2
1,2,3,4,7,8,9-HPCDF	0.5				1.560E+03	7.800E+02	1.160E+03	B2
1,2,3,4,7,8-HXCDD	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,4,7,8-HXCDF	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,6,7,8-HXCDD	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,6,7,8-HXCDF	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,7,8,9-HXCDD	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,7,8,9-HXCDF	0.5				1.560E+04	7.800E+03	1.160E+04	B2
1,2,3,7,8-PECDD	0.5				7.800E+04	3.900E+04	5.800E+04	B2
1,2,3,7,8-PECDF	0.5				7.800E+03	3.900E+03	5.800E+03	B2
2,3,4,6,7,8-HXCDF	0.5				1.560E+04	7.800E+03	1.160E+04	B2
2,3,4,7,8-PECDF	0.5				7.800E+04	3.900E+04	5.800E+04	B2
2,3,7,8-tetrachlorodibenzo-p-di	0.5				1.560E+05	7.800E+04	1.160E+05	B2
2,3,7,8-tetrachlorodibenzofuran	0.5				1.560E+04	7.800E+03	1.160E+04	B2
octachlorodibenzo-p-dioxin	0.5				1.560E+02	7.800E+01	1.160E+02	B2
octachlorodibenzofuran	0.5				1.560E+02	7.800E+01	1.160E+02	B2

No Value = No dose-response value is available for this chemical in this classification
* = All toxicity values are from Integrated Risk Information System (IRIS) unless otherwise noted
** = Modifying factor applied only to dermal RfDs and SFs, from ATSDR
H = Health Effects Assessment Summary Tables
A = HEAST Alternative
E = EPA-NCEA Regional Support provisional service
W = Withdrawn from IRIS or HEAST

3.1.2.4 Adjustment of Dose-Response Parameters

Risks associated with dermal exposures are evaluated using toxicity values that are specific to dermally absorbed doses. Most oral toxicity values are based on administered doses rather than absorbed doses (TCE is an important exception). Therefore, in accordance with Region EPA 3 (1995b) and EPA (1989a, Appendix A), the toxicity values based on administered doses were adjusted before they were used for evaluation of absorbed doses. Dermal RfDs and SFs are obtained from oral RfDs and SFs via the following relationships:

$$RfD_{Adjusted} = RfD_{Oral} * ABSEFF_{Oral}$$

$$SF_{Adjusted} = {SF_{Oral}}/{ABSEFF_{Oral}}$$

where $ABSEFF_{Oral}$ = Absorption Efficiency in the study that is the basis of the oral toxicity value.

The default ABSEFFs are designated by EPA Region 3 for selected compounds (EPA, 1995b) and are shown on Table 3-3.

3.1.2.5 Relative Potency Factors for PAHs

Carcinogenic PAHs are related by chemical structure. Only benzo(a)pyrene [B(a)P] has an EPA-published SF (EPA, 1997a). All other carcinogenic PAHs have SFs based on their potency relative to B(a)Ps, and these factors are published by EPA (1997b). Table 3-4 shows the relative potency factors [which are also commonly known as toxicity equivalence factors (TEFs)].

3.1.2.6 Relative Potency Factors for Dioxins/Furans

Dioxins and furans are related by chemical structure. Only 2,3,7,8-tetrachlorodibenzodioxin (TCDD) has an EPA-published SF (EPA, 1995a). All other 2,3,7,8-substituted dioxins and furans have SFs based on their potency relative to 2,3,7,8-TCDD, and these factors are published by EPA (1992e). Table 3-5 shows the relative potency factors (which are also commonly known as TEFs).

TABLE 3-2

EPA WEIGHT OF EVIDENCE CARCINOGENIC CLASSIFICATIONS
NASJRB WILLOW GROVE, PENNSYLVANIA

EPA Category	Description of Group	Description of Evidence
Group A	Human carcinogen	Sufficient evidence from epidemiologic studies to support a causal association between exposure and cancer.
Group B1	Probable human carcinogen	Limited evidence of carcinogenicity in humans from epidemiologic studies.
Group B2	Probable human carcinogen	Sufficient evidence of carcinogenicity in animals; inadequate evidence of carcinogenicity in humans.
Group C	Possible human carcinogen	Limited evidence of carcinogenicity in animals.
Group D	Not classified	Inadequate evidence of carcinogenicity in animals.
Group E	No evidence of carcinogenicity	No evidence for carcinogenicity in at least two adequate animal tests or in both epidemiological and animal studies.

TABLE 3-3

ABSORPTION FACTORS FOR THE DERMAL PATHWAY
NASJRB WILLOW GROVE, PENNSYLVANIA

Chemical	Absorption Factors For Dermal Pathway
PCBs	6%
Chlorinated Dioxins	3%
Cadmium	1%
Arsenic	3.2%
Ethylbenzene	3%
Toluene	3%
Xylenes	3%
Tetrachloroethene	3%
Pesticides	10%
Pentachlorophenol	24.4%
Other Inorganics	1%
Other Organics	10%

TABLE 3-4

RELATIVE POTENCY OF CARCINOGENIC PAHS
NASJRB WILLOW GROVE, PENNSYLVANIA

Chemical	Relative Potency Factors
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Benzo(a)pyrene	1
Chrysene	0.001
Dibenz(a,h)anthracene	1
Indeno(1,2,3-cd)pyrene	0.1

TABLE 3-5

TOXICITY EQUIVALENCY FACTORS (TEFS) – DIOXIN/FURAN COMGENERS NASJRB, WILLOW GROVE, PENNSYLVANIA

Dioxin/Furan Congener	TEFs
2,3,7,8-TCDD	1
2,3,7,8-PeCDD	0.5
2,3,7,8-HxCDD	0.1
2,3,7,8-HpCDD	0.01
OCDD	0.001
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
2,3,7,8-HxCDF	0.1
2,3,7,8-HpCDF	0.01
OCDF	0.001

3.1.3 Exp sure Assessment

The purpose of this section is to evaluate the potential for human exposure to the chemicals detected in the environmental media at Site 1. This section characterizes the exposure setting and the potentially exposed populations, identifies actual or potential exposure routes, presents a general conceptual site model, and summarizes the methods used to generate exposure estimates. The nature and extent of contamination upon which the exposures are based are presented in Section 4.0. To determine whether there is an actual or potential exposure, the most likely pathways of contaminant release and transport, as well as the human and environmental activity patterns, must be considered. A complete exposure pathway has three components: a source, a route of transport, and an exposure point for receptors. These components are addressed in this section.

3.1.3.1 Characterization of the Exposure Setting

Section 4 provides a characterization of general site conditions, including meteorology, topography and surface water hydrology, soils, regional geology, regional hydrogeology, and ecology.

3.1.3.2 Potential Receptors

The receptors chosen for Site 1 at NASJRB Willow Grove are presented in this section. The current exposure scenarios are as follows:

- Occupational Worker - The full-time on-site worker is an adult who works at NASJRB Willow Grove year round. This receptor is potentially exposed to COPCs in surface soil via ingestion, dermal contact, and inhalation.

- Adolescent and Adult Trespasser - A trespasser is an adult or adolescent who trespasses at NASJRB Willow Grove. These receptors are potentially exposed to COPCs in surface soil via ingestion, dermal contact, and inhalation and to COPCs in surface water via ingestion and dermal contact. Cancer and non-cancer risks will be estimated separately for adolescent and adult trespassers.

Future exposure scenarios are, as follows:

- Future Excavation Worker - A future excavation worker is an adult who is assumed to work at NASJRB Willow Grove in the future during any type of excavation activity. This receptor is potentially exposed to COPCs in surface and subsurface soil via ingestion, dermal contact, and

inhalation. Additionally, this receptor is potentially exposed to VOCs in shallow groundwater via inhalation.

- Future Resident - A future resident is a person who will live in a residence at or near NASJRB Willow Grove in a hypothetical future scenario. This receptor resides at a residence as a child (from age 0 to 6 years) and as an adult (for 24 years exposure duration). This receptor is potentially exposed to COPCs in groundwater via ingestion, dermal contact, and inhalation (adult resident only) and to COPCs in surface soil via ingestion, dermal contact, and inhalation. Non-cancer risks will be estimated separately for child and adult; cancer risks are considered cumulative (risks are summed over child and adult periods of exposure). Potential exposure to subsurface soils following real estate development will be discussed qualitatively.

- Future Child Recreational Receptor - A future recreational receptor is a child who participates in recreational activities at NASJRB Willow Grove in a hypothetical future scenario. This receptor is potentially exposed to surface soil via ingestion, dermal contact, and inhalation and to surface water and sediment via ingestion and dermal contact.

3.1.3.3 Exposure Routes by Medium

There are five environmental media at NASJRB Willow Grove through which potential receptors (see previous section) can be either directly or indirectly exposed to site-related COPCs: surface soil, subsurface soil, sediment, surface water, and groundwater. Potential exposure routes include ingestion, dermal contact, and inhalation.

3.1.3.3.1 Surface Soil

Surface soil exposure routes include incidental ingestion, dermal contact, and inhalation of fugitive dust. All scenarios are based on COPC representative concentrations in surface soils. All three exposure routes will be evaluated using occupational workers (current scenario), adolescent and adult trespassers (current scenario), excavation workers (future scenario), residential receptors (future scenario), and recreational receptors (future scenario). These receptors were chosen because it is unknown whether NASJRB Willow Grove will remain open to industrial employees only or whether NASJRB Willow Grove (or a portion of it) might become a residential or recreational area in the future. For fugitive dust emissions, the assumption of surface cover will resemble the type of vegetation, paving, and buildings that are currently in place.

For surface soil, low levels of VOCs did not warrant full-scale modeling and an estimation of the exposure. VOCs were generally not detected in surface soil. Therefore, exposure to volatilized chemicals is expected to be negligible at NASJRB Willow Grove, and ingestion and dermal contact would contribute to the bulk of the risk.

3.1.3.3.2 Subsurface Soil

Because there is currently no direct contact with subsurface soil, only potential future incidental ingestion, dermal contact, or inhalation of fugitive dusts could be evaluated. All three exposure routes were evaluated using excavation workers (future scenario). The exposure scenarios for subsurface soil are based on the assumption that subsurface soil could eventually become surface soil if excavations, erosion, construction, or landscaping activities occurred. Exposure scenarios related to concentrations in subsurface soil are conservative based on this assumption. For fugitive dust emissions from subsurface soil under the future industrial scenario, the assumption of surface cover would be based on the type of vegetation, paving, and buildings that are currently in place. Additionally, a qualitative discussion of the impact on real estate landscaping for future residential receptors will be presented.

3.1.3.3.3 Sediment

Sediment exposure routes include incidental ingestion and dermal contact. These exposure routes will be evaluated using adult and adolescent trespassers (current scenario) and recreational receptors (future scenario). Inhalation of chemicals in sediment was eliminated as a pathway because the sediment is not expected to be in a dry stream. Furthermore, the frequency of contact with sediment by these receptors is expected to be low.

3.1.3.3.4 Surface Water

Surface water exposure routes include incidental ingestion and dermal contact. These exposure routes will be evaluated using adult and adolescent trespassers (current scenario) and recreational receptors (future scenario). Inhalation of VOCs in surface water was eliminated as a pathway because VOCs were detected infrequently in surface water. Furthermore, the frequency of contact with surface water by the these receptors is expected to be low.

3.1.3.3.5 Groundwater

The groundwater exposure route includes ingestion, dermal contact while bathing or showering, and inhalation of airborne vapors during showering. This exposure route will be evaluated using child and

adult residential r ceptors (future scenario). Additionally, inhalation of VOCs in shallow groundwater during excavation activities will be evaluated. This exposure route will be evaluated using the excavation worker (future scenario). Future groundwater conditions at the site will not be modeled. For the HHRA, it is assumed that migration of COPCs in groundwater is currently occurring and current groundwater conditions adequately represent this phenomenon.

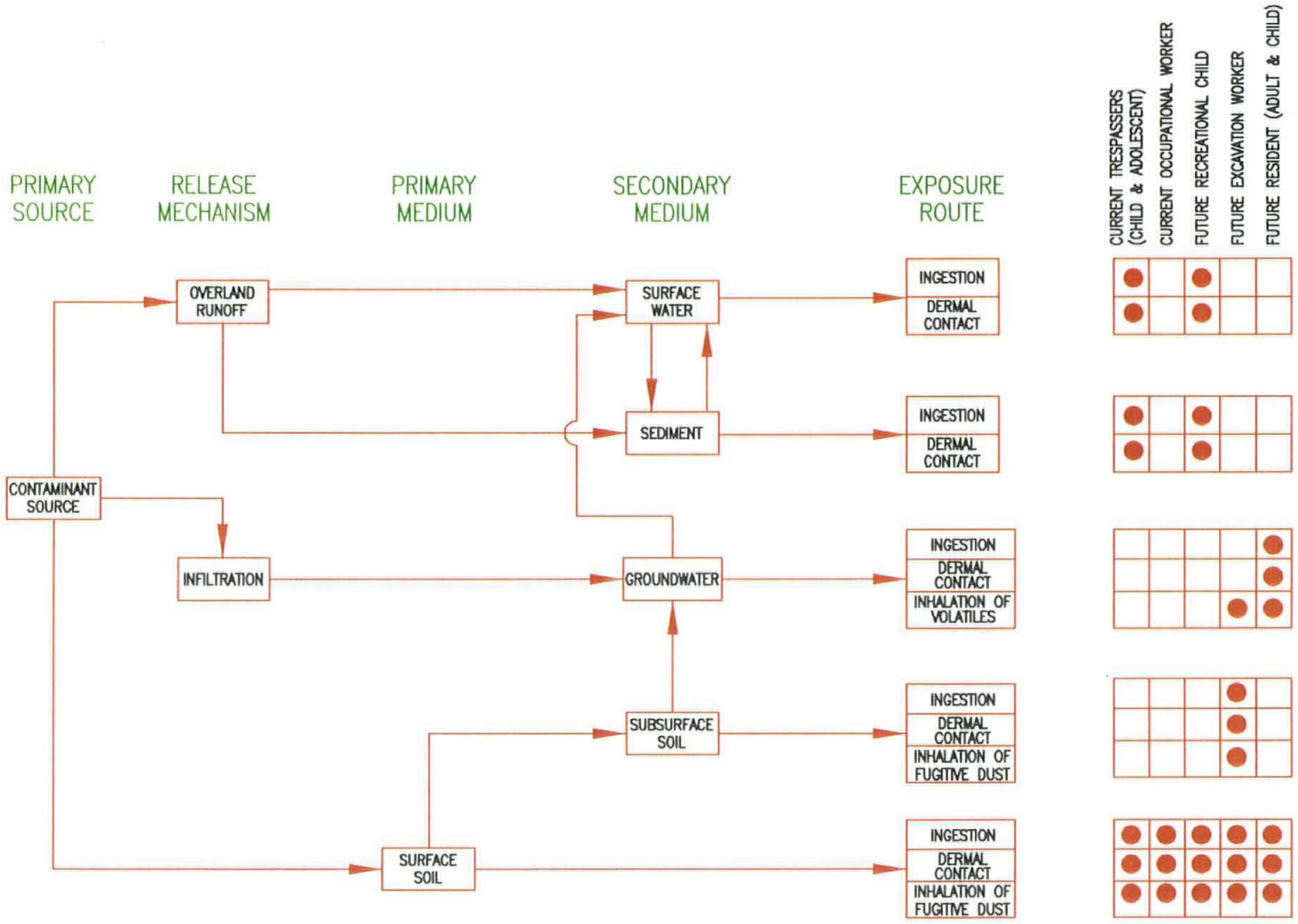
3.1.3.4 Conceptual Site Model

The conceptual site model for NASJRB Willow Grove incorporates information on the potential chemical sources, affected media, release mechanisms, routes of migration, and known or potential human receptors. The purpose of the conceptual site model is to provide a framework in which to identify potential exposure pathways occurring at the sites. Information provided on site characterization, chemical characterization, local land and water uses, and potential receptors is used to identify potential exposure pathways for the site. The general conceptual site model for NASJRB Willow Grove is presented in Figure 3-1.

3.1.3.5 Exposure Estimates

The estimation methods and models used in this section are consistent with current EPA risk assessment guidance (EPA, 1989a; EPA, 1991a; EPA, 1996c). Exposure estimates associated with each exposure route are presented below. All exposure scenarios incorporate the representative concentrations in the estimation of intakes. Two types of exposure scenarios are considered in this HHRA, reasonable maximum exposure (RME) and central tendency exposure (CTE). RME incorporates input parameters into the exposure scenarios that are protective of 90 or 95 percent of the population, and CTE incorporates input parameters that are representative of an average or median exposure scenario. CTE is only to be run at a particular site when the total cancer risk exceeds 1E-04 (considered the upper bound of EPA's acceptable risk range) or when the noncarcinogenic HI is greater than 1.0.

Noncarcinogenic risks are estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency that represent the number of hours per day and the number of days per year that exposure occurs. This is used along with the "averaging time," which converts the daily exposure frequency and duration to an annual exposure by dividing by 365 days per year of exposure. Noncarcinogenic risks for some exposure routes (e.g., soil) are generally greater for children than for adults because of the much lower body weights of children and their similar or higher ingestion rates. Carcinogenic risks, on the other hand, are calculated as an incremental lifetime risk and, therefore, incorporate terms to represent the exposure duration (years) over the course of a lifetime (70 years).



DRAWN BY LDL DATE 4/26/02	Tetra Tech NUS, Inc.	CONCEPTUAL SITE MODEL SITE 1 – PRIVET ROAD COMPOUND NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	CONTRACT NO. 5466
CHECKED BY DATE			OWNER NO. 2207 (RI SITE 1)
REVISED BY DATE			APPROVED BY DATE
SCALE NONE			DRAWING NO. FIGURE 3-1 REV.

5466/SITE 1/5466gf101.dwg

3.1.3.5.1 Surface and Subsurface Soil Exposure

Three potential exposure routes are associated with direct exposure to surface soil and subsurface soil at NASJRB Willow Grove. These exposure routes include ingestion, dermal contact, and inhalation of fugitive dust. The methods used to assess these routes of exposure are discussed in the following text. Incidental soil ingestion, dermal contact, and inhalation of fugitive dust exposure are estimated from the following equations (EPA, 1989a):

Ing stion

$$INTAKE_{INGESTION}(mg/kg)/day = \frac{CS * IR_{soil} * FI * CF_1 * EF * ED}{BW * AT * 365^{days}/_{year}}$$

D rmal Contact

$$INTAKE_{DERMAL}(mg/kg)/day = \frac{DA_{event} * SA * EF * ED * EV}{BW * AT * 365^{days}/_{year}} \text{(Adults)}$$

$$INTAKE_{DERMAL} = \frac{DA_{event} * EV * EF}{AT * 365^{days}/_{year}} * \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i} \text{(Children, accounts changing SA and BW)}$$

$$DA_{event} = CS * AF * ABS_{dermal} * CF_1$$

Inhalation of COPCs in Fugitive Dust

Fraction inhaled and retained in lungs:

$$INTAKE_{INHALATION-LUNG}(mg/kg)/day = I_{LUNG} = \frac{X * CS * IR_{air} * ET * EF * ED * IF_R}{BW * AT * 365^{days}/_{year}}$$

Fraction inhaled and eventually swallowed:

$$INTAKE_{INHALATION-INGESTION}(mg/kg)/day = I_{INGESTION} = \frac{X * CS * IR_{air} * ET * EF * ED * IF_O}{BW * AT * 365^{days}/_{year}} \text{ Total}$$

Inhalation is the sum of the two fractions:

$$INTAKE_{INHALATION-TOTAL}(mg/kg)/day = I_{LUNG} + I_{INGESTION}$$

$$X = Q_I * F_I * CF_2$$

$$Q_I = \frac{R_{10}}{P_R}$$

$$R_{10} = E_{10} * A$$

$$E_{10} = \left[(0.036) * (1 - V) * \left(\frac{U}{Ut} \right)^3 * F(x) \right]$$

$$Ut = U^* * \left[\frac{1}{0.4} \right] * \ln\left(\frac{z}{z_o} \right)$$

where:

CS	=	Chemical concentration in soil (mg/kg or µg/kg soil)
IR_{soil}	=	Soil ingestion rate (mg soil/day)
IR_{air}	=	Inhalation rate (m^3/hr)
FI	=	Fraction ingested from contaminated source (unitless)
ET	=	Exposure time (hr/day)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
BW	=	Body weight (kg)
AT	=	Averaging time (years)
DA_{event}	=	Dose absorbed per unit area per event (mg/cm^2-event)
CF_1	=	Conversion factor (1×10^{-6} kg/mg for inorganics; 1×10^{-9} kg/µg for organics)
SA	=	Skin surface area available for contact (cm^2/day)
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)
AF	=	Soil-to-skin adherence factor (mg/cm^2)
ABS_{dermal}	=	Absorption fraction (unitless)
E_{10}	=	PM_{10} emission factor (g/m^2 sec)
V	=	vegetative cover
U	=	mean annual wind speed (m/s)
Ut	=	threshold value of wind speed at 7 m (m/s)
z	=	height above surface (m)
z_o	=	roughness height (m)
U^*	=	friction velocity (m/sec)

$F(x)$	=	function based on $x = 0.886 \times Ut/U$
R_{10}	=	Emission rate of soil (g/sec)
A	=	source area (m^2)
Q_I	=	wind erosion scaling factor (g/sec)
P_R	=	fraction of time wind erosion occurs (0.296)
X	=	average annual downwind respirable concentration (mg/m^3)
F_I	=	unscaled conc. due to unit erosion rate [(ug/m^3)/(g/sec)]
CF_2	=	conversion factor (1 mg/1,000 ug)
IF_R	=	inhaled fraction retained in lungs (0.125)
IF_O	=	inhaled fraction eventually swallowed (0.625)

A sample calculation for ingestion of soil is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-6 through Table 3-15 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current occupational workers, current adolescent and adult trespassers, future child and adult residents, future excavation workers, and future recreational children. EPA or conventional values were used for all input parameters.

A sample calculation for dermal contact with surface soil is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-6 through Table 3-15 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current occupational workers, current adolescent and adult trespassers, future child and adult residents, future excavation workers, and future recreational children. EPA or conventional values were used for most input parameters. For the dermal pathway, it was assumed that the primary areas of skin available for adult receptors (current and future) contact would be the hands and arms; for children (future) and adolescents (current), 25 percent of body surface area would be exposed.

A sample calculation for inhalation of fugitive dust is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-6 through Table 3-15 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current occupational workers, current adolescent and adult trespassers, future child and adult residents, future excavation workers, and future recreational children. EPA or conventional values were used for most input parameters. Inhalation exposure to fugitive dust was calculated for receptors only using the equations established by EPA (1989a) and Cowherd, et al. (1984). Exposure to fugitive dust emissions from surface soil in an area of interest can be estimated by first calculating the average annual rate of PM_{10} (particulate matter less than 10 microns in diameter) particulate emissions, the average annual PM_{10} concentration downwind from the source area, and the downwind COPC concentration associated with

TABLE 3-6

EXPOSURE PARAMETERS FOR SURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
OCCUPATIONAL WORKER – RME SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	OCCUPATIONAL WORKER	UNITS	SOURCE
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	50	mg/day	EPA, 1991a
FI	1	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	kg/µg	
EF	250	days/year	EPA, 1991a
ED	25	years	EPA, 1989a, 1991a
ET	8	hours/day	Assumption
EV	1	event/day	Assumption
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	25	years	EPA, 1991a
SA	3,508*	cm^2	EPA, 1995
IR_{air}	0.833	m^3/hour	EPA, 1991a
BW	70	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	
V	0.7	unitless	Estimated from site visit
U	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	m/s	
F(x)	1.9	unitless	Cowherd et al., 1984
CF_2	0.001	Mg/ug	
R_{10}	Calculated	g/sec	
A	10000	M^2	Estimated from site visit
Q_I	Calculated	g/sec	
P_R	0.296	Unitless	Cowherd et al., 1984
X	Calculated	Mg/m^3	Cowherd et al., 1984
F_I	3.837	$(ug/m^3)/(g/sec)$	Cowherd et al., 1984
Z	7	M	Cowherd et al., 1984
z_o	0.7	M	Cowherd et al., 1984
U*	0.35	M/sec	Cowherd et al., 1984
IF_R	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	Unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands.

TABLE 3-7

EXPOSURE PARAMETERS FOR SURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
OCCUPATIONAL WORKER – CTE SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	OCCUPATIONAL WORKER	UNITS	SOURCE
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	50	mg/day	EPA, 1991a
FI	1	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{2\text{-organics}}$	1E-09	kg/µg	
EF	250	days/year	EPA, 1991a
ED	9	years	EPA, 1989a, 1991a
ET	8	hours/day	Assumption
EV	1	Events/day	Assumption
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	9	years	EPA, 1991a
SA	3,508*	cm^2	EPA, 1992a
IR_{air}	0.833	m^3/hour	EPA, 1991a
BW	70	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	
V	0.7	unitless	Estimated from site visit
U	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	m/s	
F(x)	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	g/sec	
A	10000	m^2	Estimated from site visit
Q_I	Calculated	g/sec	
P_R	0.296	unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	(ug/m^3)/(g/sec)	
Z	7	m	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands.

TABLE 3-8

EXPOSURE PARAMETERS FOR SURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
ADOLESCENT AND ADULT TRESPASSERS – RME SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CS	Chemical Specific	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	100	100	mg/day	EPA, 1991a
FI	1	1.0	Unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	1E-09	kg/µg	
EF	30	24	days/year	EPA, 1991a
ED	11	19	Years	EPA, 1989a, 1991a
ET	4	4	hours/day	Assumption
AT_{cancer}	70	70	Years	EPA, 1991a
$AT_{non\text{-}cancer}$	11	19	Years	EPA, 1991a
SA	See Appendix A	3,508*	cm^2	EPA, 1992a
IR_{air}	0.833	0.833	m^3/hour	EPA, 1991a
BW	40	70	Kg	EPA, 1991a
AF	1	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	Chemical Specific	Unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	Calculated	g/m^2 sec	
V	0.7	0.7	Unitless	Estimated from site visit
U	4.3	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	Calculated	m/s	
F(x)	1.9	1.9	Unitless	Cowherd et al., 1984
R_{10}	Calculated	Calculated	g/sec	
A	10000	10000	m^2	Estimated from site visit
Q_I	Calculated	Calculated	g/sec	
P_R	0.296	0.296	Unitless	Cowherd et al., 1984
X	Calculated	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	3.837	$(ug/m^3)/(g/sec)$	
Z	7	7	M	Cowherd et al., 1984
z_o	0.7	0.7	M	Cowherd et al., 1984
U*	0.35	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	0.001	mg/ug	
IF_R	0.125	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	0.625	Unitless	Cowherd et al., 1984
CA	Calculated	Calculated	mg/m^3	

*Average of male and female surface areas for arms and hands.

TABLE 3-9

EXPOSURE PARAMETERS FOR SURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
ADOLESCENT AND ADULT TRESPASSERS – CTE SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CS	Chemical Specific	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	50	50	mg/day	EPA, 1991a
FI	1	1.0	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	1E-09	kg/µg	
EF	15	12	days/year	EPA, 1991a
ED	2	7	Years	EPA, 1989a, 1991a
ET	4	4	hours/day	Assumption
AT_{cancer}	70	70	Years	EPA, 1991a
$AT_{non\text{-}cancer}$	2	7	Years	EPA, 1991a
SA	See Appendix A	5,750*	cm^2	EPA, 1992a
IR_{air}	0.833	0.833	m^3/hour	EPA, 1991a
BW	40	70	Kg	EPA, 1991a
AF	1	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	Chemical Specific	Unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	Calculated	g/m^2 sec	
V	0.7	0.7	Unitless	Estimated from site visit
U	4.3	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	Calculated	m/s	
F(x)	1.9	1.9	Unitless	Cowherd et al., 1984
R_{10}	Calculated	Calculated	g/sec	
A	10000	10000	m^2	Estimated from site visit
Q_I	Calculated	Calculated	g/sec	
P_R	0.296	0.296	Unitless	Cowherd et al., 1984
X	Calculated	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	3.837	$(ug/m^3)/(g/sec)$	
Z	7	7	M	Cowherd et al., 1984
z_o	0.7	0.7	M	Cowherd et al., 1984
U*	0.35	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	0.001	mg/ug	
IF_R	0.125	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	0.625	Unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands.

TABLE 3-10

EXPOSURE PARAMETERS FOR SURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
RECREATIONAL CHILD – RME SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD 3-8	UNITS	SOURCE
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	200	mg/day	EPA, 1991a
FI	1.0	Unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	kg/µg	
EF	7	Days/year	EPA, 1991a
ED	6	years	EPA, 1989a, 1991a
ET	8	Hours/day	Assumption
EV	1	Events/day	
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	6	years	EPA, 1991a
SA	See Appendix A	cm^2	EPA, 1992a
IR_{air}	0.833	m^3/hour	EPA, 1991a
BW	21.3	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	Unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	Estimated from site visit
V	0.7	Unitless	Cowherd et al., 1984
U	4.3	m/s	
Ut	Calculated	m/s	Cowherd et al., 1984
F(x)	1.9	Unitless	
R_{10}	Calculated	g/sec	Estimated from site visit
A	10000	m^2	
Q_I	Calculated	g/sec	Cowherd et al., 1984
P_R	0.296	Unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	
F_I	3.837	(ug/m^3)/(g/sec)	
Z	7	M	Cowherd et al., 1984
z_o	0.7	M	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	Unitless	Cowherd et al., 1984
CA	Calculated	mg/m^3	

TABLE 3-11

EXPOSURE PARAMETERS FOR SURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
RECREATIONAL CHILD – CTE SCENARIO
NASJRB, WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD 3-8	UNITS	SOURCE
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	100	mg/day	EPA, 1991a
FI	1.0	Unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	kg/µg	
EF	7	Days/year	EPA, 1991a
ED	2	years	EPA, 1989a, 1991a
ET	8	Hours/day	Assumption
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	2	years	EPA, 1991a
SA	See Appendix A	cm^2	EPA, 1992a
IR_{air}	0.833	m^3/hour	EPA, 1991a
BW	21.3	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	Unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	Estimated from site visit
V	0.7	Unitless	Cowherd et al., 1984
U	4.3	m/s	
Ut	Calculated	m/s	Cowherd et al., 1984
F(x)	1.9	Unitless	
R_{10}	Calculated	g/sec	Estimated from site visit
A	10000	m^2	
Q_I	Calculated	g/sec	Cowherd et al., 1984
P_R	0.296	Unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	
F_I	3.837	$(ug/m^3)/(g/sec)$	
Z	7	M	Cowherd et al., 1984
z_o	0.7	M	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	Unitless	Cowherd et al., 1984

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TABLE 3-12

EXPOSURE PARAMETERS FOR SURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
FUTURE RESIDENT – RME SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD (0-6 YRS)	ADULTS	UNITS	SOURCE
CS	Chemical Specific	Chemical Specific	mg/kg	EPA 1989a
IR_{soil}	200	100	mg soil/day	EPA 1991d
IR_{air}	0.833	0.833	m^3/hour	EPA 1989a
FI	1	1	Unitless	Assumption
ET	24	24	hours/day	Conventional
EF	350	350	days/year	EPA 1991d
ED	6	24	Years	EPA 1989a, 1991d
EV	1	1	events/day	
BW	15	70	Kg	EPA 1991d, 1989a
AT_{cancer}	70	70	Years	EPA, 1989a
$AT_{non\text{-}cancer}$	6	24	Years	EPA 1989a
DA_{event}	Chemical Specific	Chemical Specific	mg/cm^2-event	
$CF_{1\text{-}inorganics}$	1×10^{-6}	1×10^{-6}	kg/mg	
$CF_{1\text{-}organics}$	1×10^{-9}	1×10^{-9}	kg/ug	
SA	-	3,508*	cm^2	EPA 1996e
SA_i	Varies with age	-	cm^2	EPA 1989a
ED_i	1-year increments	-	Years	EPA 1989a, 1991d
BW_i	Varies with age	-	Kg	EPA 1996e
AF	1	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical Specific	Chemical Specific	Unitless	EPA 1995a
E_{10}	Calculated	Calculated	g/m^2 sec	
V	0.7	0.7	Unitless	Estimated from site visit
U	4.3	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	Calculated	m/s	
F(x)	1.9	1.9	Unitless	Cowherd et al., 1984
R_{10}	Calculated	Calculated	g/sec	
A	10000	10000	m^2	Estimated from site visit
Q_i	Calculated	Calculated	g/sec	
P_R	0.296	0.296	Unitless	Cowherd et al., 1984
X	Calculated	Calculated	mg/m^3	Cowherd et al., 1984
F_i	3.837	3.837	(ug/m^3)/(g/sec)	
Z	7	7	M	Cowherd et al., 1984
z_o	0.7	0.7	M	Cowherd et al., 1984
U*	0.35	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	0.001	mg/ug	
IF_R	0.125	0.125	Unitless	Cowherd et al., 1984
IF_O	0.625	0.625	Unitless	Cowherd et al., 1984
CA	Calculated	Calculated	Mg/m^3	

*Average of male and female surface areas for arms and hands.

TABLE 3-13

EXPOSURE PARAMETERS FOR SURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
FUTURE RESIDENT – CTE SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD (0-6 YRS)	ADULTS	UNITS	SOURCE
CS	Chemical Specific	Chemical Specific	mg/kg	EPA 1989a
IR_{soil}	100	50	mg soil/day	EPA 1991d
IR_{air}	0.833	0.833	m^3/hour	EPA 1989a
FI	1	1	Unitless	Assumption
ET	24	24	hours/day	Conventional
EF	350	350	days/year	EPA 1991d
ED	2	7	Years	EPA 1989a, 1991d
EV	1	1	Events/day	
BW	15	70	Kg	EPA 1991d, 1989a
AT_{cancer}	70	70	Years	EPA, 1989a
$AT_{non\text{-}cancer}$	2	7	Years	EPA 1989a
DA_{event}	Chemical Specific	Chemical Specific	mg/cm^2-event	
$CF_{1\text{-}inorganics}$	1×10^{-6}	1×10^{-6}	kg/mg	
$CF_{1\text{-}organics}$	1×10^{-9}	1×10^{-9}	kg/ug	
SA	-	3,508*	cm^2	EPA 1996e
SA_i	Varies with age	-	cm^2	EPA 1989a
ED_i	1-year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with age	-	kg	EPA 1996e
AF	1	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical Specific	Chemical Specific	unitless	EPA 1995a
E_{10}	Calculated	Calculated	g/m^2 sec	
V	0.7	0.7	unitless	Estimated from site visit
U	4.3	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	Calculated	m/s	
F(x)	1.9	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	Calculated	g/sec	
A	10000	10000	m^2	Estimated from site visit
Q_I	Calculated	Calculated	g/sec	
P_R	0.296	0.296	unitless	Cowherd et al., 1984
X	Calculated	Calculated	mg/m^3	Cowherd et al., 1984
F_I	Calculated	Calculated	$(ug/m^3)/(g/sec)$	
Z	7	7	m	Cowherd et al., 1984
z_o	0.7	0.7	m	Cowherd et al., 1984
U*	0.35	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	0.001	mg/ug	
IF_R	0.125	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	0.625	unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands.

TABLE 3-14

EXPOSURE PARAMETERS FOR SURFACE AND SUBSURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
EXCAVATION WORKER – RME SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

Parameter	Excavation Worker	Units	Source
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	480	mg/day	EPA, 1991a
FI	1	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{2\text{-organics}}$	1E-09	kg/µg	
EF	30	days/year	EPA, 1991a
ED	1	years	EPA, 1989a, 1991a
ET	8	hours/day	Assumption
EV	1	Events/day	
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	1	years	EPA, 1991a
SA	3,508*	cm^2	EPA, 1992a
IR_{air}	2.5	m^3/hour	EPA, 1991a
BW	70	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	
V	0.7	unitless	Estimated from site visit
U	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	m/s	
F(x)	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	g/sec	
A	10000	m^2	Estimated from site visit
Q_I	Calculated	g/sec	
P_R	0.296	unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	$(ug/m^3)/(g/sec)$	
Z	7	m	Cowherd et al., 1984

TABLE 3-14 (C ntinu d)
EXPOSURE PARAMETERS FOR SURFACE AND SUBSURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
EXCAVATION WORKER – RME SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA
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Parameter	Excavation Worker	Units	Source
z_o	0.7	m	Cowherd et al., 1984
U*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	unitless	Cowherd et al., 1984

*Average of male and female surface areas for arms and hands.

TABLE 3-15

EXPOSURE PARAMETERS FOR SURFACE AND SUBSURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
EXCAVATION WORKER – CTE SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

Parameter	Excavation Worker	Units	Source
CS	Chemical Specific	mg/kg or µg/kg	Analysis
IR_{soil}	480	mg/day	EPA, 1991a
FI	1	unitless	Assumption
$CF_{1\text{-inorganics}}$	1E-06	kg/mg	
$CF_{1\text{-organics}}$	1E-09	kg/µg	
EF	15	days/year	EPA, 1991a
ED	1	years	EPA, 1989a, 1991a
ET	8	hours/day	Assumption
EV	1	Event/day	
AT_{cancer}	70	years	EPA, 1991a
$AT_{non\text{-}cancer}$	1	years	EPA, 1991a
SA	3,508*	cm^2	EPA, 1992a
IR_{air}	2.5	m^3/hour	EPA, 1991a
BW	70	kg	EPA, 1991a
AF	1	mg/cm^2 per event	EPA, 1992a, 1995a
ABS_{dermal}	Chemical Specific	unitless	EPA, 1995a EPA, 1995h
E_{10}	Calculated	g/m^2 sec	
V	0.7	unitless	Estimated from site visit
U	4.3	m/s	Cowherd et al., 1984
Ut	Calculated	m/s	
F(x)	1.9	unitless	Cowherd et al., 1984
R_{10}	Calculated	g/sec	
A	10000	m^2	Estimated from site visit
Q_I	Calculated	g/sec	
P_R	0.296	unitless	Cowherd et al., 1984
X	Calculated	mg/m^3	Cowherd et al., 1984
F_I	3.837	$(ug/m^3)/(g/sec)$	
Z	7	m	Cowherd et al., 1984

TABLE 3-15 (Continued)
EXPOSURE PARAMETERS FOR SURFACE AND SUBSURFACE SOIL INGESTION, DERMAL CONTACT, AND INHALATION
EXCAVATION WORKER – CTE SCENARIO
NASJRB, WILLOW GROVE, PENNSYLVANIA
Pag 2 of 2

Parameter	Excavation Worker	Units	Source
z_o	0.7	m	Cowherd et al., 1984
U^*	0.35	m/sec	Cowherd et al., 1984
CF_2	0.001	mg/ug	
IF_R	0.125	unitless	Cowherd et al., 1984
IF_O	0.625	unitless	Cowherd et al., 1984

PM_{10} and then applying this concentration to estimate the intake rate for the receptors. The input parameters were generally those provided in the Cowherd model, which allows limited parameter choices for area and distance to the area of interest. Specific details regarding the application of the model can be found in the source document (Cowherd, et al., 1984).

3.1.3.5.2 Sediment Exposure

Two potential exposure routes are associated with direct contact with sediment at NASJRB Willow Grove: ingestion and dermal contact. These scenarios were evaluated using the same basic equations as ingestion and dermal exposures for surface soil, which were explained above.

Ingestion

$$INTAKE_{INGESTION}(mg/kg)/day = \frac{CS * IR_{sediment} * FI * CF * EF * ED}{BW * AT * 365^{days}/_{year}}$$

Dermal Contact

$$INTAKE_{DERMAL}(mg/kg)/day = \frac{DA_{event} * SA * EF * ED * EV}{BW * AT * 365^{days}/_{year}} \text{ (Adults)}$$

$$INTAKE_{DERMAL} = \frac{DA_{event} * EV * EF}{AT * 365^{days}/_{year}} * \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i} \text{ (Children, accounts changing SA and BW)}$$

$$DA_{event} = CS * AF * ABS_{dermal} * CF_1$$

where:

CS	=	Chemical concentration in sediment (mg/kg or µg/kg sediment)
$IR_{sediment}$	=	Sediment ingestion rate (mg soil/day)
FI	=	Fraction ingested from contaminated source (unitless)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

CF	=	Conversion factor (1×10^{-6} kg/mg for inorganics; 1×10^{-9} kg/µg for organics)
SA	=	Skin surface area available for contact (cm^2/day)
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)
AF	=	Soil-to-skin adherence factor (mg/cm^2)
ABS_{dermal}	=	Absorption factor (unitless)

A sample calculation for ingestion of sediment is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-16 through Table 3-19 for RME and CTE scenarios. As discussed in Section 3.4.3, the potential receptors for this scenario were current adolescent and adult trespassers and future recreational children. EPA or conventional values were used for all input parameters.

A sample calculation for dermal contact with sediment is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-16 through Table 3-19 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current adolescent and adult trespassers and future recreational children. EPA or conventional values were used for most input parameters. For the dermal pathway, it was assumed that the primary areas of skin available for adult receptors (current) contact would be the hands, arms, and feet; for children (future) and adolescents (current), 25 percent of body surface area would be exposed.

3.1.3.5.3 Surface Water Exposure

Two potential exposure routes are associated with surface water exposure at NASJRB Willow Grove: ingestion and dermal contact. These scenarios were evaluated using the same basic equations as ingestion and dermal exposures for groundwater, which were explained above.

Ingestion

$$INTAKE_{INGESTION}\ (mg/kg)/day = \frac{CW * IR_{surfacewater} * CF_1 * EF * ED}{BW * AT * 365\ {}^{days}/_{year}}$$

TABLE 3-16

EXPOSURE PARAMETERS FOR SEDIMENT INGESTION AND DERMAL CONTACT TRESPASSER ADOLESCENT AND ADULT – RME SCENARIO NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CS	Chemical-Specific	Chemical-Specific	mg/kg	EPA 1989a
$IR_{sediment}$	100	100	mg sed/day	EPA 1991d
FI	1	1	unitless	Professional judgment
EF	30	24	days/year	Assumption
ED	11	19	years	EPA 1991d
BW	40	70	kg	EPA 1996e
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	11	19	years	EPA 1989a
EV	1	1	events/day	
DA_{event}	Chemical-Specific	Chemical-Specific	mg/cm^2-event	
$CF_{inorganics}$	1×10^{-6}	1×10^{-6}	kg/mg	
$CF_{organics}$	1×10^{-9}	1×10^{-9}	kg/ug	
SA	-	4,734*	Cm^2	EPA, 1995
SA_i	Varies with age	-	cm^2	EPA 1985
ED_i	1-year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with age	-	kg	EPA 1985
AF	1	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical-Specific	Chemical-Specific	unitless	EPA 1995a

* Average of male and female surface area for hands, arms, and feet.

TABLE 3-17

EXPOSURE PARAMETERS FOR SEDIMENT INGESTION AND DERMAL CONTACT TRESPASSER ADOLESCENT AND ADULT – CTE SCENARIO NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CS	Chemical-Specific	Chemical-Specific	Mg/kg	EPA 1989a
$IR_{sediment}$	50	50	mg sed/day	EPA 1991d
FI	1	1	Unitless	Professional judgment
EF	15	12	Days/year	Assumption
ED	2	7	Years	EPA 1991d
BW	40	70	Kg	EPA 1996e
AT_{cancer}	70	70	Years	EPA 1989a
$AT_{non\text{-}cancer}$	2	7	Years	EPA 1989a
EV	1	1	Events/day	
DA_{event}	Chemical-Specific	Chemical-Specific	mg/cm^2-event	
$CF_{inorganics}$	1×10^{-6}	1×10^{-6}	kg/mg	
$CF_{organics}$	1×10^{-9}	1×10^{-9}	Kg/ug	
SA	-	4,734*	Cm^2	EPA, 1995
SA_i	Varies with age	-	Cm^2	EPA 1985
ED_i	1-year increments	-	Years	EPA 1989a, 1991d
BW_i	Varies with age	-	Kg	EPA 1985
AF	1	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical-Specific	Chemical-Specific	Unitless	EPA 1995

* Average of male and female surface area for hands, arms, and feet.

TABLE 3-18

EXPOSURE PARAMETERS FOR SEDIMENT INGESTION AND DERMAL CONTACT RECREATIONAL CHILD – RME SCENARIO NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD VALUE (3-8 YRS)	UNITS	SOURCE
CS	Chemical-Specific	mg/kg	EPA 1989a
$IR_{sediment}$	200	mg sed/day	EPA 1991d
FI	1	Unitless	Professional judgment
EF	7	days/year	Assumption
ED	6	Years	EPA 1991d
BW	21.3	Kg	EPA 1996e (Ave. 3-8 yrs.)
AT_{cancer}	70	Years	EPA 1989a
$AT_{non\text{-}cancer}$	6	Years	EPA 1989a
EV	1	events/day	
DA_{event}	Chemical-Specific	mg/cm^2-event	
$CF_{inorganics}$	1×10^{-6}	kg/mg	
$CF_{organics}$	1×10^{-9}	kg/ug	
SA_i	Varies with age	cm^2	EPA 1985
ED_i	1-year increments	Years	EPA 1989a, 1991d
BW_i	Varies with age	Kg	EPA 1985
AF	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical-Specific	Unitless	EPA 1995

TABLE 3-19

EXPOSURE PARAMETERS FOR SEDIMENT INGESTION AND DERMAL CONTACT RECREATIONAL CHILD – CTE SCENARIO NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD VALUE (3-8 YRS)	UNITS	SOURCE
CS	Chemical-Specific	mg/kg	EPA 1989a
$IR_{sediment}$	100	mg sed/day	EPA 1991d
FI	1	Unitless	
EF	7	days/year	Assumption
ED	2	Years	EPA 1991d
BW	21.3	Kg	EPA 1996e (Ave. 3-8 yrs.)
AT_{cancer}	70	Years	EPA 1989a
$AT_{non\text{-}cancer}$	2	Years	EPA 1989a
EV	1	events/day	
DA_{event}	Chemical-Specific	mg/cm^2-event	
$CF_{inorganics}$	1×10^{-6}	kg/mg	
$CF_{organics}$	1×10^{-9}	kg/ug	
SA_i	Varies with age	cm^2	EPA 1985
ED_i	1-year increments	Years	EPA 1989a, 1991d
BW_i	Varies with age	Kg	EPA 1985
AF	1	mg/cm^2	EPA 1992e
ABS_{dermal}	Chemical-Specific	Unitless	EPA 1995

Dermal Contact

$$INTAKE_{DERMAL}(mg/kg)/day = \frac{DA_{event} * SA * EF * ED * EV}{BW * AT * 365\, {}^{days}/_{year}}$$ (Adults)

$$INTAKE_{DERMAL} = \frac{DA_{event} * EV * EF}{AT * 365\, {}^{days}/_{year}} * \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i}$$ (Children, accounts for varying SA and BW)

$$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

For inorganics (steady state approach):

$$PC_{event} = K_{pw-inorg} * t_{event}$$

For organics (non-steady state approach):

Case 1:

$$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

$$PC_{event} = 2 * K_{pw-org} * \sqrt{\frac{6 * \tau * t_{event}}{\pi}}$$

where $t_{event} < t^*$ (for the specific organic chemical)

Case 2:

$$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

$$PC_{event} = K_{pw-org} * (({}^{t_{event}}/_{(1+B)}) + 2\tau * ({}^{(1+3B)}/_{(1+B)})$$

where $t_{event} > t^*$ (for the specific organic chemical)

where:

CW	=	Concentration of contaminant in surface water (µg/L)
$IR_{groundwater}$	=	Surface water ingestion rate (L/day)
CF_1	=	Conversion factor (mg/10^3 µg)
CF_2	=	Conversion factor (L/10^3 cm^3)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
AT	=	Averaging time (years)
SA	=	Surface area (cm^2)
BW	=	Body weight (kg)

DA_{event}	=	Dose absorbed per unit area per event [mg/(event-cm^2)]
PC_{event}	=	Diffusion depth per event (cm/event)
$K_{pw\text{-}inorg}$	=	Permeability coefficient from water (cm/hr)
t_{event}	=	Duration of event (hr/event)
$K_{pw\text{-}org}$	=	Permeability coefficient from water (cm/hr)
τ	=	Lag time (hr)
t^*	=	Time to reach steady state (hr)
B	=	Octanol water partition coefficient divided by 10^4 (dimensionless)
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)

A sample calculation for ingestion of surface water is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-20 through Table 3-23 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current adolescent and adult trespassers and future recreational children. EPA or conventional values were used for all input parameters.

A sample calculation for dermal contact with surface water is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-20 through Table 3-23 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were current adolescent and adult trespassers and future recreational children. EPA or conventional values were used for all input parameters. The approach for dermal contact with surface water is based on the assumption that water contaminants are present in dilute solution and that percutaneous absorption is controlled by the flux of water. K_{pw}, B, τ, and t^* were chemical-specific values obtained from EPA (1992e) or derived from the molecular weight and K_{ow} as demonstrated therein. As recommended by the guidance, default $K_{pw\text{-}inorg}$ values of 1E-3 cm/hr were used for metals for which experimental values had not been obtained (EPA, 1992e). For the dermal pathway, it was assumed that the primary areas of skin available for adult receptors (current and future) contact would be the hands, arms, and feet; for children (future) and adolescents (current), 25 percent of body surface area would be exposed.

3.1.3.5.4 Groundwater Exposure

Three potential exposure routes are associated with direct contact with groundwater at the site: ingestion, dermal contact, and inhalation of vapors during showering or excavation activities (from shallow groundwater). The methods used to assess these routes of exposure are discussed in the following text.

TABLE 3-20

EXPOSURE PARAMETERS FOR SURFACE WATER INGESTION AND DERMAL CONTACT TRESPASSER ADOLESCENT AND ADULT – RME SCENARIO NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	ADOLESCENT	ADULT	UNIT	SOURCE
CW	Chemical-Specific	Chemical-Specific	ug/liter	EPA 1989a
$IR_{surface\ water}$	0.065	0.065	liters/day	EPA 1989a
CF_1	0.001	0.001	mg/10^3 ug	
CF_2	0.001	0.001	liters/10^3 cm^3	
EF	30	24	days/year	EPA 1989a
ED	11	19	years	EPA 1991d
EV	1	1	events/day	
BW	40	70	Kg	EPA 1996e
AT_{cancer}	70	70	Years	EPA 1989a
$AT_{non\text{-}cancer}$	11	19	Years	EPA 1989a
DA_{event}	Chemical-Specific	Chemical-Specific	Mg/event-cm^2	
SA	-	3,508*	Cm^2	EPA 1985
SA_i	Varies with Age	-	Cm^2	EPA 1985
ED_i	1 year increments	-	Years	EPA 1989a
BW_i	Varies with Age	70	Kg	EPA 1985
AF	1	1	Mg/cm^2	EPA 1992e
$K_{pw\text{-}inorg}$	0.001	0.001	Cm/hour	EPA 1992e
$K_{pw\text{-}org}$	Chemical-Specific	Chemical-Specific	Cm/hour	EPA 1992e
t_{event}	2.6	2.6	Hour/event	
t^*	Chemical-Specific	Chemical-Specific	Hour	EPA 1992e
τ	Chemical-Specific	Chemical-Specific	Hour	EPA 1992e
PC_{event}	Chemical-Specific	Chemical-Specific	Cm/event	
B	Chemical-Specific	Chemical-Specific	Unitless	EPA 1992e

TABLE 3-21

EXPOSURE PARAMETERS FOR SURFACE WATER INGESTION AND DERMAL CONTACT
TRESPASSER ADOLESCENT AND ADULT – CTE SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	ADOLESCENT	ADULT	UNITS	SOURCE
CW	Chemical-Specific	Chemical-Specific	ug/liter	EPA 1989a
$IR_{surface\ water}$	0.065	0.065	liters/day	EPA 1989a
CF_1	0.001	0.001	mg/10^3 ug	
CF_2	0.001	0.001	liters/10^3 cm^3	
EF	15	12	days/year	EPA 1989a
ED	2	7	years	EPA 1991d
EV	1	1	events/day	
BW	40	70	kg	EPA 1996e
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	2	7	years	EPA 1989a
DA_{event}	Chemical-Specific	Chemical-Specific	mg/event-cm^2	
SA	-	3,508*	Cm^2	EPA 1995
SA_i	Varies with Age	-	cm^2	EPA 1985
ED_i	1 year increments	-	years	EPA 1989a
BW_i	Varies with Age	70	kg	EPA 1985
AF	1	1	mg/cm^2	EPA 1992e
$K_{pw\text{-}inorg}$	0.001	0.001	cm/hour	EPA 1992e
$K_{pw\text{-}org}$	Chemical-Specific	Chemical-Specific	cm/hour	EPA 1992e
t_{event}	2.6	2.6	hour/event	
t*	Chemical-Specific	Chemical-Specific	hour	EPA 1992e
τ	Chemical-Specific	Chemical-Specific	hour	EPA 1992e
PC_{event}	Chemical-Specific	Chemical-Specific	cm/event	
B	Chemical-Specific	Chemical-Specific	unitless	EPA 1992e

TABLE 3-22

EXPOSURE PARAMETERS FOR SURFACE WATER INGESTION AND DERMAL CONTACT RECREATIONAL CHILD – RME SCENARIO NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD VALUE (3-8 YEAR)	UNITS	SOURCE
CW	Chemical-Specific	ug/liter	EPA 1989a
$IR_{surface\ water}$	0.065	liters/day	EPA 1989a
CF_1	0.001	mg/10^3 ug	
CF_2	0.001	liters/10^3 cm^3	
EF	7	days/year	EPA 1989a
ED	6	years	EPA 1991d
EV	1	events/day	
BW	21.3	kg (Ave. 3-8 yrs.)	EPA 1996e
AT_{cancer}	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	6	years	EPA 1989a
DA_{event}	Chemical-Specific	mg/event- cm^2	
SA_i	Varies with Age	cm^2	EPA 1985
ED_i	1 year increments	years	EPA 1989a
BW_i	Varies with Age	kg	EPA 1985
AF	1	mg/cm^2	EPA 1992e
$K_{pw\text{-}inorg}$	0.001	cm/hour	EPA 1992e
$K_{pw\text{-}org}$	Chemical-Specific	cm/hour	EPA 1992e
t_{event}	2.6	hour/event	
t^*	Chemical-Specific	hour	EPA 1992e
τ	Chemical-Specific	hour	EPA 1992e
PC_{event}	Chemical-Specific	cm/event	
B	Chemical-Specific	unitless	EPA 1992e

TABLE 3-23

EXPOSURE PARAMETERS FOR SURFACE WATER INGESTION AND DERMAL CONTACT RECREATIONAL CHILD – CTE SCENARIO NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD VALUE (3-8 YRS)	UNITS	SOURCE
CW	Chemical-Specific	ug/liter	EPA 1989a
$IR_{surface\ water}$	0.065	liters/day	EPA 1989a
CF_1	0.001	mg/10^3 ug	
CF_2	0.001	liters/10^3 cm^3	
EF	7	days/year	EPA 1989a
ED	2	years	EPA 1991d
EV	1	events/day	
BW	21.3	kg (Ave. 3-8 yrs.)	EPA 1996e
AT_{cancer}	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	2	years	EPA 1989a
DA_{event}	Chemical-Specific	mg/event- cm^2	
SA_i	Varies with Age	cm^2	EPA 1985
ED_i	1 year increments	years	EPA 1989a
BW_i	Varies with Age	kg	EPA 1985
AF	1	mg/cm^2	EPA 1992e
$K_{pw\text{-}inorg}$	0.001	cm/hour	EPA 1992e
$K_{pw\text{-}org}$	Chemical-Specific	cm/hour	EPA 1992e
t_{event}	2.6	hour/event	
t^*	Chemical-Specific	hour	EPA 1992e
τ	Chemical-Specific	hour	EPA 1992e
PC_{event}	Chemical-Specific	cm/event	
B	Chemical-Specific	unitless	EPA 1992e

Exposures via incidental groundwater ingestion, dermal contact, and inhalation of volatile organic vapors are estimated using the following equations (EPA, 1989a):

Ingestion

$$INTAKE_{INGESTION}\ (mg/kg)/day = \frac{CW * IR_{groundwater} * CF_1 * EF * ED}{BW * AT * 365\ {}^{days}/_{year}}$$

D rmal Contact

$$INTAKE_{DERMAL}\ (mg/kg)/day = \frac{DA_{event} * SA * EF * ED * EV}{BW * AT * 365\ {}^{days}/_{year}}$$ (Adults)

$$INTAKE_{DERMAL} = \frac{DA_{event} * EV * EF}{AT * 365\ {}^{days}/_{year}} * \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i}$$ (Children, accounts for varying SA and BW)

$$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

For inorganics (steady state approach):

$$PC_{event} = K_{pw-inorg} * t_{event}$$

For organics (non-steady state approach):

Case 1:

$$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

$$PC_{event} = 2 * K_{pw-org} * \sqrt{\frac{6 * \tau * t_{event}}{\pi}}$$

where $t_{event} < t^*$ (for the specific organic chemical)

Case 2:

$$DA_{event} = PC_{event} * CW * CF_1 * CF_2$$

$$PC_{event} = K_{pw-org} * ((t_{event}/(1+B)) + 2\tau * ((1+3B)/(1+B))$$

where $t_{event} > t^*$ (for the specific organic chemical)

Inhalation f COPCs in Volatile Organic Vap rs (Sh w ring)

$$INTAKE_{INHALATION}(mg/kg)/day = \frac{D * EF * ED}{AT * 365\ {}^{days}/_{year}}$$

Where:

$$D = \frac{IR_{air} * S}{BW * Ra * CF_3} * Q \quad \text{AND} \quad Q = Ds + \left\{\frac{e^{-Ra*Dt}}{Ra}\right\} - \left\{\frac{e^{-Ra*(Ds-Dt)}}{Ra}\right\} \quad \text{AND}$$

$$S = \frac{Cwd * Fr}{Sv} \quad \text{AND} \quad Cwd = CW * \left(1 - e^{-KaL*ts*6/d*CF_4*CF_5}\right) \quad \text{AND}$$

$$KaL = \frac{KL}{\sqrt{\frac{T_1 * \mu_S}{T_S * \mu_1}}} \quad \text{AND} \quad KL = \frac{1}{\left(\frac{1}{kl}\right) + \left(\frac{R * T_2}{H * kg}\right)} \quad \text{AND}$$

$$kg = kH * \sqrt{\frac{MWH}{MW}} \quad \text{AND} \quad kl = kC * \sqrt{\frac{MWC}{MW}}$$

Inhalation of COPCs in Volatile Organic Vapors (Excavation)

$$INTAKE_{INHALATION}(mg/kg)/day = \frac{C_{air,chemical} * IR * EF * ED}{AT * 365\ {}^{days}/_{year}}$$

$$C_{air,chemical} = CW * CF_1 * H * {}^{1}/_{R} * {}^{1}/_{T_3}$$

where:

CW	=	Concentration of contaminant in groundwater (µg/L)
$IR_{groundwater}$	=	Groundwater ingestion rate (L/day)
CF_1	=	Conversion factor (mg/10^3 µg)
CF_2	=	Conversion factor (L/10^3 cm^3)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
EV	=	Event frequency (events/day)
AT	=	Averaging time (years)
SA	=	Surface area (cm^2)
BW	=	Body weight (kg)
DA_{event}	=	Dose absorbed per unit area per event [mg/(event-cm^2)]

PC_{event}	=	Diffusion depth per event (cm/event)
$K_{pw\text{-}inorg}$	=	Permeability coefficient from water (cm/hr)
t_{event}	=	Duration of event (hr/event)
$K_{pw\text{-}org}$	=	Permeability coefficient from water (cm/hr)
τ	=	Lag time (hr)
t^*	=	Time to reach steady state (hr)
B	=	Octanol water partition coefficient divided by 10^4 (dimensionless)
SA_i	=	Surface area exposed at age i (cm^2)
ED_i	=	Exposure duration at age i (years)
BW_i	=	Body weight at age i (kg)
D	=	Inhalation dose (mg/kg/shower)
CF_3	=	Conversion factor: 10^6 ug x L / (mg x m^3)
Q	=	Function of air exchange rate and time in shower and shower room (min)
IR_{air}	=	Inhalation rate (L/min)
S	=	Indoor VOC generation rate (ug/m^3/min)
Ra	=	Rate of air exchange (min^{-1})
Ds	=	Duration of shower (min)
Dt	=	Total time in shower room (min)
Cwd	=	Concentration leaving water droplet (ug/L)
Fr	=	Shower flow rate (L/min)
Sv	=	Shower room air volume (m^3)
KaL	=	Adjusted overall mass transfer coefficient (cm/hr)
ts	=	Shower droplet time (sec)
6/d	=	Specific interfacial area (1/mm)
CF_4	=	Conversion factor (1hr/3600 sec)
CF_5	=	Conversion Factor (10 mm/cm)
d	=	Shower droplet diameter (mm)
KL	=	Mass transfer coefficient (cm/hr)
T_1	=	Calibration water temperature of KL (°K)
Ts	=	Shower water temperature (°K)
μ_1	=	Water viscosity at T1 (centipoise)
μ_s	=	Water viscosity at Ts (centipoise)
R	=	Ideal gas law constant [atm-m^3/(mole-°K)]
T_2	=	Absolute temperature (°K)
H	=	Henry's Law constant (atm-m^3/mole)
kg	=	Gas-film mass transfer coefficient (cm/hr)
kl	=	Liquid-film mass transfer coefficient (cm/hr)

kH	=	kg for water (cm/hr)
kC	=	kl for carbon dioxide (cm/hr)
MWH	=	Molecular weight of water (g/mole)
MWC	=	Molecular weight of carbon dioxide (g/mole)
MW	=	Molecular weight of the chemical (g/mole)
$C_{air,chemical}$	=	Concentration in Air (mg/m^3)
T_3	=	Temperature (°K)

A sample calculation for ingestion of groundwater is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-24 and Table 3-25 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were future adult and child residential receptors. EPA or conventional values were used for all input parameters.

A sample calculation for dermal contact with groundwater is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-24 and Table 3-25 for RME and CTE scenarios. As discussed in Section 3.1.3.2, the potential receptors for this scenario were future adult (showering) and child (bathing) residential receptors. EPA or conventional values were used for most input parameters. The approach for dermal contact with groundwater is based on the assumption that water contaminants are present in dilute solution and that percutaneous absorption is controlled by the flux of water. Adult and child residents were assumed to take daily showers and baths, respectively, and therefore their total body surface areas were used. K_{pw}, B, τ, and t* were chemical-specific values obtained from EPA (1992f) or derived from the molecular weight and K_{ow} as demonstrated therein. As recommended by the guidance, default $K_{pw\text{-}inorg}$ values of 1E-3 cm/hr were used for metals for which experimental values had not been obtained (EPA, 1992f). The age-adjusted, body-weight-normalized surface areas exposed while bathing for a resident child is 2,728 cm^2-year/kg.

A sample calculation for inhalation of volatile COPCs during showering is provided in Appendix J. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 3-24 and 3-25. As discussed in Section 3.1.3.3, the potential receptors for this scenario were future adult (showering) residential receptors and future excavation workers (excavation scenario). EPA or conventional values were used for most input parameters. Inhalation exposure to groundwater (during showering) was calculated for adult residents only using the equations established by EPA (1989a) and Foster and Chrostowski (1987).

TABLE 3-24

EXPOSURE PARAMETERS FOR GROUNDWATER INGESTION, DERMAL CONTACT, AND INHALATION
RESIDENTIAL CHILD AND ADULT RECEPTORS – RME SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD VALUE (0-6 YRS)	ADULT	UNIT	SOURCE
CW	Chemical-Specific	Chemical-Specific	ug/liter	EPA 1989a
$IR_{groundwater}$	1	2	liters/day	EPA 1991d
CF_1	0.001	0.001	mg/10^3 µg	
CF_2	0.001	0.001	liters/10^3 cm^3	
EF	350	350	days/year	EPA 1991d
ED	6	24	years	EPA 1989a, 1991d
EV	1	1	event/day	
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	6	24	years	EPA 1989a
SA	-	18150	cm^2	EPA 1996e
BW	15	70	kg	EPA 1989a, 1991d
DA_{event}	Chemical-Specific	Chemical-Specific	mg/event-cm^2	
PC_{event}	Chemical-Specific	Chemical-Specific	cm/event	
$K_{pw\text{ - inorganic}}$	0.001	0.001	cm/hour	EPA 1992e
t_{event}	0.33	0.25	hr/event	Assumption
$K_{pw\text{ - organic}}$	Chemical-Specific	Chemical-Specific	cm/hour	EPA 1992e
τ	Chemical-Specific	Chemical-Specific	hours	EPA 1992e
t*	Chemical-Specific	Chemical-Specific	hour	EPA 1992e
B	Chemical-Specific	Chemical-Specific	unitless	EPA 1992e
SA_i	Varies with Age	-	cm^2	EPA 1985
ED_i	1 year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with Age	-	kg	EPA 1985, 1991d
D	-	Chemical-Specific	mg/kg/shower	
CF_3	-	1000000	ug*L/mg*m^3	
Q	-	Chemical-Specific	minutes	
IR_{air}	-	14	liters/minutes	EPA 1989a
S	-	Chemical-Specific	ug/m^3/min	
Ra	-	0.01667	min^{-1}	Foster and Chrostowski, 1987
Ds	-	15	minutes	EPA, 1996e
Dt	-	20	minutes	Professional judgment
Cwd	-	Chemical-Specific	ug/liter	
Fr	-	20	liters/minute	Professional judgment
Sv	-	6	m^3	Professional judgment
KaL	-	Chemical-Specific	cm/hour	
ts	-	2	seconds	
d	-	1	mm	
KL	-	Chemical-Specific	cm/hour	
T_1	-	293	°K	
Ts	-	318	°K	Foster and Chrostowski, 1987

TABLE 3-24 (Continu d)
EXPOSURE PARAMETERS FOR GROUNDWATER INGESTION, DERMAL CONTACT, AND INHALATION
RESIDENTIAL CHILD AND ADULT RECEPTORS – RME SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA
Page 2 of 2

PARAMETER	CHILD VALUE (0-6 YRS)	ADULT	UNIT	SOURCE
μ_1	-	1.002	centipoise	
μ_s	-	0.596	centipoise	
R^*T_2	-	0.0241	atm/m^3-mole	
CF_4	-	1/3600	Hr/sec	
CF_5	-	10	Mm/cm	
T_3	-	298	°K	
$C_{air,chemical}$	-	Calculated	Mg/m^3	
H	-	Chemical-Specific	atm-m^3/mole	
Kg	-	Chemical-Specific	cm/hour	
Kl	-	Chemical-Specific	cm/hour	
KH	-	3000	cm/hour	
KC	-	20	cm/hour	
MWH	-	18	g/mole	
MWC	-	44	g/mole	
MW	-	Chemical-Specific	g/mole	

TABLE 3-25

EXPOSURE PARAMETERS FOR GROUNDWATER INGESTION, DERMAL CONTACT, AND INHALATION
RESIDENTIAL CHILD AND ADULT RECEPTORS – CTE SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA

PARAMETER	CHILD VALUE (0-6 YRS)	ADULT	UNIT	SOURCE
CW	Chemical-Specific	Chemical-Specific	ug/liter	EPA 1989a
$IR_{groundwater}$	0.7	1.4	liters/day	EPA 1991d
CF_1	0.001	0.001	mg/10^3 µg	
CF_2	0.001	0.001	liters/10^3 cm^3	
EF	350	350	days/year	EPA 1991d
ED	2	7	years	EPA 1989a, 1991d
EV	1	1	event/day	
AT_{cancer}	70	70	years	EPA 1989a
$AT_{non\text{-}cancer}$	2	7	years	EPA 1989a
SA	2728	18150	cm^2	EPA 1996e
BW	15	70	kg	EPA 1989a, 1991d
DA_{event}	Chemical-Specific	Chemical-Specific	mg/event-cm^2	
PC_{event}	Chemical-Specific	Chemical-Specific	cm/event	
$K_{pw\text{ - inorganic}}$	0.001	0.001	cm/hour	EPA 1992e
t_{event}	0.33	0.25	hr/event	Assumption
$K_{pw\text{ - organic}}$	Chemical-Specific	Chemical-Specific	cm/hour	EPA 1992e
τ	Chemical-Specific	Chemical-Specific	hours	EPA 1992e
t*	Chemical-Specific	Chemical-Specific	hour	EPA 1992e
B	Chemical-Specific	Chemical-Specific	unitless	EPA 1992e
SA_i	Varies with Age-- See Text	-	cm^2	EPA 1985
ED_i	1 year increments	-	years	EPA 1989a, 1991d
BW_i	Varies with Age-- See Text	-	kg	EPA 1985, 1991d
D	-	Chemical-Specific	mg/kg/shower	
CF_3	-	1000000	ug*L/mg*m^3	
Q	-	Chemical-Specific	minutes	
IR_{air}	-	14	liters/minutes	EPA 1989a
S	-	Chemical-Specific	ug/m^3/min	
Ra	-	0.01667	min^{-1}	Foster and Chrostowski, 1987
Ds	-	15	minutes	EPA, 1996e
Dt	-	20	minutes	Professional judgment
Cwd	-	Chemical-Specific	ug/liter	
Fr	-	20	liters/minute	Professional judgment
Sv	-	6	m^3	Professional judgment
KaL	-	Chemical-Specific	cm/hour	
ts	-	2	seconds	
d	-	1	mm	
KL	-	Chemical-Specific	cm/hour	

TABLE 3-25 (Continued)
EXPOSURE PARAMETERS FOR GROUNDWATER INGESTION, DERMAL CONTACT, AND INHALATION
RESIDENTIAL CHILD AND ADULT RECEPTORS – CTE SCENARIO
NASJRB WILLOW GROVE, PENNSYLVANIA
Page 2 of 2

PARAMETER	CHILD VALUE (0-6 YRS)	ADULT	UNIT	SOURCE
T_1	-	293	°K	
Ts	-	318	°K	Foster and Chrostowski, 1987
μ_1	-	1.002	centipoise	
μ_s	-	0.596	centipoise	
R^*T_2	-	0.0241	atm/m^3-mole	
CF_4	-	1/3600	Hr/sec	
CF_5	-	10	Mm/cm	
T_3	-	298	°K	
$C_{air,chemical}$	-	Calculated	Mg/m^3	
H	-	Chemical-Specific	atm-m^3/mole	
Kg	-	Chemical-Specific	cm/hour	
Kl	-	Chemical-Specific	cm/hour	
KH	-	3000	cm/hour	
KC	-	20	cm/hour	
MWH	-	18	g/mole	
MWC	-	44	g/mole	
MW	-	Chemical-Specific	g/mole	

3.1.3.6 Blo d-L ad M deling

As outlined in OSWER Directive 9355.4-12 (EPA, 1994a), EPA has implemented an approach to evaluating lead risks that recognizes the multimedia nature of lead exposures, incorporating absorption and pharmacokinetic information. Research has been done concerning lead intake and resultant blood-lead levels. Determinations of lead uptake from soil, sediment, drinking water, and surface water were considered. For the purposes of this risk assessment, each pathway was evaluated separately so that the contribution of lead from each source and each exposure route could be evaluated. Potential blood-lead level increases were estimated and are discussed, along with the potential implications of blood-lead results for each site. The following paragraphs present information that is useful in estimating lead exposure.

No threshold has been defined for effects related to blood-lead increases. The estimated increases at these sites are well below the concentrations at which effects such as anemia and neuropathy occur (40 µg/dL and above) (Doull et al., 1986). Effects below 10 µg/dL are difficult to define. Inhibition of certain enzymes involved in red blood cell metabolism has been reported to occur at 10 to 15 µg/dL and possibly lower (EPA, 1991b). Small increases in blood pressure have been related to adults with blood-lead levels down to 7 µg/dL (EPA, 1991b). Probably the subpopulation most sensitive to effects at the 3 to 7 µg/dL range (where the concentrations estimated for this study area would fall) would be infants, whose early neurological development can be affected by blood-lead concentrations reportedly down to 5 µg/dL (EPA, 1991b). Lead is also a fairly common environmental contaminant and, for this reason, typical blood-lead levels in the population at large may already exceed the concentrations discussed here.

For drinking water exposure, children 0 through 6 months old are expected to experience blood-lead increases at the rate of 0.26 µg/dL per µg/L lead in water up to 15 µg/L and at the rate of 0.04 µg/dL for every µg/L lead in water above 15 µg/L (EPA, 1991b). For older children, the ratio is 0.12 µg/dL blood lead per µg/L lead in water up to 15 µg/L and 0.06 µg/dL for every µg/L lead in water above 15 µg/L (EPA, 1991b). For adults, the ratio is approximately 0.06 µg/dL blood lead per µg/L in water (EPA, 1991b).

Dietary intake of lead is assumed to produce increases of 0.02 to 0.04 µg/dL blood lead per µg/day ingested by adults and 0.16 µg/dL blood lead per µg/day ingested by infants (EPA, 1986).

Blood-lead levels are estimated to increase by 0.6 to 6.8 µg/dL per 1,000 mg/kg lead in soil (EPA, 1986). Estimates of blood-lead levels in residential children (age 0 through 6 years) were made using the Integrated Exposure and Uptake Biokinetic (IEUBK) Model (version 0.99) developed by EPA. The model was applied to each site where lead was selected as a COPC in surface soil. The output for each run of the IEUBK Model is a histogram that presents the estimated percentage of residential children (age 0

through 6 years) with a blood-lead level above 10 µg/dL (considered to be the significant cutoff level above which adverse effects cannot be ruled out). When the percentage of the population estimated to have blood levels above 10 µg/dL is greater than five percent, EPA considers the potential for adverse effects to be significant (EPA, 1994b). These histograms, along with input information particular to each run of the IEUBK model, are presented in Appendix A of the Supplemental RFI/RI Report. The estimated percentage of residential children (age 0 through 6 years) with a blood-lead level above 10 µg/dL is also presented in the site-specific text contained in subsequent sections of this report. Uncertainties associated with the IEUBK model are discussed in Section 3.1.5.9.

Noncarcinogenic risks for occupational workers from exposures to lead in soil were estimated using the Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (EPA, 1996). The model is based on a biokinetic slope factor that estimates fetal blood-lead concentration in women exposed to lead-contaminated soil. A simplified (linear) representation of lead biokinetics is used to predict quasi-steady-state blood-lead concentrations among adults who have relatively steady patterns of site exposures (exposure duration of at least 90 days and exposure frequencies greater than once per week). The intake assumptions used in the model were the maximum (RME) and the average (CTE) soil lead concentrations at the site, a 50 mg-per-day soil ingestion rate, and a 219 days-per-year exposure frequency. The biokinetic model input parameters were a biokinetic slope factor (ug/dl adult blood-lead per ug/day uptake) of 0.4, a constant of proportionality between fetal blood-lead concentration at birth and maternal blood-lead concentration of 0.9, a soil absorption factor of 0.12 (equal to the product of the relative bioavailability of 0.6 and a soluble lead absorption factor of 0.2), a background blood lead (typical concentration for women of childbearing age not exposed to the site) of 1.7 ug/dl, and a geometric standard deviation of 1.8 (representative of a relatively homogeneous population demographic).

3.1.4 Risk Characterization

Potential human health risks resulting from the exposures outlined in the preceding sections are characterized on a quantitative and qualitative basis in this section. Quantitative risk estimates are generated based on risk assessment methods outlined in current EPA guidance (EPA, 1989a).

Noncarcinogenic risk estimates are presented in the form of Hazard Quotients (HQs) and Hazard Indices (HIs), which are determined through integration of estimated intakes with published RfDs. Incremental cancer risk estimates are provided in the form of dimensionless probabilities based on SFs. Estimated human intakes were developed for each of the specific exposure routes discussed in the preceding sections. Both carcinogenic and noncarcinogenic risks are summarized for each exposure route Section 4.0.

3.1.4.1 Carcinogenic Risks

Incremental cancer risk estimates are generated for each of the exposure pathways using the estimated intakes and published SFs, as follows:

$$\text{Risk} = \text{Intake} * \text{SF}$$

If the above equation results in a risk greater than 0.01, the following equation is used:

$$\text{Risk} = 1 - e^{-(\text{Intake}*\text{SF})}$$

The risk determined using these equations is a unitless expression of an individual's increased likelihood of developing cancer as a result of exposure to carcinogenic chemicals. An incremental cancer risk of 1E-06 indicates that the exposed receptor has a one in one million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons. The calculated cancer risks should be recognized as upper-limit estimates. SFs are the upper 95 percent confidence limit of a dose-response curve generally derived from animal studies. Actual human risk, while not identifiable, is not expected to exceed the upper limit based on the SFs and may, in fact, be lower.

EPA has generally defined risks in the range of 1E-04 to 1E-06 or less as being acceptable for most hazardous waste facilities addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). For CERCLA activities, residual risks on the order of 1E-06 are the primary goal but are often modified by such regulatory requirements as MCLs or chemical-specific clean-up goals.

3.1.4.2 Noncarcinogenic Risks

Noncarcinogenic risks are estimated using the concept of HQs and HIs. The HQ is the ratio of the estimated intake and the RfD for a selected chemical of concern, as follows:

$$\text{HQ} = \frac{\text{Intake}}{\text{RfD}}$$

HIs are the sums of the individual HQs for the COPCs. If the value of the HQ or the HI exceeds unity (1.0), the potential for noncarcinogenic health risks associated with exposure to that particular chemical or particular chemical mixture, respectively, cannot be ruled out (EPA, 1986b). If the individual HQs are less than 1.0 and the HI is greater than 1.0, particular attention should be paid to the target organ(s) affected

by each chemical because these are generally the organ(s) associated with RfD-derived effects, and toxicity for different organs is not truly additive. The HI is not a mathematical prediction of the severity of toxic effects; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

3.1.4.3 Lead Risks

EPA's approach to evaluating lead risks goes beyond providing a single-point estimate output and incorporates absorption and pharmacokinetic properties. Section 3.1.3.6 discusses background information related to blood-lead estimation methods. Soil concentrations for lead were assessed for each applicable site where lead was selected as a COPC.

3.1.4.4 Receptor Risks

Receptor risks are presented in the form of tables and summary text. Each of these sections includes summaries of risks estimated by the exposure scenarios. It should be noted that, in each risk summary table where HQs are reported as "N/A," the HQs were not calculable because no RfD has been established. Usually in such cases, carcinogenicity is considered to be more important, since carcinogenicity will generally be seen at lower doses than noncarcinogenic effects. Cancer risks of zero or "N/A" generally indicate that the chemical is not carcinogenic or that an SF has not yet been developed.

3.1.5 Uncertainty Analysis

As discussed in EPA (1989a), the risk measures used in Superfund site risk assessments are not fully probabilistic estimates of risk but rather are conditional estimates based on a considerable number of assumptions about exposure and toxicity. There are uncertainties associated with each aspect of risk assessment, from environmental data collection through risk characterization. To support decision-making processes, significant uncertainties in the risk assessment for NASJRB Willow Grove are noted in the following sections.

3.1.5.1 Uncertainties in the Physical Setting and Receptor Exposure Pathways

Reliable information on current land uses at NASJRB Willow Grove sites was based on actual current land use. Current occupational, current trespasser, future excavation, residential, and recreational land use scenarios were considered in the risk assessment for each site. Future land use at the site is unknown; this is source of uncertainty for this risk assessment. Based on known and projected activity patterns, current and future receptors in the study area were considered to engage in a range of activities adequately

approximated by default exposure parameter assumptions. It is unknown whether some of these receptors will actually exist, adding to the uncertainty in the risk assessment. However, for any future land use, the chosen receptors are expected to adequately define any significant change in the current land use pattern.

3.1.5.2 Environmental Data Collection Uncertainties

Selection of Locations and Number of Samples

For each site, the areal extent of the samples (including the number collected and location of the sampling points) in a particular medium impacts the calculation of representative concentrations. Every effort was made to collect samples that reflect actual site conditions and to include areas thought to contain the most significant contamination or exposure problems. In addition, a dynamic sampling plan was utilized that allowed expansion of the initial sampling plan in order to collect sufficient data to resolve important contaminant attribution questions. Therefore, the magnitude of this uncertainty on risks is expected to be low.

Selection of Samples with Naturally Occurring Background Levels

A number of background samples were collected that measure the range of concentrations of substances in each medium that are associated with non-site-related sources within the vicinity of the NASJRB Willow Grove. The diversity and abundance of inorganics in soil and sediment samples are determined by the soil's content in bedrock or other deposits and the effects of climatic and biological factors. However, if native soil types are encountered in site-related samples that are unlike those of background samples, then the evaluation of naturally occurring levels could be biased and might lead to overestimation or underestimation of the amount of contamination attributable to the NASJRB Willow Grove sites.

The abundance of inorganics in groundwater samples is determined by, among other things, the particular geological formation in which the well is screened and the content of suspended solids occurring as a result of the well sampling process. If groundwater results from a particular site are compared to background wells that are constructed and sampled in a different manner, then this could lead to an over- or underestimation of the amount of contamination attributable to the NASJRB Willow Grove.

3.1.5.3 Analytical Data Uncertainti s

Incorporation of Data from Different Investigations

Because of uncertainties regarding the validation status and usability of results from earlier investigations performed by various parties, only validated data were used from this RI/FS for the risk assessment. Data obtained during earlier investigations were examined during project planning and were used to focus the sample collection effort to include potential areas of interest. Historical data were used in this risk assessment from solid and some aqueous media. Data were collected over several years at all eight sites. The contaminant concentrations could have changed at the sites based on migration or physical removal of contaminated media. Therefore, uncertainty exists in using historical data because current conditions may not be represented by historical data. Areal extent of the samples (including the number collected and location of the sampling points) in a particular medium at a site was one such uncertainty. Every effort was made to collect samples that reflect actual site conditions. However, biased sampling may have occurred if an unknown area of contamination at a particular site was under- or over-sampled. Established data validation procedures were applied to define uncertainties in terms of qualifying data as inaccurate or imprecise and eliminate data points that are unusable for risk assessment. This treatment does not eliminate all uncertainty but focuses attention on potential areas of concern regarding accuracy, precision, and data gaps.

Analytical Data Usability

Established data validation procedures were applied to define analytical uncertainties in terms of qualifying data as inaccurate or imprecise and to eliminate data points that are unusable for risk assessment. This treatment does not eliminate all uncertainty but focuses attention on potential areas of concern regarding accuracy, precision, and data gaps. As discussed in Section 1.5, the overall percentages of rejected data points were acceptably low on a site-by-site basis, and data rejection was limited to substances that were neither associated with site activities nor present at high levels.

3.1.5.4 Data Evaluation Uncertainties

Accuracy of Statistical Tests Used in Background Comparisons

When a limited number of points are sampled, such as occurred for surface water or sediment samples, reduced accuracy is expected for the upper 95 percent tolerance limit. In such cases, this statistic is still expected to, on the average, estimate the upper 95 percentile of the population. However, for an individual case, the true percentage of the population that exceeds the calculated tolerance limit will be more likely to

differ markedly from the predicted five percent when too few samples are collected. In the event that the upper 95 percent tolerance limit for background samples is overestimated, this could defeat the attempt to identify site-related samples with levels greater than naturally occurring background and may lead to an underestimate of the risk attributable to a site. To help ensure that data points above background were not overlooked, a conservative combination of several background tests was used (the test of proportions, Fisher's exact test, the upper ranks test, the quantile test, the 95 percent UTL test, the Mann-Whitney U-test, Gehan's test, the student's t-test, and Satterthwaite's t-test).

Statistically Representative Exposure Concentrations

Uncertainties exist regarding selection of a concentration for input into the quantitative risk assessment. The use of the representative concentration to estimate risk is generally regarded as a conservative estimate since this entails using either the upper 95 percent confidence limit on the arithmetic mean (based on normal or log-transformed data distribution) or the maximum concentration. The choice of the representative concentration as the value for input into the risk assessment generally lowers the chances of under estimation of the actual risk present in a pathway at a particular area of interest to a potential receptor. However, the use of the representative concentration may overestimate the actual risk present in an exposure pathway at a particular area of interest.

Distributional Shape of the Sample Population

The ability (power) of the W test to be able to correctly identify genuine differences between the shape of a sample population versus a reference normal or lognormal population is reduced when too few samples are collected. If an incorrect distributional assumption is made based on this test, this could lead to an over- or underestimate of the upper 95 percent concentration, which in turn would create some additional uncertainty as to whether the calculated risk is a reasonable approximation of high end exposure.

3.1.5.5 Exposure Model Applicability and Assumptions

Uncertainties in Chemical-Specific Properties

The chemical-specific parameters such as K_{oc} were literature-derived values that are measured under conditions that may or may not be representative of on-site conditions. Parameters such as vapor pressure and solubility were not always obtainable at the desired temperature. Parameters such as the K_d for metals are strongly influenced by other factors such as the chemical form of the metal, the soil type, and pH.

Groundwater Concentration Uncertainties

Uncertainties associated with the lack of groundwater modeling at the site include the assumption that current conditions are indicative of future concentrations of contaminants. Contaminants may increase (due to migration, sediment loading, or chemical transformation) or decrease (due to migration or transformation) over time and vary from area to area.

To prevent use of metals data that might not be representative of the formation, the selection of unfiltered or unfiltered monitoring well results for use in the risk assessment was based upon a sample-by-sample evaluation of turbidities and aluminum, iron, and manganese concentrations. In addition, low-flow bladder pumps were used in all new monitoring wells to minimize the chances of suspended solids occurring during the sampling process.

Fugitive Dust Emissions Model Assumptions

Exposure to fugitive dust emissions conservatively assumes that residents will be exposed to the same concentration indoors as outdoors (a very conservative assumption), that soils within an area have unlimited erosion potential, that emissions can be estimated from mean annual windspeed and vegetative cover, and that dispersion concentrations can be estimated from source area, downwind distance to receptors, and region-wide meteorological factors. For receptors exposed to fugitive dust emissions, it was assumed that future conditions would approximate typical light industrial conditions in terms of the estimated fraction vegetative cover. If future vegetative cover is different in a residential area, then dust exposures could be lower or higher than estimated by the model. However, the impact of this error would not be significant because a worst-case (no vegetative cover) scenario would only increase exposures calculated by the model by a factor of 5, and while inhalation exposures at NASJRB Willow Grove sites were estimated as several orders of magnitude below levels of concern.

Soil Dermal Absorption Model Applicability

The model for dermal exposure to soil and sediment assumes that only a very thin, constant thickness layer of soil is available for contaminant transfer to the stratum corneum and that a constant amount of contaminant, proportional to the soil concentration, will be absorbed per unit area of skin and per exposure event. However, adherence to skin varies with such factors as particle size, soil type, and organic carbon content. As estimated by EPA (1992e), the absorbed dermal dose could vary by as much as a factor of 50 from the model estimates, even assuming that activity patterns lead to the exposure duration applied in the experimental trials used to develop absorption factors. Because of the lack of reliable data regarding dermal absorption factors, the risk assessment provides default soil absorption factors for all substances except

chemicals for which well documented absorption factors are available (arsenic, cadmium, pentachlorophenol, PCBs, chlorinated dioxins, ethylbenzene, toluene, xylenes, and PCE). Even so, considerable uncertainty exists with the accuracy of estimates applied for these four chemicals.

Dermal Absorption from Contaminant Exposures in Aqueous Media

Prediction of absorption rates for lipophilic compounds is difficult due to, among other reasons, the possibility of a second absorption pathway that depends on the lipid content of the stratum corneum at the application site. Experimental determination of absorption rates indicates that interspecies differences are considerable, which, along with other variabilities related to condition and age of skin, differences in lag time, and site of application effects, yields appreciable uncertainty in estimated dermal exposures by using published chemical-specific permeation functions. In addition, literature data indicate a variation by as much as a factor of 300 in chemical absorption rates for skin in different anatomical areas of the body. It should also be noted that children generally have greater absorption rates than adults.

Model Assumptions for Inhalation of VOCs during Showering

Uncertainties exist in the exposure model for the inhalation of volatiles during showering such as chemical-specific rates of volatilization, droplet size, and droplet residence time in the shower. Most of the inputs into the models were considered conservative; therefore, the output may overestimate the exposure for this route.

3.1.5.6 Exposure Intake Parameter Uncertainties

Standard Default Exposure Assumptions

Exposure assumptions can add uncertainty into the risk assessment process based on input values selected for each exposure route. For example, not all people weigh 70 kilograms, drink 2 liters of water per day, and live at the same residence for 30 years. The rationale for each assumption was provided in each table of input parameters. Receptor characteristics, such as age and body weight, were based on published values. Conservative values (based on reasonable maximum exposure or professional judgment) were used in most exposure equations, except where average values were expected to better correspond to actual site conditions.

Soil Ingestion Rates

In the case of current and future residential receptors, soil ingestion rates were based on non-contact-intensive activities. A higher level of short-term incidental soil ingestion by workers engaged in residential home construction (excavation, underground utility work, road repair and construction) or heavy landscaping (tree and shrub planting, drainage routing, or land re-sloping) results. However, contact-intensive activities are typically event driven (for construction) and so should average out to less than 1-month duration per year for a typical exposed individual. Other receptors that are exposed to surface soil at the site should have risks below that of the residential receptor.

The use of current subsurface soil concentrations to represent future subsurface excavation exposure concentrations assumes two things that add to the uncertainty of this risk assessment. First, this xposure scenario assumes that soil would be excavated to the sampling depth. Second, this exposure scenario assumes that, once the soil is excavated to the subsurface soil sampling depth, no degradation of the chemicals in the subsurface soil would have taken place and/or no additional contamination would be transported to the soils. These uncertainties may cause either an under- or overestimation of the xposure at a particular site.

3.1.5.7 Toxicity Assessment Uncertainty

There is uncertainty associated with the RfDs and SFs. The uncertainty results from the extrapolation of animal data to humans, the extrapolation of carcinogenic effects from the laboratory high-dose to the environmental low-dose scenarios, and interspecies and intraspecies variations in toxicological endpoints caused by chemical exposure. The use of EPA SF values is generally considered to be conservative because the doses are based on no-effect or lowest-observed-effect levels and then further reduced with uncertainty factors to increase the margin of safety by a factor in the neighborhood of 10 to 1,000-fold. The RfDs and SFs of some chemicals have not been established, and therefore toxicity could not be quantitatively assessed. In most cases, where RfDs were unavailable for carcinogens, the carcinogenic risk is considered to be much more significant since carcinogenic effects usually occur at much lower doses.

Additional uncertainties were associated with the adjustment of oral dose-response parameters to compute dermally absorbed doses. As noted, when absorption factors were not available, the chemical was assumed to be 100 percent absorbed during the RfD or SF study. Although this is likely to be realistic for volatile compounds, the assumption could be underprotective for chemicals absorbed less than 100 percent.

For chemicals coded with a "W" in Table 3-1, toxicity constants were utilized that have been obtained from the Integrated Risk Information System (IRIS), pending further agency review. In these cases, there may be

additional uncertainty in the associated SFs or RfDs, based on the original or new studies that were the basis for considering a reevaluation of toxicological properties. If the uncertainty related to using a withdrawn toxicity constant is critical (i.e., found to drive a significant risk at a site), then additional information be can obtained on the exact reasons for withdrawal from the EPA Environmental Criteria and Assessment Office (ECAO), Cincinnati, Ohio.

3.1.5.8 Risk Characterization Uncertainty

From a toxicological standpoint, it is not strictly correct to add HQs for a total HI, because RfDs are based on effects to various target organs. However, if the HI is less than 1.0, this demonstrates that, even when this conservative calculation is performed, the noncarcinogenic HI does not indicate a hazard for a particular exposure pathway. This is a conservative approach that will generally overestimate the HI for a particular pathway. To reduce the extent of overestimation when significant risks occurred at an area of interest, a less conservative approach was used wherein noncancer risks were grouped and summed together for only those chemicals affecting the same target organ or organ system. One additional source of uncertainty in the HI approach is that these models assumed that chemicals did not interact synergistically (a possible underestimate of the actual risk) or antagonistically (a possible overestimate of the actual risk).

3.1.5.9 IEUBK Modeling Uncertainty

The IEUBK model accounts for the multimedia nature of lead exposure, incorporates absorption and pharmacokinetic information, and allows the risk manager to consider the potential distributions of exposure and risk likely to occur at a site (the model goes beyond providing a single-point estimate output). Although uncertainties are associated with blood-lead modeling using the IEUBK model, these uncertainties are considered lower than those that conceivably would result from similar lead evaluations performed using a traditional toxicity slope-based approach. Important uncertainties and limitations in the use of the IEUBK model are as follows:

The IEUBK model is predictive of blood lead for residential children in the range of 6 months to 7 years of age, which typically is considered to be a more sensitive subpopulation than adults. The model does not apply to adults in either residential or occupational settings. In addition, the IEUBK model does not predict the blood-lead levels of pregnant women and does not include an exposure component based on the transfer of lead from the mother's blood to the fetus before birth, although a significant potential exists for adverse effects of prenatal lead exposure on neurobehavioral and physical development (EPA, 1994b).

The IEUBK model uses a default of 30 percent lead absorption from soil. However, the bioavailability of lead from different sources may be variable due to differences in lead speciation, particle size, and mineral matrix

and may also vary as a function of physiological parameters such as age, nutritional status, gastric pH, and transit time. For example, lead absorption from paint chips in soil may be different than lead absorption from other chemical forms.

Blood-lead variability in the IEUBK model is characterized by a single number, the geometric standard deviation, which is set to a default value of 1.6. This value represents the aggregate uncertainty in all sources of population variability, including biological uptake, exposure, sampling, and analytical components. Child blood-lead level predictions obtained using the IEUBK model reflect only the contributions of sources entered into the model and do not take into account any existing body burden that may be the result of prior exposures or any exposures that may have taken place at alternate locations away from the household or neighborhood level, such as parks or daycare centers.

3.2 ECOLOGICAL RISK ASSESSMENT APPROACH

Ecological receptors at NASJRB Willow Grove may be at risk from contaminants associated with Site 1. Therefore, an ecological risk assessment (ERA) was performed to characterize the potential risks from site-related contaminants to ecological receptors that inhabit the installation. The ERA was conducted following guidance recommended by EPA (1977) and the Department of the Navy (DON, 1999) and was based on laboratory analyses of surface soil, surface water, and sediment samples collected from each site. This section provides an outline of the approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment followed a two-step process:

Step 1: Preliminary Problem Formulation and Ecological Effects Evaluation (Section 3.2.1)

- Preliminary Problem Formulation - This first phase of an ERA discusses the goals, breadth, and focus of the assessment. It includes general descriptions of NASJRB Willow Grove sites with emphasis on the habitats and ecological receptors present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of analytes to be assessed. Assessment and measurement endpoints are also selected in this phase. In addition, a conceptual model is developed that describes how contaminants associated with the RI sites may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this phase, medium-specific ecological screening levels for each analyte (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. This step is undertaken concurrently with the exposure assessment described below.

Step 2: Preliminary Exposure Assessment and Risk Calculation (Section 3.2.2)

- Preliminary Exposure Estimate - This portion of the ERA includes the identification of contaminant concentration data used to represent ecological exposure in various media and the selection of exposure point contaminant concentrations from those data.

- Preliminary Risk Calculation - In this step, exposure point concentrations are compared to screening levels in order to characterize potential risks to ecological receptors of concern. Analytes found to pose potential risk after these comparisons are selected as ecological chemicals of potential concern COPCs.

Due to the potential complexity of ERAs, they are usually conducted using a tiered approach and punctuated with scientific/management decision points (SMDPs). SMDPs are meetings involving the risk managers and risk assessment team and are conducted to evaluate the work up to that point and to ensure that the ecological risk assessment is proceeding in an efficient manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met. The results are then used to identify the data required for the next tier, if necessary. The Tier 1 ERA is also known as a screening risk assessment. The screening risk assessment uses conservative (i.e., stringent) assumptions to evaluate site data and determine whether additional ecological risk assessment or accelerated site cleanup may be warranted or whether the site poses negligible ecological risks.

The second tier is a baseline ERA (BERA), which is conducted if the results of the screening-level ERA indicate that additional study is warranted. The BERA comprises Steps 3 through 7 of the eight-step ERA process and is a more focused study of the initial COPCs. The beginning of the BERA also presents a more balanced evaluation of the conservativeness inherent in the first two steps of the ERA process (DON, 1999).

3.2.1 Preliminary Problem Formulation and Ecological Effects Evaluation

Section 3.2.1.1 discusses the components of problem formulation and Section 3.2.1.2 discusses the components of ecological effects evaluation.

3.2.1.1 Preliminary Problem Formulation

Ecological Setting

The preliminary problem formulation contains a description of the background of the site and a general description of the ecological setting at NASJRB Willow Grove. These topics are presented in Section 1.4.

The main area of interest at NASJRB Willow Grove for this ERA is Site 1. Site 1 is described in detail in Section 4.

Habitat Types and Ecological Receptors

Descriptions of habitat types and ecological receptors were composed for Site 1 and are presented in this report. Data regarding habitats and ecological receptors were obtained from previous reports and from biological characterizations conducted at the installation during this investigation. Information on the occurrence of threatened and endangered species on and near the four sites was obtained from the U.S. Fish and Wildlife Service, the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, the PADEP, and the Natural Resources Manager at NASJRB Willow Grove.

Contaminant Sources, Release Mechanisms, and Migration Pathways

Site-specific contaminant sources, release mechanisms, and migration pathways are discussed for Site 1 in Section 4 of this report. The general transport mechanisms that were investigated include combustion, volatilization, wind erosion, overland runoff, and infiltration of contaminants. Constituents in soil could volatilize from surficial material or become airborne through wind erosion. Contaminated fugitive dust could be generated during ground-disturbing activities such as construction or excavation. Contaminants could then be dispersed in the surrounding environment and transported to downwind locations, where they could become deposited in surface soil, surface water, or sediment. Combustion was probably a major transport mechanism during the period when the landfills and fire training area were in use. However, combustion is assumed to currently represent a negligible transport mechanism at NASJRB Willow Grove since open burning activities have ceased.

Precipitation runoff could carry constituents to nearby surface water and sediment. Infiltrating precipitation could cause the contamination of subsurface soil and groundwater. Upon infiltrating the soil column and reaching the water table, a contaminant may be carried with the flow of groundwater to downgradient locations. Groundwater from the site may eventually discharge to surface water; contaminants could be subsequently deposited in sediment or accumulate in the tissues of aquatic organisms.

Exposure Routes

Terrestrial animals could be exposed to soil contaminants through the ingestion of contaminated food items. Animals can also incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items to which soil has adhered (such as roots and tubers). Terrestrial vegetation could be exposed to contaminants via direct aerial deposition and root translocation. However,

aerial deposition was not investigated, primarily because the contaminant sources at the sites under investigation are largely covered by vegetation. Terrestrial animal receptors may also come into contact with contaminants in surface water through drinking, although this exposure route represents a negligible portion of total exposure for most receptors. Exposure to contaminants in the soil via dermal contact may occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons minimize transfer of contaminants across dermal tissue.

Inhalation does not represent a significant exposure pathway because air contaminant concentrations are assumed to be quite low, even for burrowing wildlife. In addition, inhalation ecotoxicity data for chronic exposure are lacking. Therefore, the air pathway was not considered for ecological receptors.

Aquatic and semi-aquatic organisms at NASJRB Willow Grove could be exposed to contaminants via direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Aquatic and semi-aquatic organisms could also be exposed to constituents from contaminated groundwater that potentially discharges into nearby surface water.

Selection of Analytes to be Investigated

All analytes detected in surface water, sediment, and surface soil samples collected during 1991 Phase I and 1997 Phase II sampling activities were assessed in this investigation. However, calcium, magnesium, potassium, and sodium were excluded in the screening process since they are essential nutrients that are toxic only at extremely high concentrations. Due to the scarcity of data for these essential nutrients, it was not possible to develop ranges of toxicity even at high concentrations. The limited toxicity data available indicate that high dietary intake of these nutrients is well tolerated.

Assessment and Measurement Endpoints

One of the major tasks in problem formulation is the selection of assessment and measurement endpoints. An assessment endpoint is "an explicit expression of actual environmental values that are to be protected" and measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (EPA, 1997). For this ERA, the assessment endpoint was the maintenance of aquatic and terrestrial receptor populations. Therefore, the specific objectives of this assessment were to determine if exposure to contaminants present in the surface water, sediment, and soil on and near the sites is likely to result in declines in ecological receptor populations. Declines in populations could result in a shift in community structure and possible elimination of resident species from aquatic, semi-aquatic, and terrestrial environments.

Measurement endpoints serve as surrogates for assessment endpoints, since they are more easily quantified or observed than assessment endpoints. Measurement endpoints consisted of contaminant concentrations associated with adverse effects on growth, survival, and reproduction of aquatic organisms

(surface water screening levels), benthic organisms (sediment screening levels), and terrestrial vegetation and soil invertebrates (surface soil screening levels).

Conceptual Site Model

The conceptual model is designed to diagrammatically identify potentially exposed receptor populations and applicable exposure pathways, based on the physical nature of the site and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with the sites were determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has three components: a source of contaminants that can be released to the environment, a route of contaminant transport through an environmental medium, and an exposure or contact point for an ecological receptor. The conceptual model for Site 1 is presented in Section 4 of this report.

3.2.1.2 Preliminary Ecological Effects Evaluation

For this ERA, exposure-point concentrations of detected analytes in surface water, sediment, and surface soil were compared to ecologically based guidelines to determine if the analytes should be selected as COPCs. Although groundwater-to-surface-water migration of groundwater contaminants is possible at NASJRB Willow Grove, ecological receptors are not directly exposed to groundwater. Additionally, no groundwater thresholds have been developed based on ecological concerns. Potential ecological risks associated with groundwater contaminants are reflected in the evaluation of the potential risks associated with surface water and sediment, since the sources of contamination at the sites under investigation have been in place long enough for groundwater plumes to discharge into nearby surface water and sediment. Thus, groundwater contaminants were not screened against surface water contaminants in the ecological risk assessment. It is noted that an artesian flowing well formerly existed downstream from the pond near Site 3. However, this well has been permanently capped so that flow from this monitoring well is nonexistent. There are no other flowing artesian wells near any of the other sites. The Navy corrected the problem of flowing artesian monitoring wells during RI field investigations in the spring of 1997 by repairing the leaking sample assemblies. Long-term annual inspection and maintenance of these artesian monitoring wells will ensure no flow of groundwater to surface water.

Methods used for the selection of medium-specific benchmarks used in this ERA are provided below. Screening levels for surface water, sediment, and surface soil have been previously agreed to by the Navy and EPA Region 3 BTAG.

Surface Water Screening Levels

Actual exposures of aquatic receptors to surface water contaminants at NASJRB Willow Grove were assumed to be primarily chronic (long-term) exposures, usually at sublethal concentrations. Initial screening levels for this ERA were chronic screening values obtained from EPA Region 3 BTAG (EPA, 1995), EPA chronic ambient water quality criteria (AWQC), EPA final chronic values (FCVs), and Tier II values (EPA, 1996b).

Sediment Screening Levels

Initial contaminant screening levels for benthic organisms were preferentially EPA Region 3 BTAG screening levels (EPA, 1995). These values are primarily effects range-low (ER-L) values from Long and Morgan (1990) and Long et al. (1995) and apparent effects thresholds (AETs).

Surface Soil Screening Levels

Initial screening levels for soil organisms consisted primarily of EPA Region 3 BTAG screening levels (EPA, 1995), Oak Ridge National Laboratory (ORNL) surface soil screening levels, and Dutch "B" levels that represent ecological toxicity endpoints (Netherlands, 1994).

3.2.2 Preliminary Exposure Estimate and Risk Calculation

Section 3.2.2.1 describes the components of preliminary exposure estimate and Section 3.2.2.2 describes the components of preliminary risk calculation.

3.2.2.1 Preliminary Exposure Estimate

The maximum detected concentrations of analytes in surface water, sediment, and surface soil were used as exposure point contaminant concentrations for comparison to ecological screening levels in the risk calculation step. Detailed descriptions of sampling locations, data validation, data treatment, and data selection were presented in previous sections.

3.2.2.2 Preliminary Risk Calculation

The preliminary risk calculation step in the ERA process compares exposure-point contaminant concentrations with screening levels protective of ecological receptors (EPA, 1997). The ratio of the exposure-point contaminant concentration to the screening level is called the Hazard Quotient (HQ) and is defined as follows:

$$HQ_i = EPC_i/ESL_i$$

where: HQ_i = Hazard Quotient for analyte "i" (unitless)

EPC_i = Exposure Point Concentration for analyte "i" (μg/L or mg/kg)

ESL_i = Ecological Screening Level for analyte "i" (μg/L or mg/kg)

When the ratio of the exposure point concentration to its respective screening level equaled or exceeded 1.0, adverse impacts were considered possible and the contaminant was retained as a COPC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration exceeds or is less than a screening level. HQ values equal or greater than 1.0 indicate that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk.
The use of HQs is probably the most common method used for risk characterization in ERAs. Advantages of this method, according to Barnthouse et al. (1986), include the following:

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.
- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. That is, it uses single values for exposure concentrations and screening levels. The HQ method does not account for the variability in both these parameters or for incremental or cumulative toxicity.

The comparisons of maximum contaminant concentrations in each medium to screening levels are presented in screening tables. The screening tables include the frequency of detection for each analyte, the range of detected values, and contaminant-specific screening levels.

3.2.3 Step 3a: Refinement of Contaminants of Potential Concern

The ERA methods described above constitute the first two steps of the eight-step ERA process. Thus, the ERA, up to this point, can be considered to be a "screening-level" assessment, or "Tier 1" assessment, since it is based primarily on a conservative initial screening of contaminant concentrations against contaminant-specific screening levels. As will be seen in the ERA for Site 1, maximum concentrations of several analytes exceed ecological screening levels. Because of this, and since the locations and number of samples appears to be adequate to determine the nature and extent of site-related contamination, a more thorough assessment is warranted. Therefore, in accordance with EPA (1997) and Navy policy (DON, 1999), and as per discussions with Region 3 BTAG, a portion of Step 3 of the eight-step ERA process was included in this assessment.

Step 3 of the eight-step ERA process is BERA problem formulation (EPA, 1997). This step consists of several sub-steps designed to develop the goals, breadth, and focus of the BERA. The initial sub-step within Step 3 is refinement of contaminants of potential concern and is referred to as "Step 3a - Refinement of Conservative Exposure Assumptions" in the Navy's ERA guidance (DON, 1999).

The use of conservative guidelines and maximum detected concentrations in the screening-level assessment is necessary to ensure that potential risks are not underestimated. However, if the HQs derived from comparisons of maximum concentrations to conservative screening levels are used as the single factor for including a COPC in a baseline ERA without consideration of other relevant information, additional ecological studies such as toxicity testing or tissue analyses could be undertaken for COPCs that do not actually pose significant risks. For this reason, refinement of COPCs, the first sub-step within Step 3, was incorporated into the ERA. Step 3a involves the consideration of factors such as background data (mainly for inorganics), toxicological evaluation of COPCs, frequency of detection, and comparisons of COPCs to alternate guidelines (EPA, 1997; DON, 1999).

3.2.3.1 Alternate Guidelines

Less conservative guidelines are presented in Step 3a of this ERA to provide balance to the conservative screening-level assessment. For example, some sediment screening values in Steps 1 and 2 consisted of ER-L values obtained from Long et al. (1995). However, an ER-L is defined as the concentration below which adverse ecological effects "would rarely be observed," and the effects range-medium (ER-M) is the concentration below which adverse effects "would occasionally occur" (Long et al., 1995). Therefore, ascribing risk to a sediment contaminant detected in a concentration that exceeds the ER-L but is below the ER-M can be misleading. Recent studies have indicated that ER-Ms are much better indicators of pot ntial adverse effects than ER-Ls (Long et al., 1998), and therefore, ER-Ms are included in Step 3a.

Less conservative sediment guidelines also include probable effects levels (PELs) developed by the Florida Department of Environmental Protection (FDEP, 1994). The PELs are loosely analogous to ER-Ms. The data set used by Long et al. (1995) to develop ER-Ls and ER-Ms was used also by FDEP. However, unlike the ER-Ls and ER-Ms, PELs also incorporate chemical concentrations observed or predicted to be associated with no adverse biological effects (no effects data). The PEL is the geometric mean of the 50th percentile in the effects data set and 85th percentile in the no effects data set. The PEL represents the lower limit of the range of contaminant concentrations that are usually, or always, associated with adverse biological effects (FDEP, 1994).

Less conservative sediment guidelines such as severe effects levels (SELs) developed by the Ontario Ministry of the Environment (MOE) are also presented in Step 3a. MOE guidelines are based exclusively on observed effects in the field (absence of certain species). The SEL represents the contaminant level that could potentially eliminate most of the benthic organisms. Unlike National Oceanic and Atmospheric Administration (NOAA) and FDEP guidelines, MOE guidelines are based on freshwater sediments. probable effects concentrations (PECs), developed as part of EPA's Assessment and Remediation of Contaminated Sediments Program (EPA, 1996c), and other guidelines are also presented in Step 3a.

Alternate guidelines for surface water are not as plentiful as for sediments. Therefore, a broad range of alternate guidelines for surface water could not be developed. However, alternate guidelines are presented, when available, for surface water COPCs in Step 3a.

Alternate surface soil guidelines for some COPCs were available from ORNL (Efroymson et al., 1997a; 1997b) and are presented in Step 3a. These data were derived to use as screening values for investigating the potential effects of contaminants on soil litter invertebrates (i.e., earthworms), soil microbes, and plants. Other alternate ecological soil guidelines include Dutch "B" soil values indicative of "moderate soil contamination that requires further study" (Beyer, 1990) and Canadian Council of Ministers of the Environment Soil Quality guidelines (CCME, 1997).

3.2.3.2 Toxicological Evaluation of COPCs

Toxicity data and information from various sources in the literature are discussed as they relate to the interpretation of potential risks from each COPC. These sources include the USFWS Chemical Hazard Reviews, commonly referred to as the "Eisler" publications, ATSDR Toxicity Profiles on CD-ROM, and ecotoxicological journals.

3.2.3.3 Other Considerations

The establishment of background concentrations was discussed in Section 2.3. Background data were obtained from the sampling and analysis of surface water, sediment, and surface soil during Phase II activities. As a result, background data are available for use in assessing the extent to which chemical concentrations at Site 1 are due to site-related activities, since concentrations of inorganic contaminants can be naturally elevated and exceed screening values.

The frequency of detection and spatial analysis of elevated contaminant concentrations were evaluated to determine whether potential risks are widespread or limited to a small area. The magnitude of the HQs was also considered. As described earlier, the relationship between the magnitude of an HQ and toxicity is not necessarily linear. However, the magnitude of an HQ can be used as a rough approximation of the extent of potential risks, especially if there is sufficient confidence in the guideline used.

3.2.4 Ec logical Risk Assessm nt Approach Summary

Due to past contaminant releases at Site 1, a screening-level ERA was conducted for this site. Maximum contaminant concentrations in surface water, sediment, and surface soil were compared to screening-level toxicity values that are protective of ecological receptors. Potential risks to ecological receptors were investigated in the form of HQ values, which is the ratio of the representative contaminant concentration to the screening-level toxicity value. Risks were considered possible when an HQ value was equal to or greater than 1.0. Subsequently, other quantitative and qualitative factors were investigated in Step 3a to more fully assess potential risks. A "weight-of-evidence" approach (EPA, 1997) was used as part of Step 3a to determine the extent of potential risks when HQ values exceeded 1.0. Information in Step 3a was used to determine final ecological contaminants of concern (COCs).

3.2.5 Screening Level and Step 3a Uncertainty Analysis

Once an ERA is complete, the results must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. This section provides a summary of the general uncertainties involved in this ERA and discusses how the uncertainties may affect the final risk values and conclusions. Discussions of site-specific uncertainties are contained in site-specific sections of this report.

3.2.5.1 Uncertainty in the Preliminary Problem Formulation

Uncertainty in problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes. For example, the sites investigated in this ERA receive contaminant inputs from more than one source. Thus, uncertainties can exist regarding whether risk characterized at a discrete site stems from site-related contaminants.

3.2.5.2 Uncertainty in the Ecological Effects Evaluation

Uncertainty in the ecological effects evaluation results from the nature and quality of the available toxicity data used to derive toxicity screening values. This uncertainty is reduced when similar effects are observed across species, strain, gender, and exposure route; when the magnitude of the response is clearly dose related; and when postulated mechanisms of toxicity are similar for laboratory and wildlife species.

Unlike human health risk assessments, ERAs must consider risks to many different species. However, calculation of risk values for each potential receptor species is not possible. For this ERA, conservative screening values protective of a wide range of ecological receptors were sought. The underlying assumption associated with the use of these screening values is that contaminant concentrations in

excess of these values are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase or decrease a receptor's contact with a contaminant are seldom known. Also, contaminants were present in some media for which no suitable benchmarks were available, and as a result, these contaminants could not be quantitatively assessed. Risks may be biased low in these instances.

Potential risks may be under- or overestimated due to the interactive effects of contaminants. Contaminants with similar modes of action may have additive effects (e.g., organochlorine pesticides) or synergistic effects. In this case, potential risks could be underestimated. Contaminants can also have ameliorating effects on certain receptors. In this case, potential risks could be overestimated.

3.2.5.3 Uncertainty in the Exposure Estimate

Uncertainty in the exposure estimate is primarily a result of the methods used to obtain exposure point concentrations. The maximum detected contaminant concentrations were used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the maximum concentration of a chemical in a given medium was collected in a "hot spot" of contamination and was much higher than the remaining values in the data set, potential risks might be greatly overestimated. Conversely, if undiscovered hot spots exist at a site, then potential risks might be greatly underestimated.

Dermal and inhalation exposures were not evaluated in this ERA. Dermal exposure is usually limited by the outer coverings of most receptors. Nevertheless, certain portions of some receptors, such as footpads, eyes, and nose do not contain fur or feathers, and may have a higher chance of exposure. Inhalation of contaminants is insignificant for most receptors, but burrowing species such as woodchucks could be exposed to some contaminants via inhalation. However, data regarding inhalation exposure and toxicity for wildlife were not available. In summary, the dermal and inhalation exposure routes are considered to be miniscule, but since they cannot be quantitatively assessed, the associated potential risks are inherently underestimated.

3.2.5.4 Uncertainty in the Risk Calculation

Uncertainty in the risk calculation is affected by all aspects of the ERA process described in the above sections. To try to reduce the overall uncertainty in the risk assessment, the weight-of-evidence approach is used to make risk decisions. This approach considers all aspects of the assessment, including the uncertainties, to make determinations of potential risks.

4.0 SITE 1 - THE PRIVET ROAD COMPOUND

4.1 DESCRIPTION AND HISTORY

The Privet Road Compound is a fenced area that is approximately ½ acre in size and is located west of Building No. 6 (Figure 4-1). The compound was constructed to serve as a transfer station for wastes after closure of the Ninth Street Landfill (Site 3) in 1967. The compound operated between 1967 and 1975 and was used as an open disposal area where appreciable quantities of waste were burned and buried. The suspected waste-handling area extends beyond the limits of the fenced compound and covers more than 2 acres, including the present location of the bowling alley and the parking area.

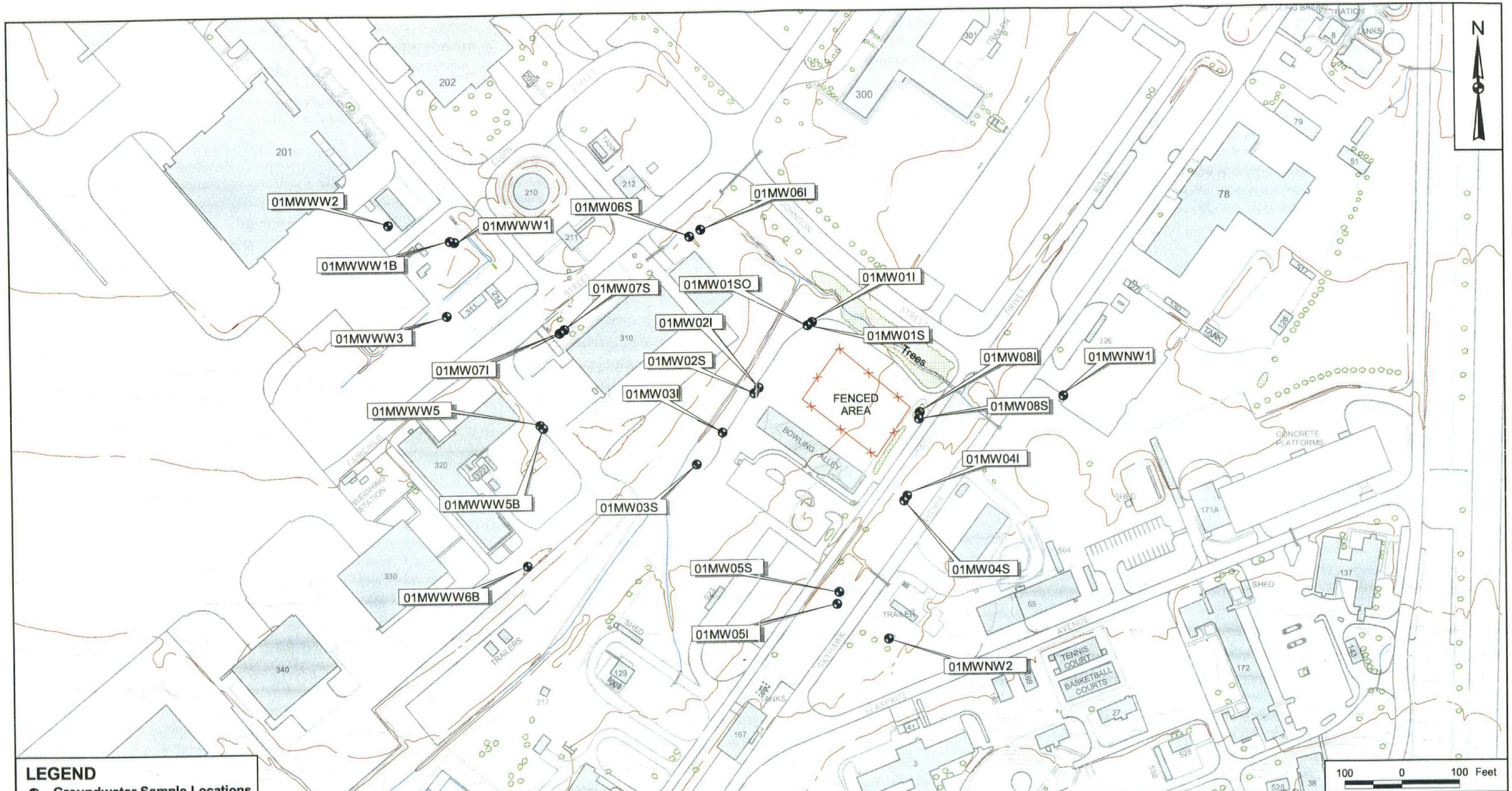
The Privet Road Compound lies within a heavily developed section of the NASJRB adjacent to Privet Road and the Air Reserve and Pennsylvania National Guard facilities. The bowling alley and associated parking area cover a significant portion of the ground surface south of the compound. The compound area contains scattered piles of miscellaneous construction materials. The ground surface slopes at a grade of approximately two percent toward the northwest.

4.2 HYDROLOGY

Although a significant portion of the ground surface in the area is covered by impermeable paving material, much of the precipitation during normal weather conditions is believed to infiltrate, due to the relatively gentle slope, intermittent vegetated areas, and the rutted and uneven nature of the ground surface in the compound area. Storm drainage swales parallel the northeastern and southeastern sides of the compound and intersect at the northern corner of the site. Runoff is prevented from entering the site from the south by grading and a storm drainage channel located along the southern side of Privet Road. Runoff from the compound that enters the drainage swales discharges to the Air Reserve Station stormwater detention basin. Water flow from the stormwater detention basin follows an unnamed tributary to Park Creek and enters the Little Neshaminy Creek drainage basin.

4.3 GEOLOGY

The geologic interpretation of the Privet Road Compound is based on the subsurface data (boring logs and geophysical logs (Appendices B, F and O) obtained during this and previous site investigations. The local geology beneath the site is generally consistent with the regional geology discussed in Section 3.



LEGEND

Groundwater Sample Locations

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY LDL	DATE 4/23/02
CHECKED BY ___	DATE 4/__/02
COST/SCHED-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

SITE FEATURES
NASJRB SITE 1 - PRIVET ROAD
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NO. 5466	OWNER NO. 2207
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. **FIGURE 4-1**	REV.

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SITE-1 apr - LAYOUT: FIGURE 4-1
DATE: 4/23/02 BY: LDL

Soil and well borings consistently encountered a variably thick overburden section underlain by weathered sandstone. The overburden consisted of sandy silt, silty sand, and silty clay. The thickness of the overburden (or the depth to the top of the weathered bedrock) ranged from approximately 4 feet in the vicinity east of Privet Road (01MW04) to about 9 feet in the northeastern corner of the compound (01MW01). Gravel-rich fill material was encountered within 2 feet of the surface at most locations within the former compound but was not encountered beyond the limits of the suspected waste area.

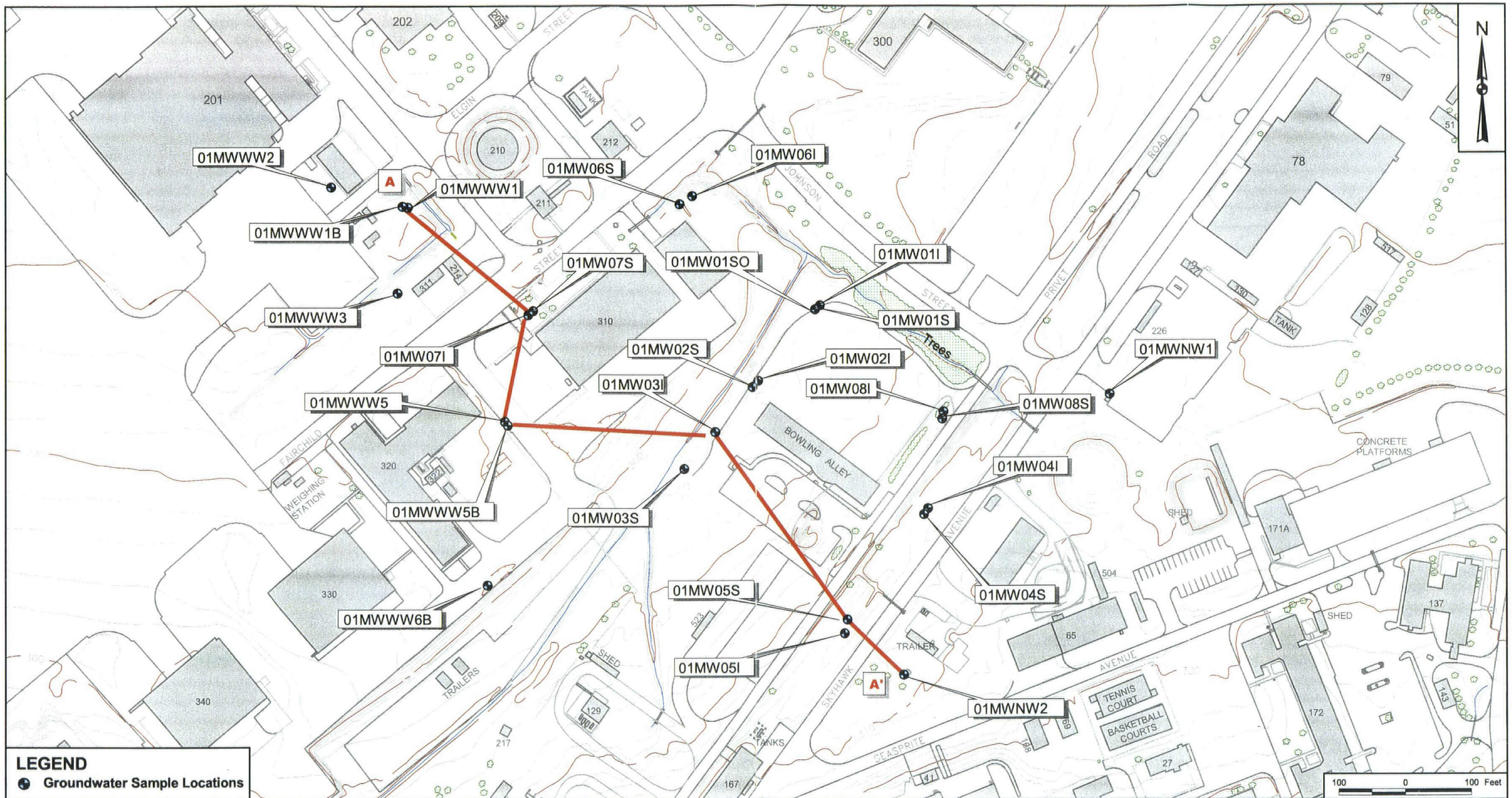
The maximum depth of the monitoring well boreholes at Site 1 is 100 feet. The bedrock to this depth typically consisted of alternating sequences of siltstone and fine- to medium-grained sandstone. Thin beds of shale and claystone were inconsistently encountered within the compound and the northern portion of the site area. In general, the bedrock lithology beneath Site 1 was more variable than that seen at the other sites investigated during this investigation. That is, thinner and vertically alternating sequences of sandstone, siltstone, and shale (or claystone) were typically encountered, rather than thick vertical sequences generally consisting of only one dominant lithology.

Driller's boring logs for Navy Supply Well No. 1 (396 feet deep) and Navy Supply Well No. 2 (351 feet deep) and the results of the borehole geophysical logging program (USGS, 2001) indicate that the lithology below the depth of investigation of the monitoring well network also is consistent with the regional geology and is generally similar to the lithology described from the shallower monitoring well boreholes. Overall, the rock becomes somewhat coarser grained with increasing subsurface depth, and the thickness of the individual lithologic units generally increases, especially below a subsurface depth of about 200 feet.

The structural geology beneath the site is illustrated by geologic cross-section A-A' (Figures 4-2 and 4-3). This section indicates that the structure (dip) of the bedrock is similar to that predicted by the regional geology, but it also reveals that lateral facies changes (such as gradations between siltstone and mudstone) are common. These facies changes are also consistent with those predicted by the regional geology and are expected, given the depositional history of the Stockton Formation.

4.4 HYDROGEOLOGY

Seven additional monitoring wells were installed to further delineate the nature and horizontal and vertical extent of groundwater contamination and to provide the additional hydraulic head data needed to refine the hydrogeologic interpretation of the site. The Site 1 monitoring well locations are illustrated in Figure 4-2. The construction details for all existing and newly installed monitoring wells are listed in Table 4-1.



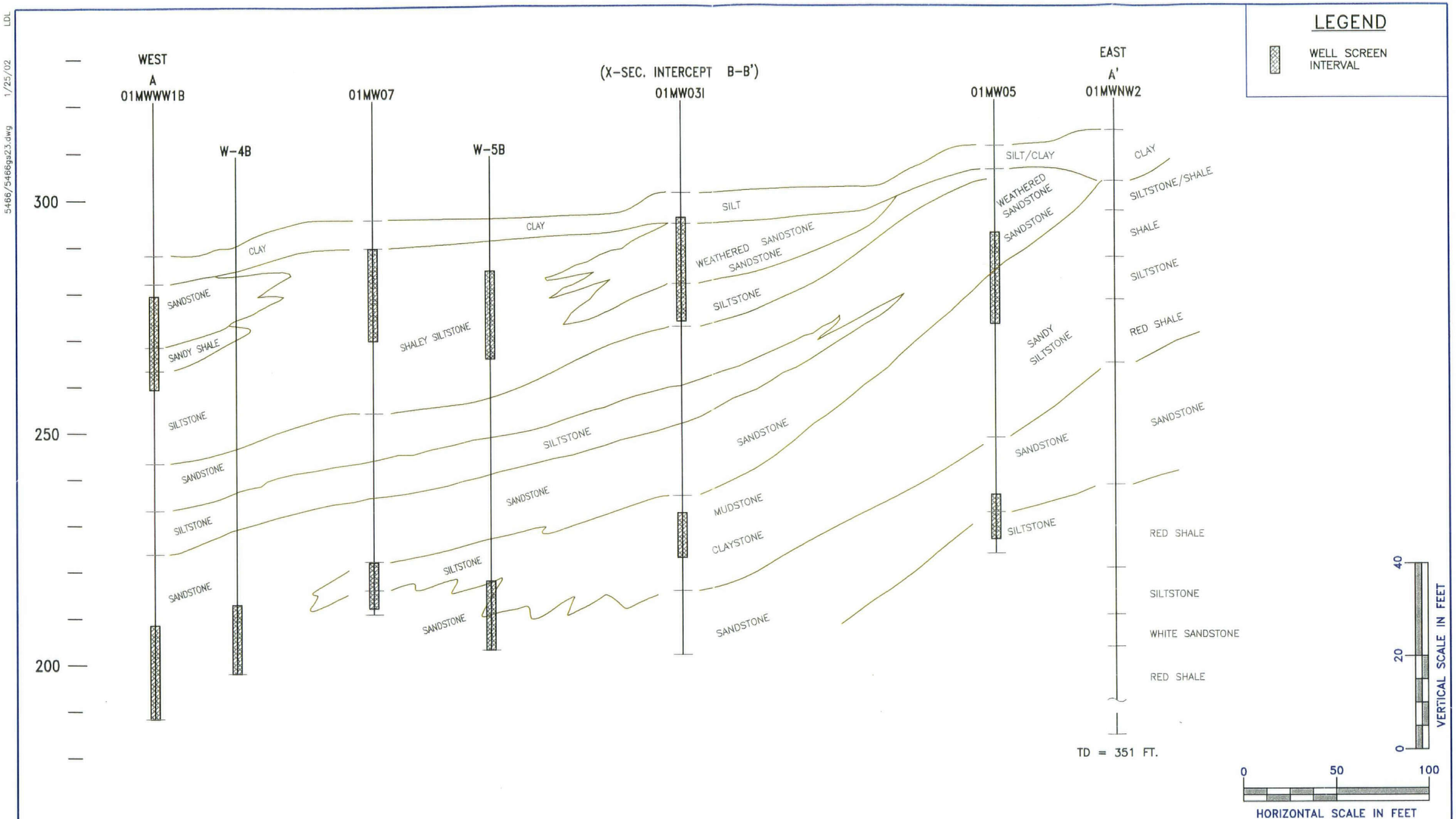
LEGEND

- Groundwater Sample Locations

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/28/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/28/02	CROSS-SECTION LOCATION MAP NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-2 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1.apr - LAYOUT: FIGURE 4-2
DATE: 2/12/02 BY: CM



DRAWN BY LDL DATE 1/25/02	Tetra Tech NUS, Inc.	CROSS-SECTION A-A'	CONTRACT NO. 5466
CHECKED BY DATE		SITE 1 – PRIVET ROAD COMPOUND	OWNER NO. 2207
REVISED BY DATE		GEOLOGIC CROSS SECTION	APPROVED BY DATE
SCALE AS NOTED		NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DRAWING NO. FIGURE 4-3 REV.

LDL 1/25/02 5466/5466gg23.dwg

5466gg23.dwg

TABLE 4-1

SITE 1: PRIVET ROAD COMPOUND
WELL CONSTRUCTION DETAILS
NASJRB WILLOW GROVE, PENNSYLVANIA

PREVIOUSLY EXISTING WELLS (ALL WELLS ARE 4-INCH DIAMETER)				
Old Designation	New Designation	Well Depth (feet bgs)	Screen Interval (feet bgs)	Elevation TOC
PRW-2	01MW02S	27	7 - 27	303.11
PRW-2B	01MW02I	88	78 - 88	302.75
PRW-3	01MW03S	26.5	6.5 - 26.5	302.60
PRW-4	01MW04S	35	15 - 35	312.43
PRW-4B	01MW04I	90	80 - 90	312.35
PRW-5	01MW05S	38.5	18.5 - 38.5	311.69
PRW-5B	01MW05I	85	75 - 85	312.11
PRW-6	01MW06S	26	6 - 26	297.15
PRW-6B	01MW06I	84.5	74.5 - 84.5	296.93
PRW-7	01MW07S	26	6 - 26	297.38
PRW-7B	01MW07I	84	74 - 84	296.28
W-1	01MWWW1	29	9 - 29	290.29
W-1B	01MWWW1B	100	80 - 100	290.19
W-2	01MWW2	21.7	? - 21.7 (toc)	290.79
W-3	01MWW3	21.95	? - 21.95 (toc)	293.38
NEW MONITORING WELLS (ALL WELLS ARE 2-INCH DIAMETER)				
--	01MW01SO	18	8 - 18	304.73
--	01MW01S	33	23 - 33	304.8
--	01MW01I	85	75 - 85	304.49
--	01MW03I	79	69 - 79	302.80
--	01MW08SO	17	7 - 17	309.87
--	01MW08S	34	24 - 34	309.89
--	01MW08I	86	76 - 86	309.69

TOC = Top of casing.

bgs = Below ground surface.

4.4.1 Long-T rm Wat r-Level Study

A long-term water-level study was conducted at the Privet Road Compound prior to the installation of any additional monitoring wells. The water-level study was conducted because it became apparent during the review of previous investigations and the scoping of the Phase II RI field investigation that the groundwater flow regime was not well understood but was apparently greatly influenced by the pumping of the Navy potable supply wells. Data limitations or unknowns included groundwater flow directions, upgradient versus downgradient directions relative to pumping versus non-pumping conditions, the effects of pumping on the horizontal and vertical gradients, the capture zones of the supply wells, and the response of the aquifer to changing meteorological conditions (precipitation and barometric pressure). The long-term water-level study was designed to obtain the spatial and temporal hydraulic head data needed to fill these data gaps. The results of the water-level study were then used to determine the locations of the new monitoring wells to be installed.

The ultimate goal in refining the interpretation of the hydrogeological regime at Site 1 is to better understand the interaction between groundwater flow and the patterns of groundwater contamination that have historically been present at and near this site. VOCs (chiefly PCE and TCE) have historically been detected in both Navy supply wells, the currently inactive Air Force supply well, the Privet Road Compound monitoring wells, and the Air Force Washrack monitoring wells. The source(s) of the VOCs, however, has not been identified, although either (or both) the Privet Road Compound and the Washrack have previously been cited as likely source areas. Although both areas have been interpreted to lie hydraulically downgradient from the Navy supply wells, it has been hypothesized that, under pumping conditions, the Navy supply wells could induce flow and capture groundwater from one or both of these areas.

Data Gathering

To conduct the water-level study, pressure transducers attached to automatic data loggers were installed in 13 monitoring wells (Table 4-2). The data loggers recorded the static water levels at 10-minute intervals. Hourly precipitation and barometric pressure data were obtained from the on-base Naval Training and Meteorology and Oceanography Detachment. In addition, a strip-chart recorder was installed in Building 6 to monitor and record the on-off cycles and times of the supply wells. According to Navy personnel, the two supply wells work in tandem (both are either on or off), and the pumping cycles are triggered by a water-level sensor in the potable water reservoir.

The water-level study commenced on March 4, 1997. A 30-day water-level study was planned. Mechanical problems with some of the pressure transducers, however, precluded the concurrent recording of water

TABLE 4-2

SITE 1: PRIVET ROAD COMPOUND
WELLS MONITORED FOR LONG-TERM WATER LEVEL STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

WELL	DEPTH	SCREENED INTERVAL
01MW02S	27	7 - 27
01MW02I	88	78 - 88
01MW03S	26.5	6.5 - 26.5
01MW04S	35	15 - 35
01MW04I	90	80 - 90
01MW05S	38.5	18.5 - 38.5
01MW05I	85	75 - 85
01MW06S	26	6 - 26
01MW06I	84.5	74.5 - 84.5
01MW07S	26	6 - 26
01MW07I	84	74 - 84
01MWWW1	29	9 - 29
01MWWW1B	100	80 - 100

elevation data from all monitoring wells over a month-long period, so a complete set of water elevation data recorded simultaneously in all wells over this period was not available. Therefore, the study was extended through April 10, 1997, which created an approximately 7-day period (April 3 through April 10) when all 13 of the data recorders were operational and simultaneously recording static water levels at 10-minute intervals. These data, which formed the basis of the study, are included in Appendix E of the Phase II RI Report. These water-level elevation data for each of the 13 monitoring wells over this 7-day period are also presented graphically in Figures 4-4 through 4-9.

One data logger remained operational through April 22, 1977. This logger was operational throughout the entire test period and recorded the water levels in monitoring wells 01MW02S, 01MW02I, and 01MW03S. These data provide the baseline and longer-term trends to which the weeklong data may be compared. This complete set of data is presented graphically in Figure 4-10. The daily meteorological data (precipitation and barometric pressure) over this same period are presented graphically in Figure 4-11.

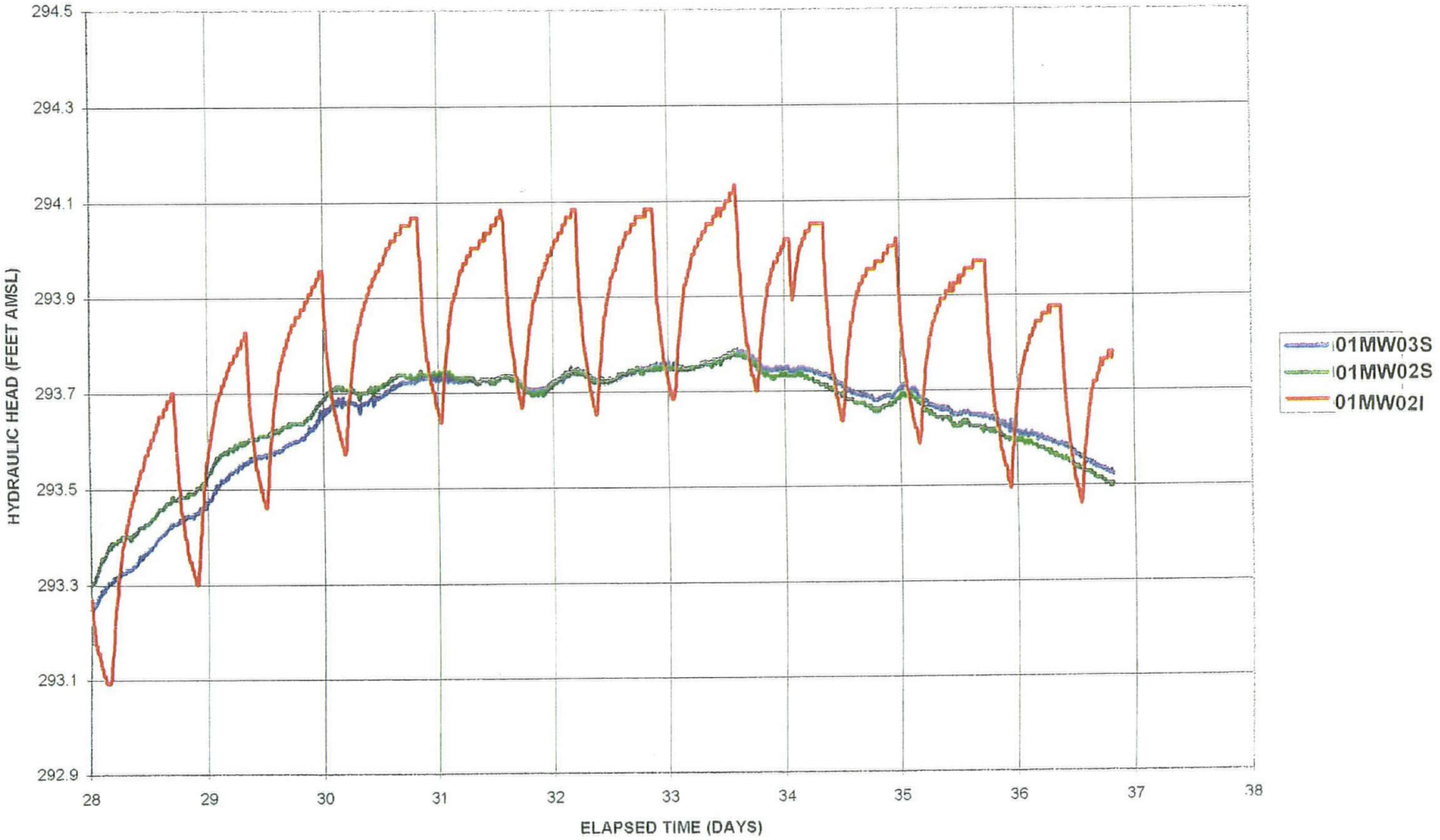
Data Interpretation

The hydraulic head within the confined aquifer showed an immediate and unequivocal response to the stressing of the aquifer by pumping. The response was the greatest in the immediate vicinity of the pumping wells (at 01MW04 and 01MW05), where the hydraulic head was lowered approximately 5 to 6 feet, but was also evident 1,600 feet away in the vicinity of the Air Force Washrack (01MWWW1B), where the hydraulic head was lowered almost 0.5 foot. The hydraulic head within the unconfined aquifer showed a subdued, yet discernible response to pumping at some locations (e.g., 01MW04 and 01MWWW1B) but not at others (e.g., 01MW05). Apparently, there is leakage between the aquifers, but the degree or amount of leakage is laterally variable and dependent on lithology and/or the local degree of bedrock fracturing.

Both the unconfined and confined aquifers displayed response to precipitation events. The meteorological data (Figure 4-11) reflect significant precipitation events on days number 10 and 27-28 and a number of lesser precipitation events. The hydraulic head in each well of the unconfined/confined monitoring well pair at cluster location 01MW02 (Figure 4-10) rose in response to each of these precipitation events. This response supports the hypothesis of aquitard leakage and some degree of communication between the aquifers and updip (unconfined) recharge of the units confined at depth in the vicinity of Site 1.

The graphs of the water-level elevations (Figures 4-4 to 4-9) illustrate that, under non-pumping conditions, the hydraulic head within the confined aquifer is higher than the hydraulic head of the unconfined aquifer, and the vertical gradient between the two aquifers is oriented upward. Under pumping conditions, the hydraulic head of the confined aquifer within the vicinity of the Privet Road Compound (at locations 01MW02, 01MW04, and 01MW05) is eventually lowered to a level below the head of the unconfined aquifer, which reverses the hydraulic gradient and may induce groundwater flow into the confined aquifer.

WATER LEVEL ELEVATION DATA
PRIVET ROAD LONG-TERM WATER LEVEL MONITORING
MONITORING WELL CLUSTERS 01MW02, 01MW03



NASJRB WILLOW GROVE
PHASE 2 REMEDIAL INVESTIGATON

FIGURE 4-4

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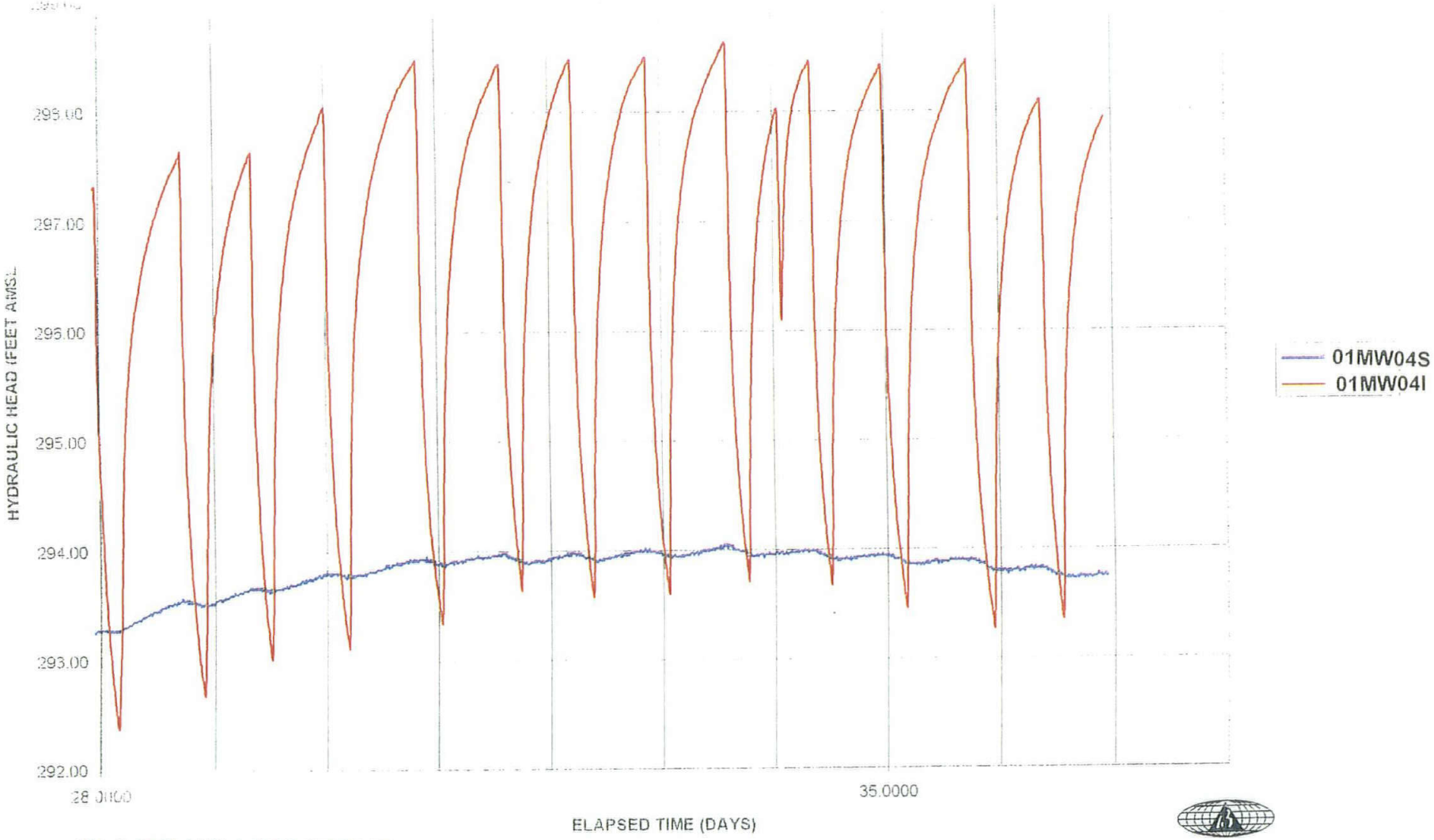
WATER LEVEL ELEVATION DATA
PRIVET ROAD LONG-TERM WATER LEVEL MONITORING
MONITORING WELL CLUSTER 01MW04



NASJRB WILLOW GROVE
PHASE 2 REMEDIAL INVESTIGATON

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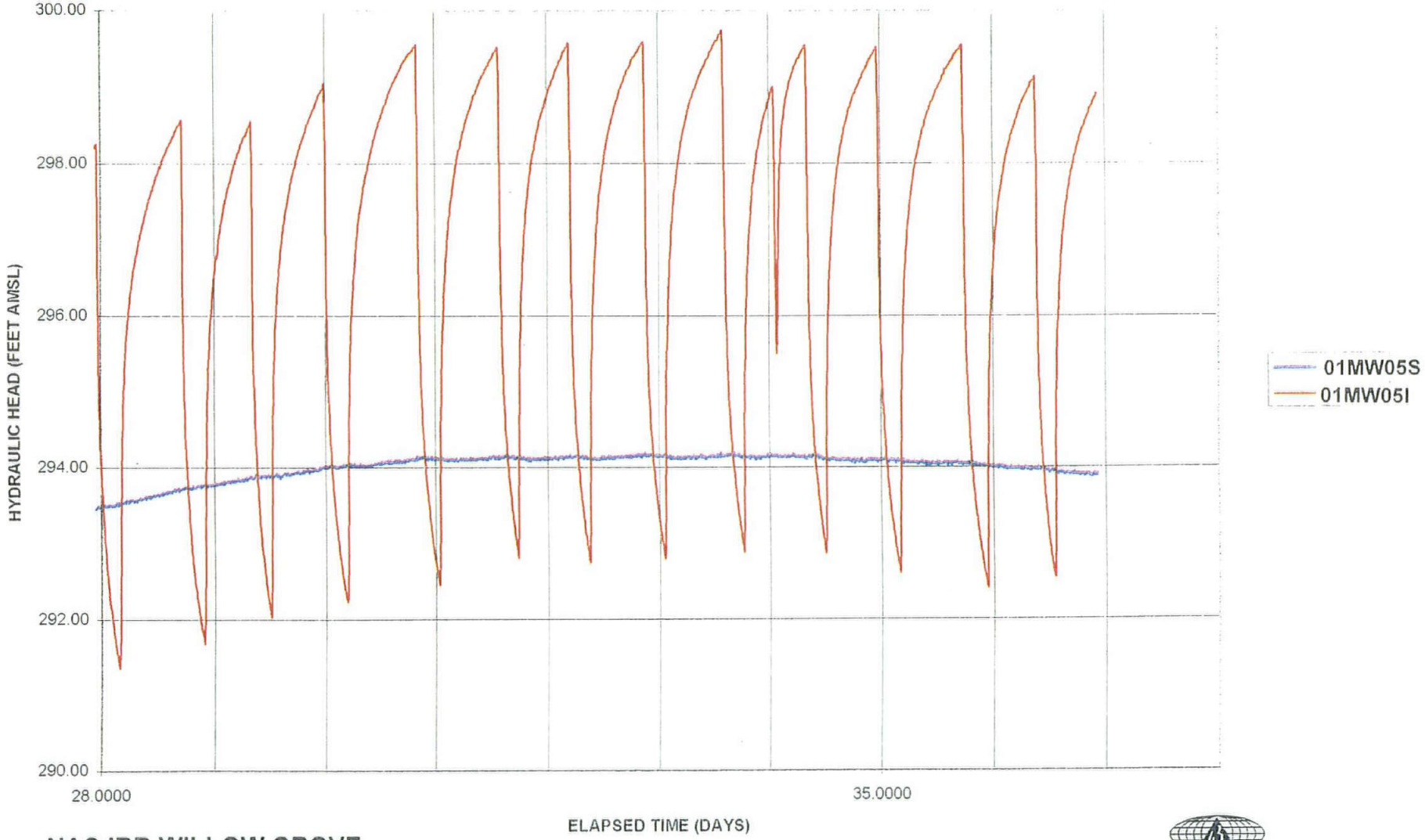
FIGURE 4-5

10/21/97

WATER LEVEL ELEVATION DATA
PRIVET ROAD LONG-TERM WATER LEVEL MONITORING
MONITORING WELL CLUSTER 01MW05



NASJRB WILLOW GROVE
PHASE 2 REMEDIAL INVESTIGATON

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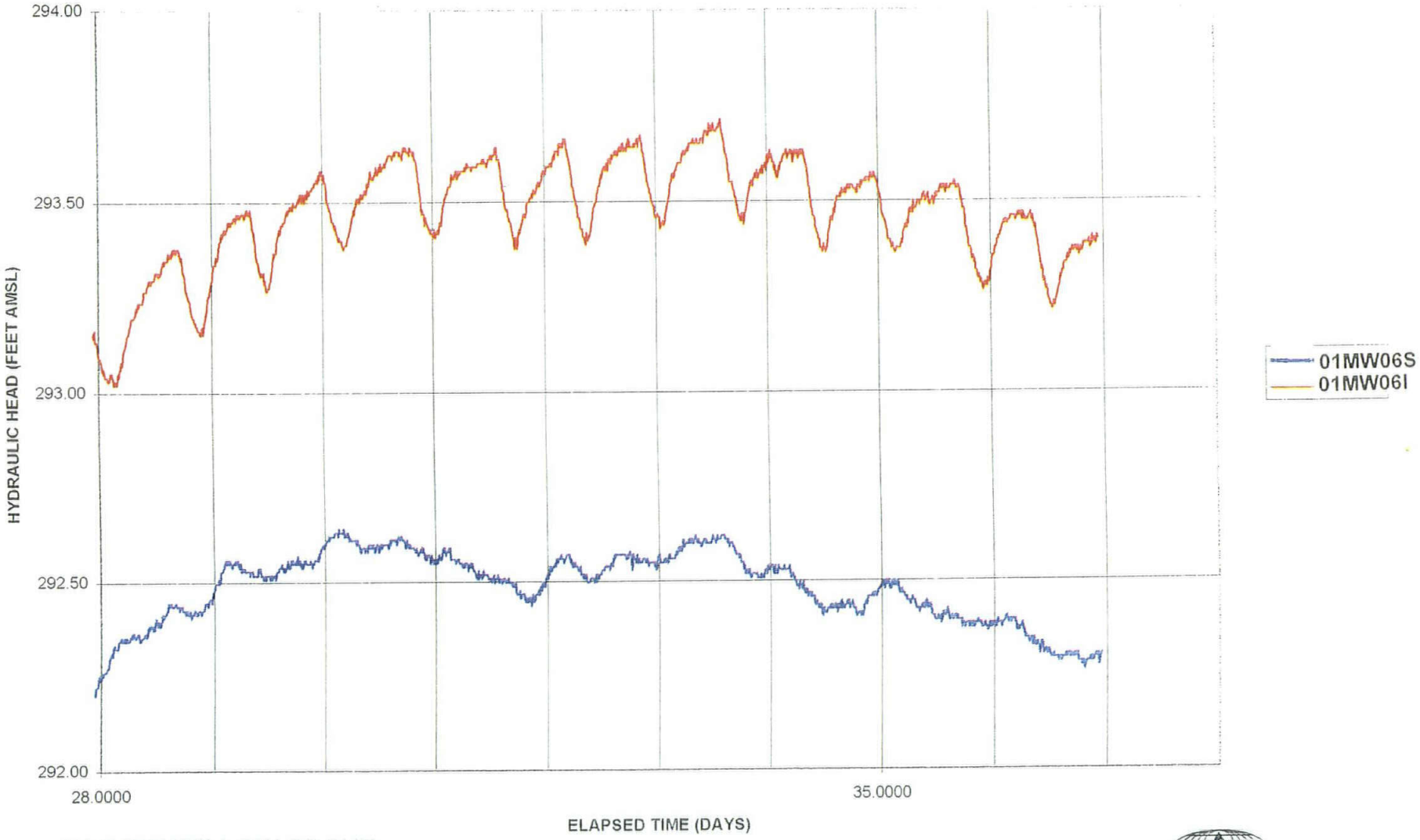
FIGURE 4-6

10/21/97

WATER LEVEL ELEVATION DATA
PRIVET ROAD LONG-TERM WATER LEVEL MONITORING
MONITORING WELL CLUSTER 01MW06



NASJRB WILLOW GROVE
PHASE 2 REMEDIAL INVESTIGATON

FIGURE 4-7

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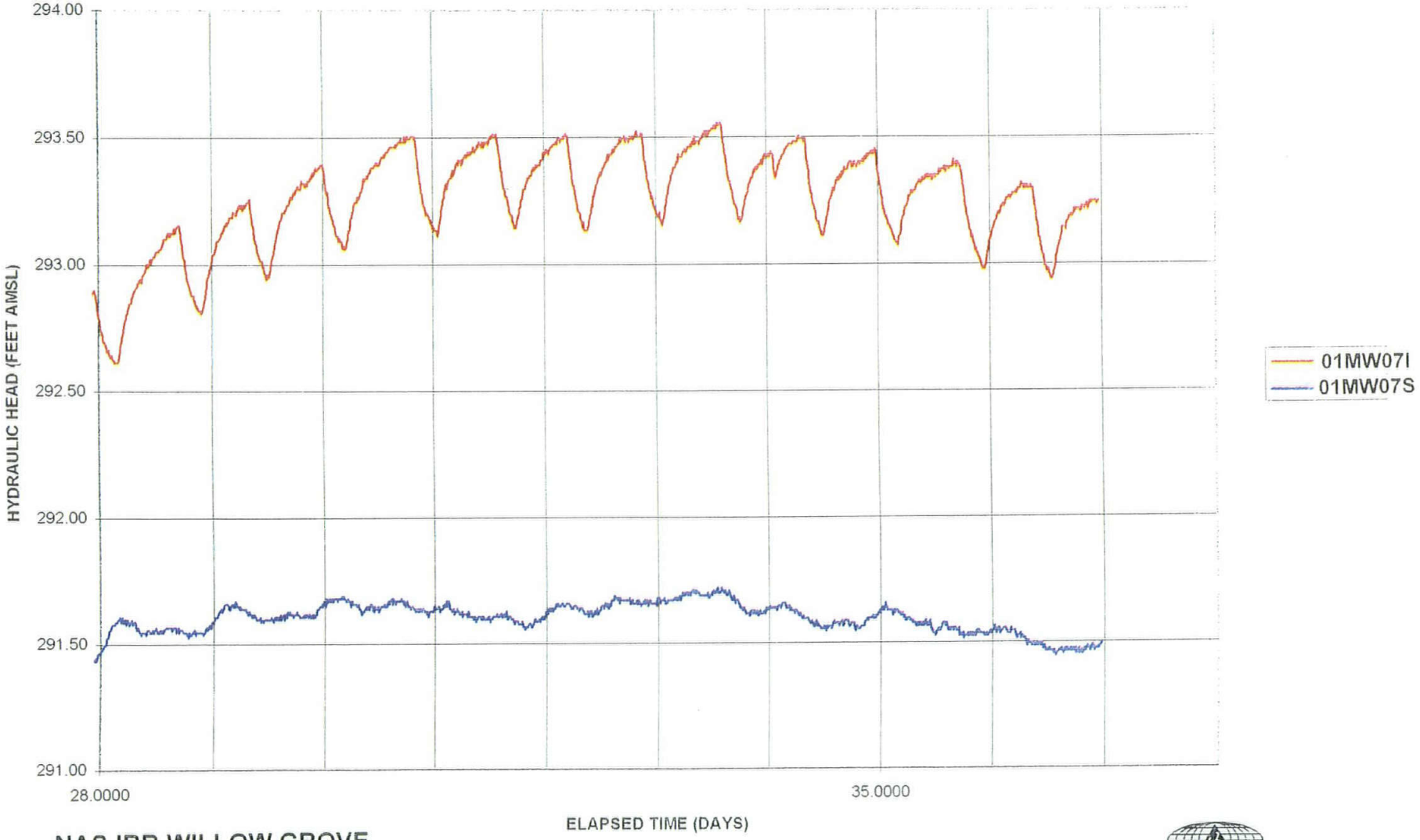
WATER LEVEL ELEVATION DATA
PRIVET ROAD LONG-TERM WATER LEVEL MONITORING
MONITORING WELL CLUSTER 01MW07



NASJRB WILLOW GROVE
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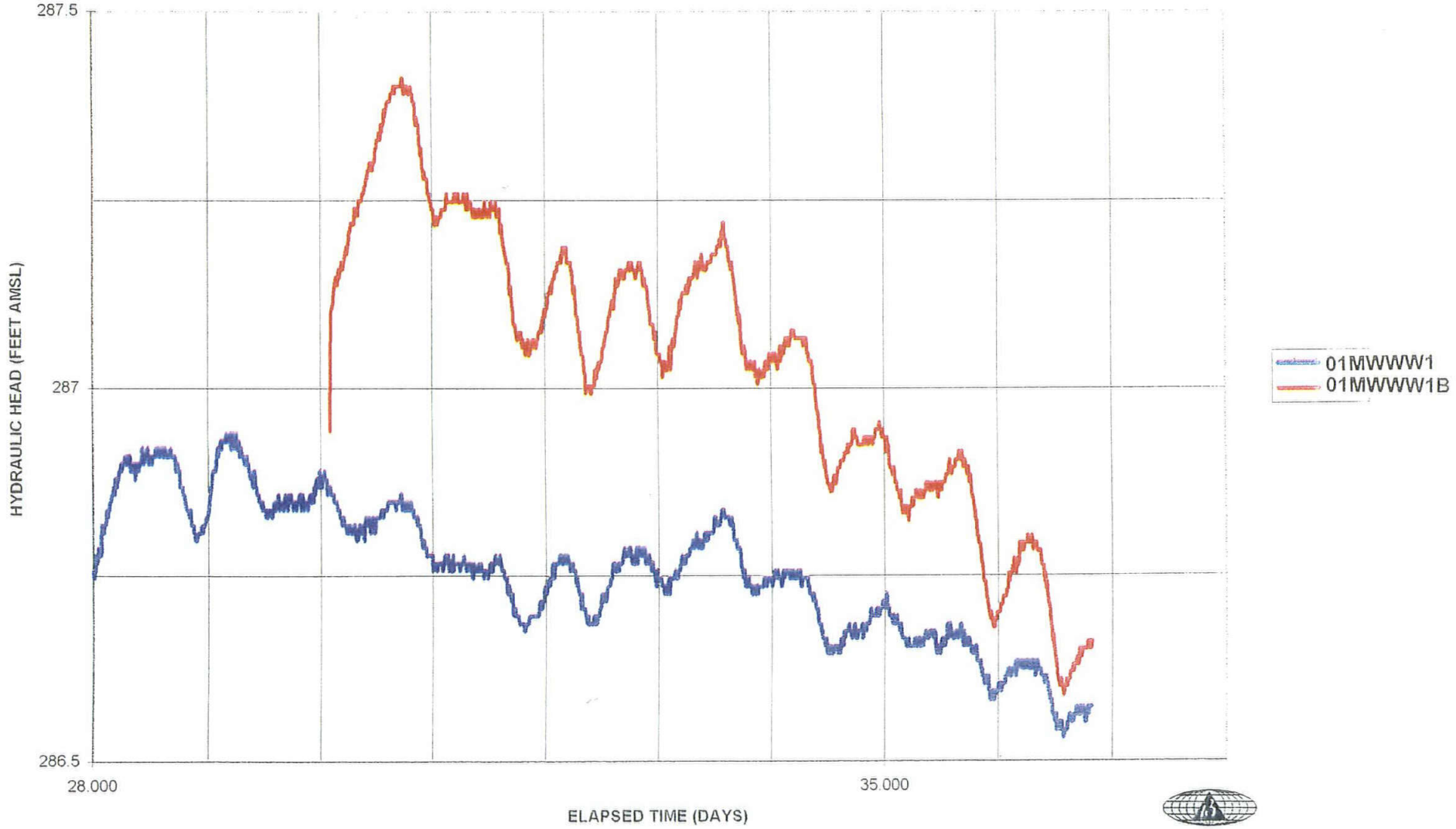
FIGURE 4-8

10/21/97

WATER LEVEL ELEVATION DATA
PRIVET ROAD LONG-TERM WATER LEVEL MONITORING
AIR FORCE WASH RACK MONITORING WELL CLUSTER



NASJRB WILLOW GROVE
PHASE 2 REMEDIAL INVESTIGATON

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FIGURE 4-9

10/21/97

NASJRB WILLOW GROVE
PHASE 2 REMEDIAL INVESTIGATON
WATER LEVEL ELEVATION DATA
PRIVET ROAD LONG-TERM WATER LEVEL MONITORING
MONITOING WELLS 01MW02S, 0IMW02I, 01MW03S

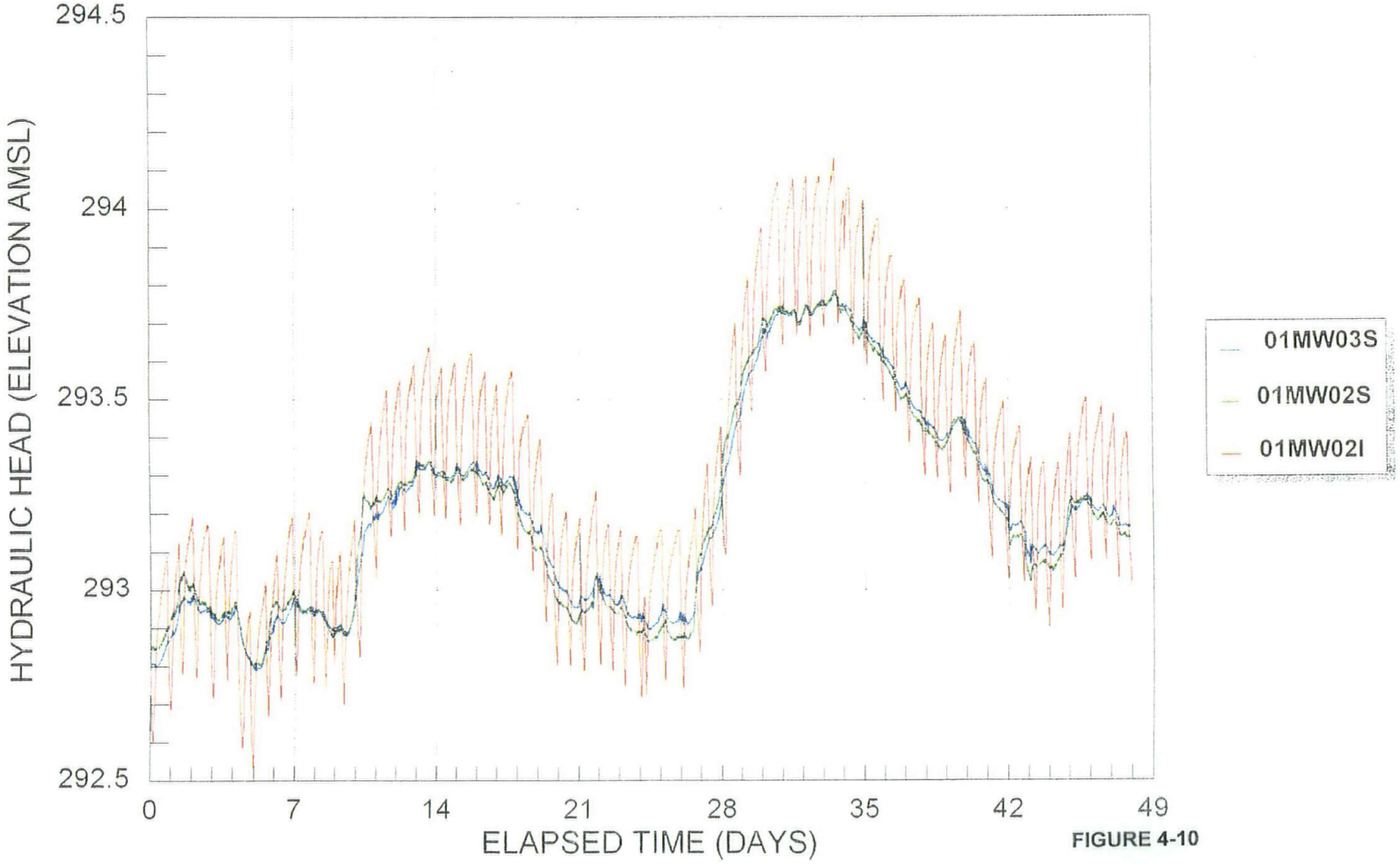

FIGURE 4-10

Day 0 = MARCH 4, 1997 at 12 NOON

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NASJRB WILLOW GROVE
PHASE 2 REMEDIAL INVESTIGATON

METEOROLOGICAL DATA
PRIVET ROAD LONG-TERM WATER LEVEL MONITORING

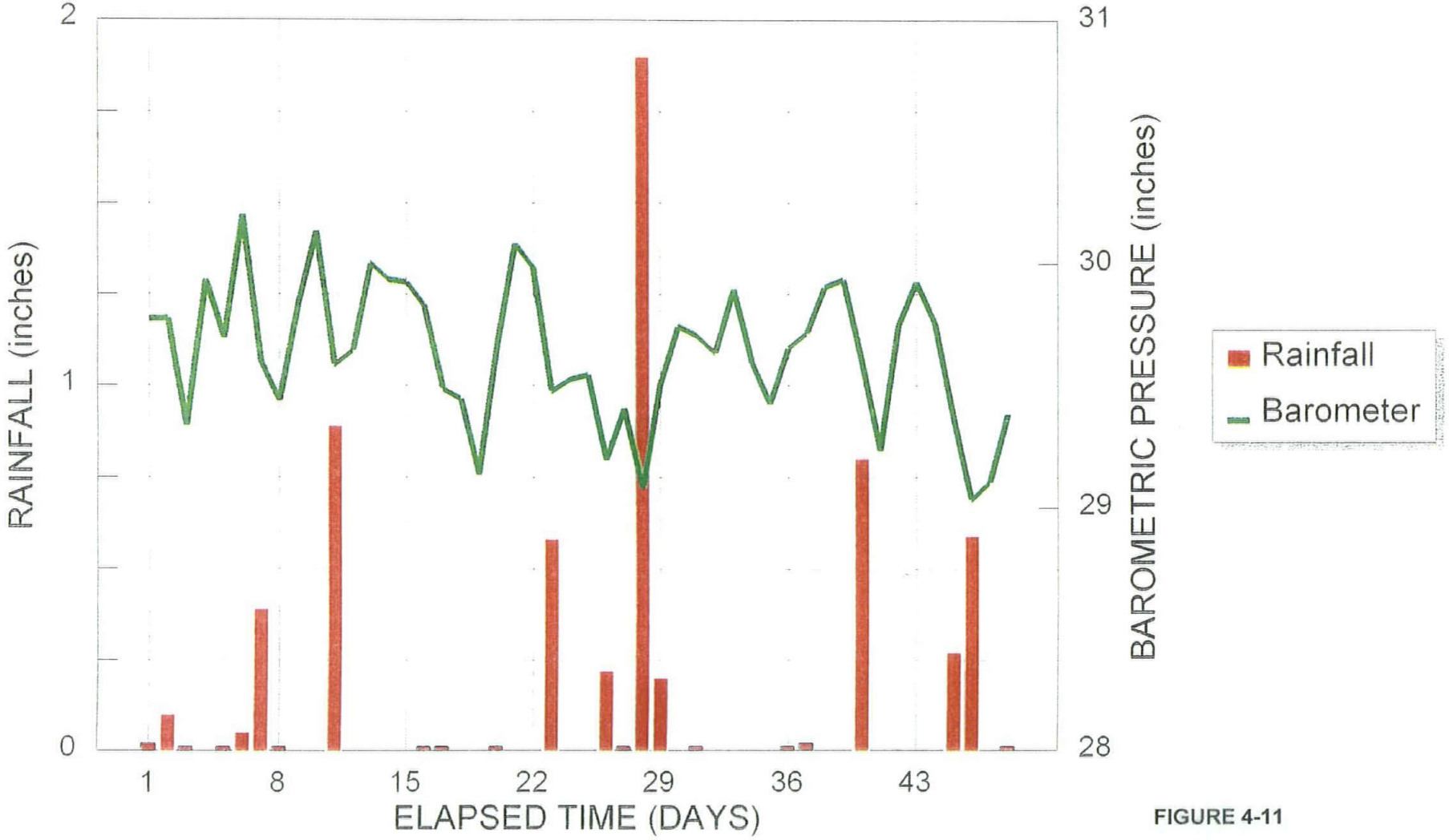

FIGURE 4-11

Day 0 = MARCH 4, 1997 at 12 NOON

BAROMETRIC PRESSURE WAS REPORTED BY THE U.S. NAVY METEOROLOGICAL STATION AT NASJRB WILLOW GROVE. READINGS WERE OBTAINED AT 12 NOON DAILY.

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10/21/97

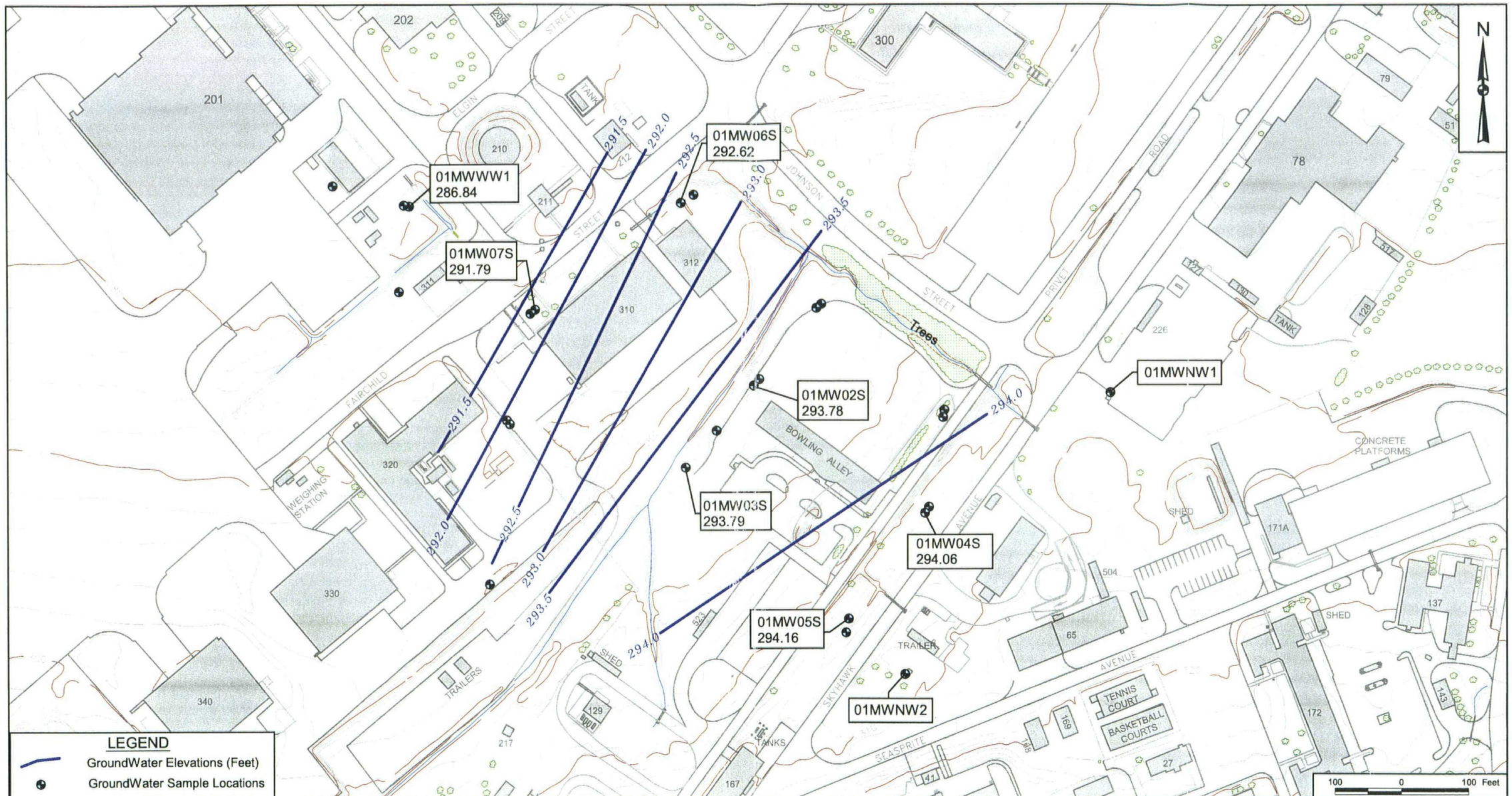
This reversal of vertical hydraulic gradient does not occur downgradient (northwest) of the compound.

Groundwater elevation contour maps were constructed for both the unconfined and the confined aquifers under both pumping and non-pumping conditions. To do this, data from one complete cycle were selected to represent the periods immediately before the pumps were turned off (to represent pumping conditions) and immediately before the pumps were turned on (to represent non-pumping conditions). A representative pumping cycle lasting from the elapsed time interval of 47,570 minutes (April 6 at 1250) to the elapsed time interval of 48,350 minutes (April 7 at 0150) was selected to represent pumping and non-pumping conditions, respectively, and the groundwater elevation data from these two time periods were plotted and contoured. The groundwater hydraulic head elevation contour maps are presented in Figures 4-12 through 4-15.

The groundwater elevation contour maps for the elapsed time of 48,350 minutes (Figures 4-12 and 4-13) show that, under non-pumping conditions, groundwater at Site 1 flowed in a generally north to northwestward direction in both the unconfined and confined aquifers. Therefore, under non-pumping conditions and prior to the installation of the subsequent Phase II monitoring wells, the Navy supply wells were interpreted to be located upgradient from the Privet Road compound, and the Air Force Washrack area was interpreted to be located downgradient from the compound.

The groundwater elevation contour maps for the elapsed time of 47,570 minutes (Figures 4-14 and 4-15) within the confined aquifer in the vicinity of Site 1 show that, under pumping conditions, groundwater in the vicinity of Site 1 was affected by the pumping of the supply wells and that some of the local groundwater flow direction is reversed as the cones of depression expand to capture groundwater beneath the compound. Although the hydraulic head within the shallow, unconfined aquifer is lowered in response to the pumping, the overall direction of groundwater flow within the unconfined aquifer was not interpreted to be altered by the well pumping.

Two discrete drawdown cones were interpreted within the confined aquifer under pumping conditions (Figure 4-15), given the data available at the conclusion of the long-term water-level study and prior to the installation of the subsequent Phase II monitoring wells. The drawdown cones were aligned roughly parallel to the strike of the bedrock, which is typical for aquifers located within the Triassic Basin. Under pumping conditions, a northeast-southwest-trending stagnation line (marking the outer boundary of the supply wells' capture zone) was developed immediately northwest of the compound. Given this interpretation, the pumping of the supply wells could induce groundwater migration from the Privet Road Compound into the supply wells, but the pumping could not induce flow (as had been interpreted in the Phase I RI) from the Air Force Washrack area. This entire interpretation, however, was constrained by the relative lack of data (three monitoring wells) within the apparent zone of influence of the supply wells and highlighted the need for the additional monitoring wells, which were subsequently installed during the Phase II RI.



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/22/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/22/02	HYDRAULIC HEAD ELEVATIONS AND GROUNDWATER FLOW CONDITIONS FOR THE UNCONFINED AQUIFER UNDER NON-PUMPING CONDITIONS NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY RET / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-12 / REV.

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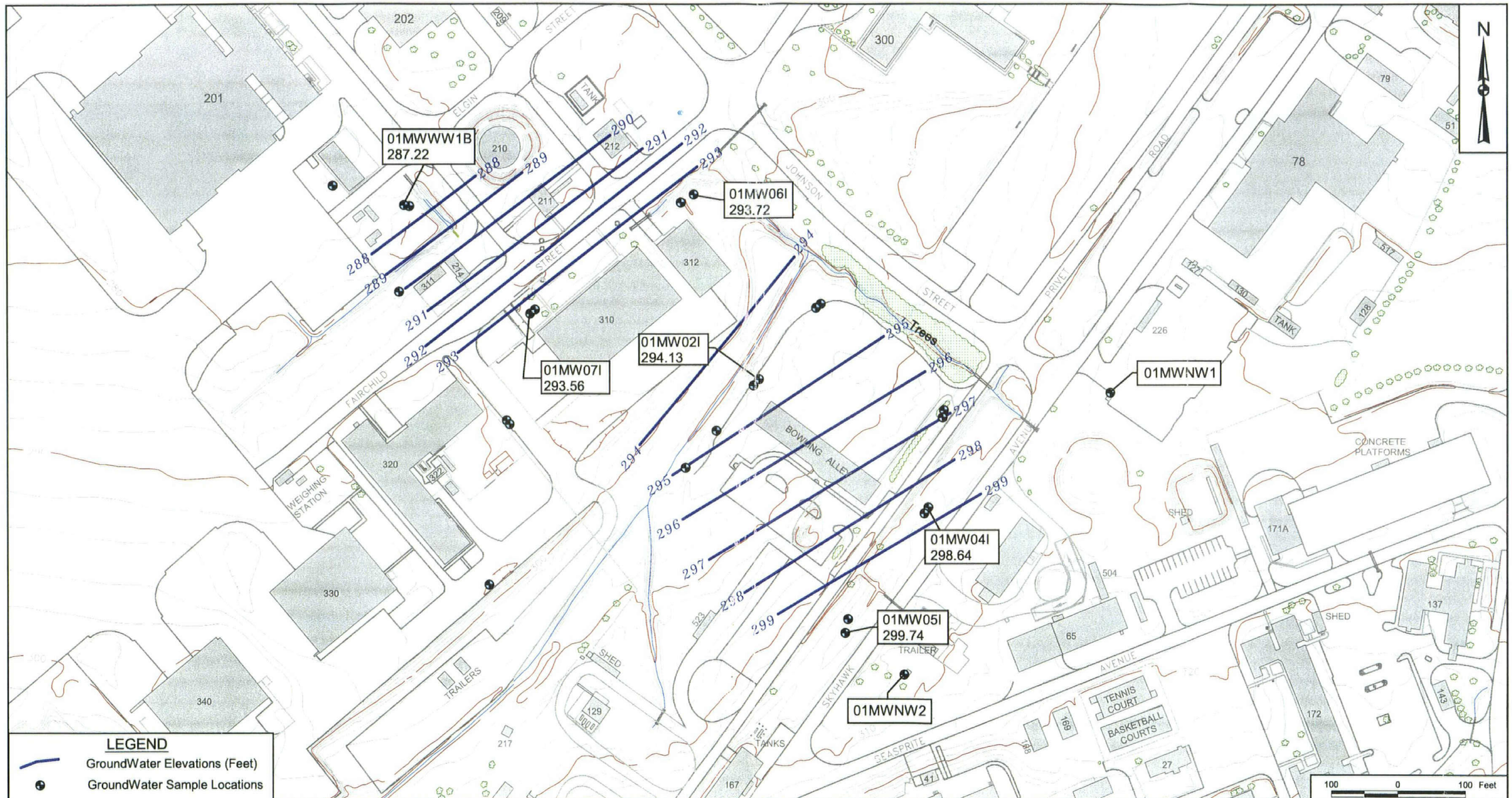
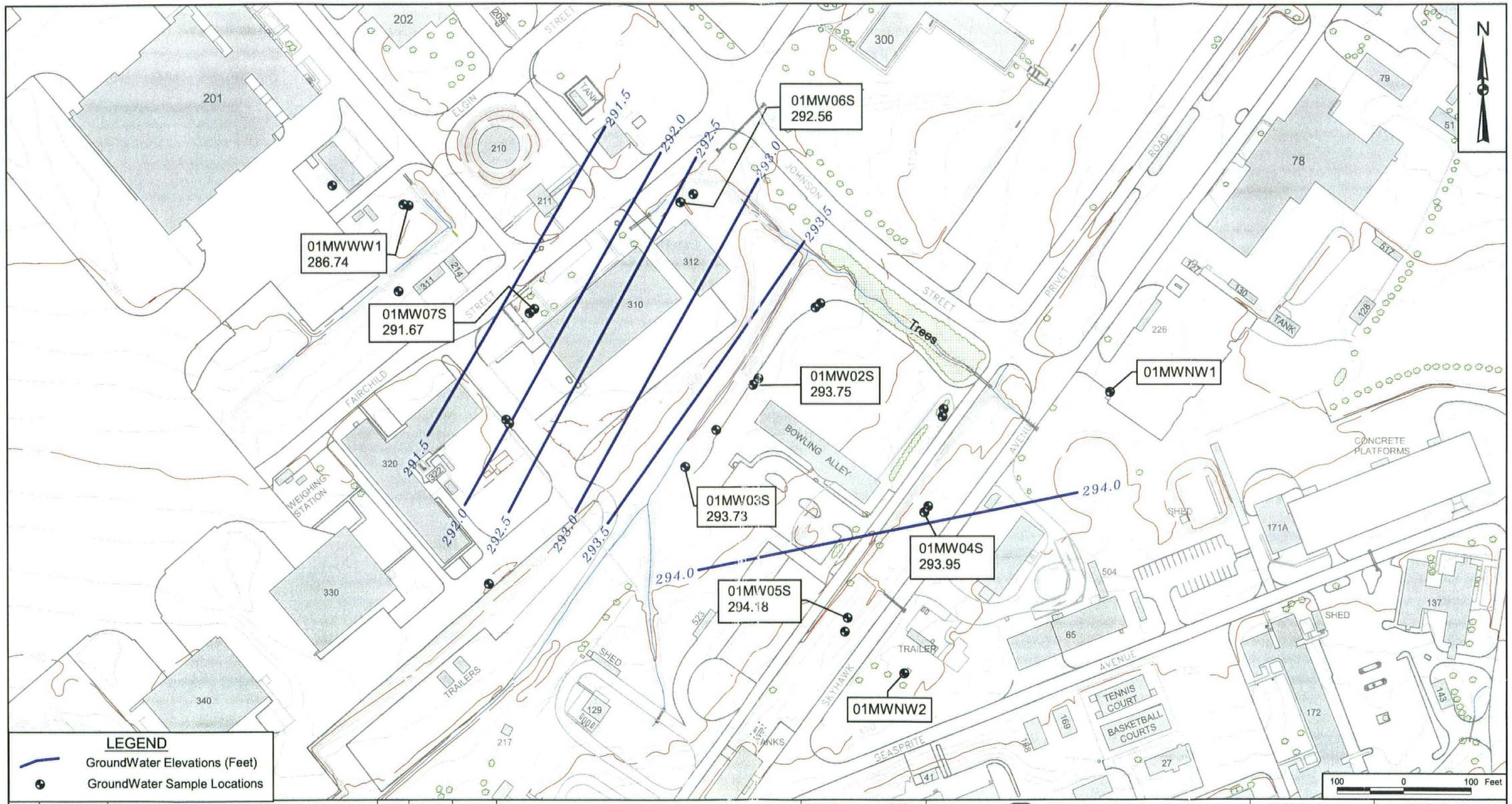
DATE: 2/12/02 BY: CM



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/22/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/22/02	HYDRAULIC HEAD ELEVATIONS AND GROUNDWATER FLOW CONDITIONS FOR THE CONFINED AQUIFER UNDER NON-PUMPING CONDITIONS NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-13 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove
SITE-1.apr - LAYOUT: FIGURE 4-13
DATE: 2/12/02 BY: CM/LDL



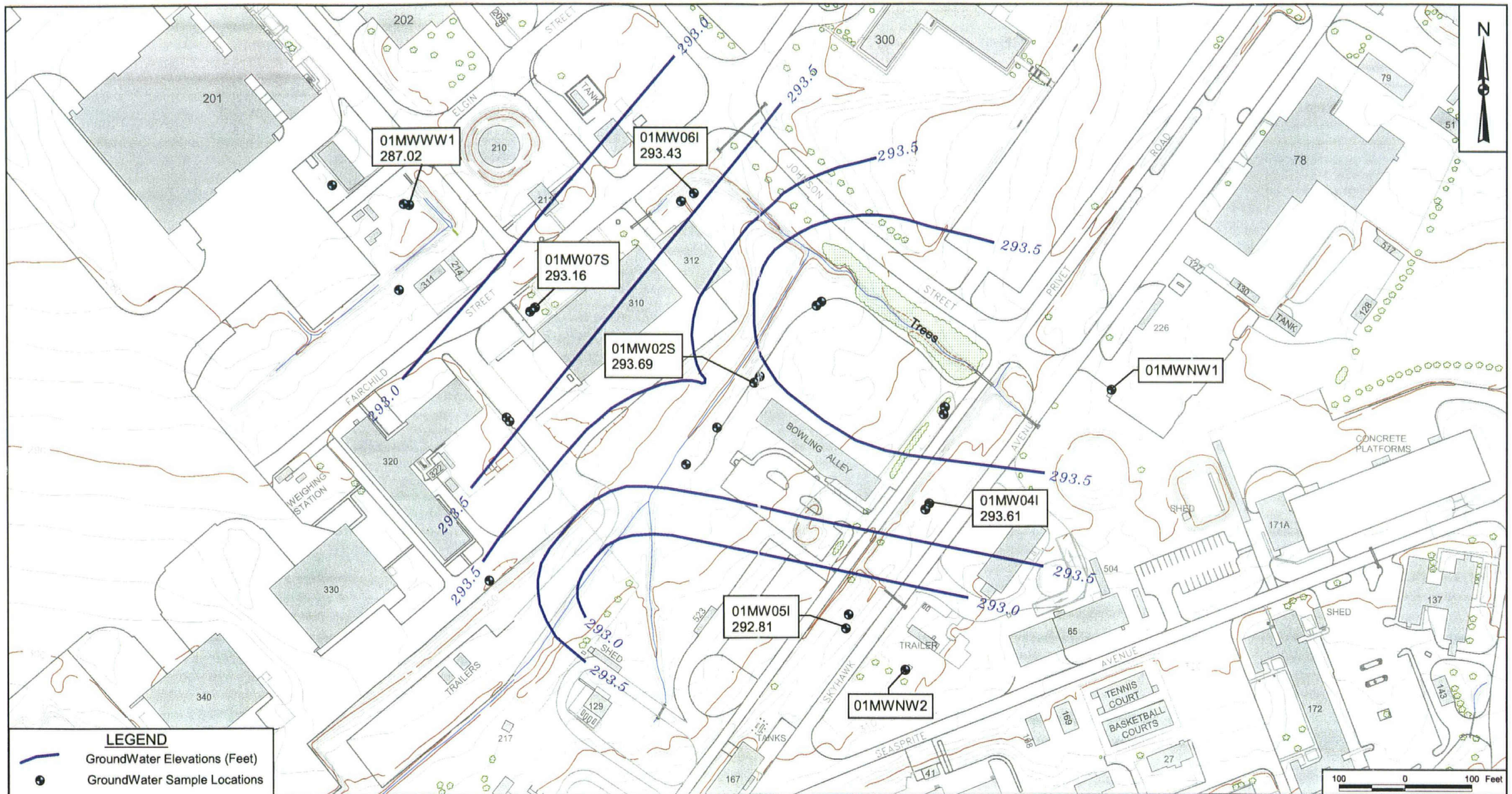
LEGEND

- GroundWater Elevations (Feet)
- GroundWater Sample Locations

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/22/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/22/02	HYDRAULIC HEAD ELEVATIONS AND GROUNDWATER FLOW CONDITIONS FOR THE UNCONFINED AQUIFER UNDER PUMPING CONDITIONS NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-14 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove
SITE-1.apr - LAYOUT: FIGURE 4-14
DATE: 2/12/02 BY: CM



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/27/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/27/02	HYDRAULIC HEAD ELEVATIONS AND GROUNDWATER FLOW CONDITIONS FOR THE CONFINED AQUIFER UNDER PUMPING CONDITIONS NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY RET / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-15 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove
SITE-1.apr - LAYOUT: FIGURE 4-15
DATE: 2/12/02 BY: CM

Conclusions Formed at the End of the Water-Level Study (prior to the installation of the Phase II Wells)

The long-term water-level study confirmed that the groundwater in the area of the Privet Road Compound exists under both unconfined and confined aquifer conditions. Under non-pumping conditions, the hydraulic head within the confined aquifer is higher and the vertical gradient between the two aquifers is oriented upward. Under pumping conditions, the hydraulic head of the confined aquifer within the vicinity of the compound (at locations 01MW02, 01MW04, and 01MW05) is eventually lowered to a level below the hydraulic head of the unconfined aquifer, which reverses the hydraulic gradient and may induce groundwater flow into the confined aquifer. This reversal of vertical hydraulic gradient does not occur downgradient (northwest) of the compound.

Groundwater flow within both the unconfined and confined aquifers is generally to the northwest under non-pumping conditions. The Privet Road Compound lies hydraulically downgradient from the supply wells, and the Air Force Washrack area lies downgradient of both the supply wells and the compound. Under pumping conditions, drawdown cones from both supply wells expand along strike and capture the groundwater from beneath the compound proper (refer to Figures 4-12 through 4-15). A stagnation line develops along the northwestern boundary of the compound, indicating that groundwater from the Washrack area is neither induced to flow to the compound area nor is it captured by the supply wells.

The primary objective of the long-term water-level study was to determine where additional hydrogeological data were needed and thus identify where additional monitoring wells should be placed. The hydrogeological interpretations discussed above were constrained by a relative lack of data, particularly in the area of the compound proper (four monitoring wells in the unconfined aquifer, three monitoring wells in the confined aquifer). In particular, data gaps existed for both aquifers along the northern border of the compound (where well PRW-1 was destroyed in the northwestern corner and no wells existed in the northeastern corner) and for the confined aquifer in the southwestern corner of the compound (at 01MW03).

4.4.2 Monitoring Well Installation and Rationale

Seven additional monitoring wells were installed to further delineate the nature and horizontal and vertical extent of groundwater contamination and to provide the additional hydraulic head data needed to refine the hydrogeologic interpretation of the site. The locations of the new monitoring wells were determined by the data gaps evident in the updated conceptual site model, which was revised to reflect the interpretations of the long-term water-level study.

A new monitoring well cluster (01MW01) was installed at the location of former monitoring well PRW-1 in the northwestern corner of the compound. This well could not be located and is assumed to have been

destroyed. Based upon available information, PRW-1 was a shallow well that was most likely screened across both the overburden and the shallow bedrock zones. New monitoring wells were installed to monitor the unconfined (01MW01S) and confined (01MW01I) bedrock aquifers. A second monitoring well (01MW01SO) was installed within the shallow bedrock borehole to monitor the saturated overburden; it was believed that two hydraulically isolated wells within the borehole would provide more useful information than one well screened across both aquifers, as had existed previously.

A new monitoring well cluster (01MW08) was installed at the northeastern corner of the Privet Road Compound to provide analytical and hydrogeological data at a location where none had been previously available. This cluster is located between the compound and supply well NW-1. Monitoring wells were installed to monitor the unconfined (01MW01S) and confined (01MW01I) bedrock aquifers and the overburden (01MW01SO). The overburden was dry at the time of well installation, which occurred during a particularly dry summer. The overburden well may yield groundwater samples during times of normal precipitation.

An intermediate monitoring well (01MW03I) was installed near existing monitoring well 01MW03S in order to complete this well cluster and to obtain groundwater quality and hydraulic head data from the confined zone at this location.

4.4.3 Groundwater Occurrence and Flow Characteristics

The occurrence and distribution of groundwater within the bedrock were similar to those typically reported for aquifers within the Triassic Basin. During drilling, the bulk of the groundwater entered the boreholes through discrete water-entry zones. Subsequent analyses of the drilling logs, borehole video tape (when present), and borehole geophysical logs revealed that the discrete water-entry zones were either bedding-plane partings at lithologic contacts or fractures within a relatively homogeneous lithologic unit. Typically, both types of water-entry zones were present within any particular borehole. The primary porosity of the various lithologic units (particularly the sandstones) most likely contributed some groundwater to each borehole, but the volume or yield could not be quantified due to the low volume of groundwater entering the borehole through the primary pore spaces relative to the volume of groundwater entering through the secondary openings.

The USGS performed borehole geophysical logging, hydraulic tests, and straddle-packer sampling of the two deep supply wells (USGS, 2001) and concluded that the wells penetrate a complex, heterogeneous, multi-aquifer system. The USGS tests indicate that well no. 1 is a more productive well than well no. 2, because the specific capacities of the total open boreholes were calculated as 10 gpm/foot for well no. 1 and as 3 gpm/foot for well no. 2. Individual (fracture or fracture zone) specific capacities in well no. 1 ranged

from 0.26 to 5.7 gpm/foot, and in well no. 2 ranged from 0.09 to 2.9 gpm/foot. There was no relation between specific capacity and the subsurface depth of the fractures in either well. Stratigraphically, the water-bearing fractures were not typically located within common lithologic units between the wells, and the same lithologic units were found to typically have different hydraulic characteristics in each well.

Groundwater Flow Directions

Groundwater flow directions at the Privet Road Compound were recalculated from new rounds of static water-level elevations performed after the installation of the Phase II monitoring wells. Two additional rounds of static water-level elevations were conducted for this investigation. These data are included in Table 4-3.

Both rounds of static water elevation measurements that include the new monitoring wells were taken under, and represent response to, pumping conditions. The results of the long-term water-level study indicated that the greatest uncertainty in groundwater flow conditions was associated with times of aquifer stress, or well pumping, and also indicated that the interpretation of the groundwater flow regime under non-pumping conditions was fairly straightforward, even with the lesser number of data points available at that time. Therefore, the groundwater flow patterns for non-pumping conditions that were defined by the previous water-level study are believed to be correct and consistent with the patterns that would have been depicted with the additional monitoring well data, had another round of water levels been obtained under the non-pumping scenario. This conclusion is supported by the subsequent interpretation of regional groundwater flow performed by the USGS (USGS, 2001) that similarly depicts a northwestward direction of groundwater flow in the vicinity of Site 1.

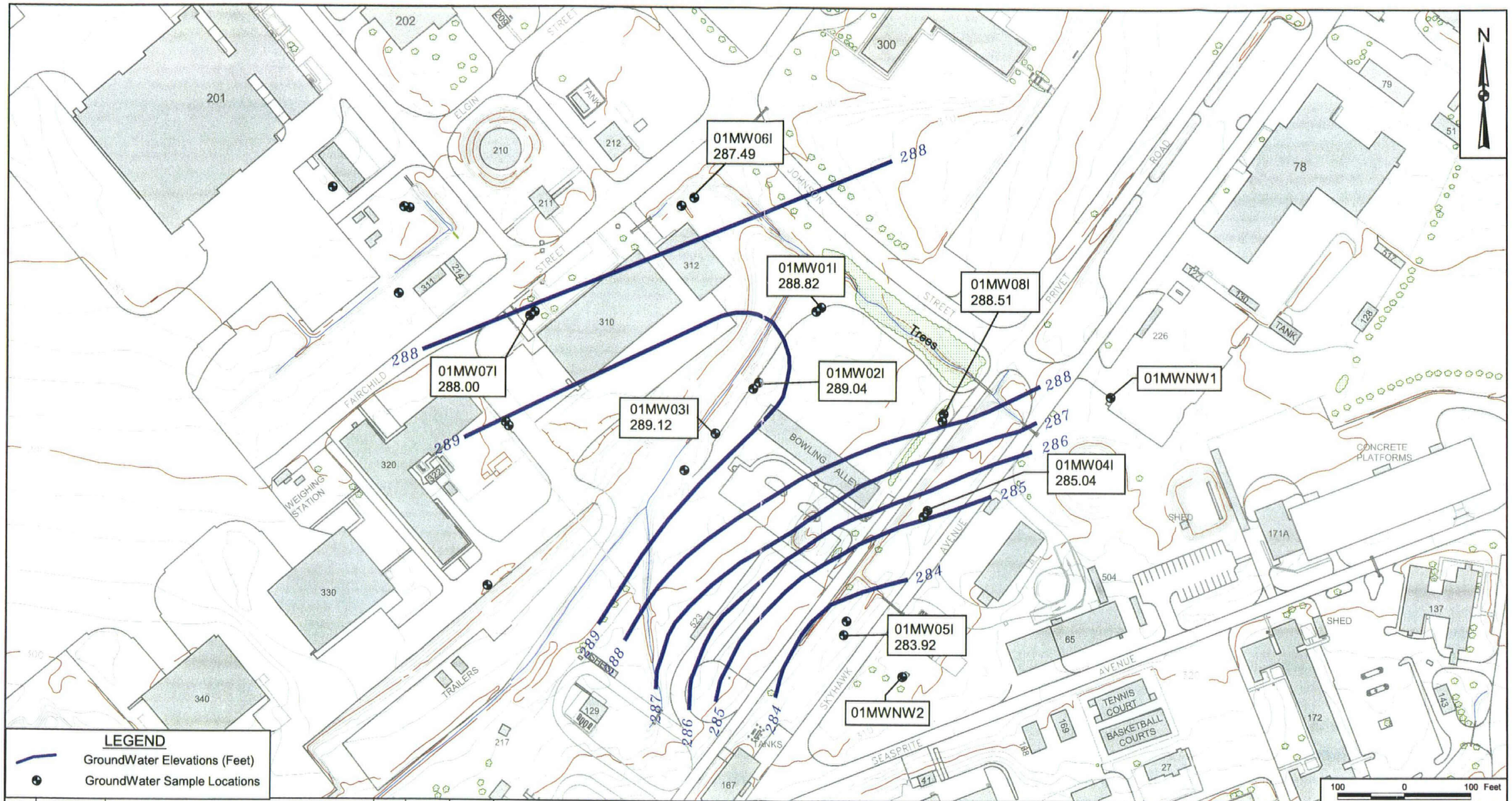
The revised interpretation of groundwater flow in the confined zone under pumping conditions is presented in Figures 4-16 and 4-17. With the additional data supplied by the new monitoring wells, the pumping of the two Navy supply wells is interpreted to create a large, laterally extensive drawdown cone formed by the overlapping of the two individual cones, rather than the two individual, non-overlapping drawdown cones that were originally mapped. Either interpretation results in the same conclusion, however, that groundwater from beneath the Privet Road compound can be drawn into the supply wells under pumping conditions. The position of the stagnation line, or the interpretation of the wells' capture zone, has not changed significantly under the revised interpretation and still borders the northwestern border of the compound. The revised interpretation therefore also confirms the original observation that groundwater from the downgradient Air Force Washrack area cannot be drawn into the Navy supply wells.

TABLE 4-3

SITE 1 STATIC-WATER-LEVEL MEASUREMENTS
PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE, PENNSYLVANIA

Well Number	TOC Elevation	Date and Time of Measurement	Depth to Water (feet below TOC[1])	Groundwater Elevation	Date and Time of Measurement	Depth to Water (feet below TOC[1])	Groundwater Elevation
01MW01SO	304.73	07/02/97 1146	15.23	289.50	08/07/97 1706	16.06	288.67
01MW01S	304.8	07/02/97 1148	15.35	289.45	08/07/97 1704	16.14	288.66
01MW01I	304.49	07/02/97 1150	15.67	288.82	08/07/97 1703	16.39	288.10
01MW02S	303.108	07/02/97 1154	13.44	289.67	08/07/97 1658	14.23	288.88
01MW02I	302.748	07/02/97 1156	13.71	289.04	08/07/97 1659	14.43	288.32
01MW03S	302.598	07/02/97 1200	12.94	289.66	08/07/97 1652	13.75	288.85
01MW03I	302.8	07/02/97 1203	13.68	289.12	08/07/97 1654	14.40	288.40
01MW04S	312.428	07/02/97 1203	23.84	288.59	08/07/97 1635	23.62	288.81
01MW04I	312.348	07/02/97 1206	27.31	285.04	08/07/97 1633	26.49	285.86
01MW05S	311.688	07/02/97 1156	22.97	288.72	08/07/97 1640	22.82	288.87
01MW05I	312.108	07/02/97 1159	28.19	283.92	08/07/97 1639	27.43	284.68
01MW06S	297.148	07/02/97 1146	9.13	288.02	08/07/97 1627	8.71	288.44
01MW06I	296.928	07/02/97 1143	9.44	287.49	08/07/97 1625	9.05	287.88
01MW07S	297.378	07/02/97 1152	9.33	288.05	08/07/97 1619	8.87	288.51
01MW07I	296.278	07/02/97 1150	8.28	288.00	08/07/97 1620	7.90	288.38
01MW08SO	309.87	07/02/97 1208	NA	NA	08/07/97 1647	NA	NA
01MW08S	309.89	07/02/97 1210	20.39	289.50	08/07/97 1646	21.19	288.70
01MW08I	309.69	07/02/97 1213	21.18	288.51	08/07/97 1644	21.86	287.83
01MWWW1	290.29				08/07/97 1605	5.53	284.76
01MWWW1B	290.19				08/07/97 1603	4.33	285.86
01MWWW2	290.79				08/07/97 1614	7.75	283.04
01MWWW3	293.38				08/07/97 1609	7.98	285.40

NOTES: [1] TOC = Top of casing.
NA= Not applicable (well 01MW08SO is a "dry well").
Wells 01MWWW1, 01MWWW1B, 01MWWW2, and 01MWWW3 not measured July 2, 1997.



LEGEND

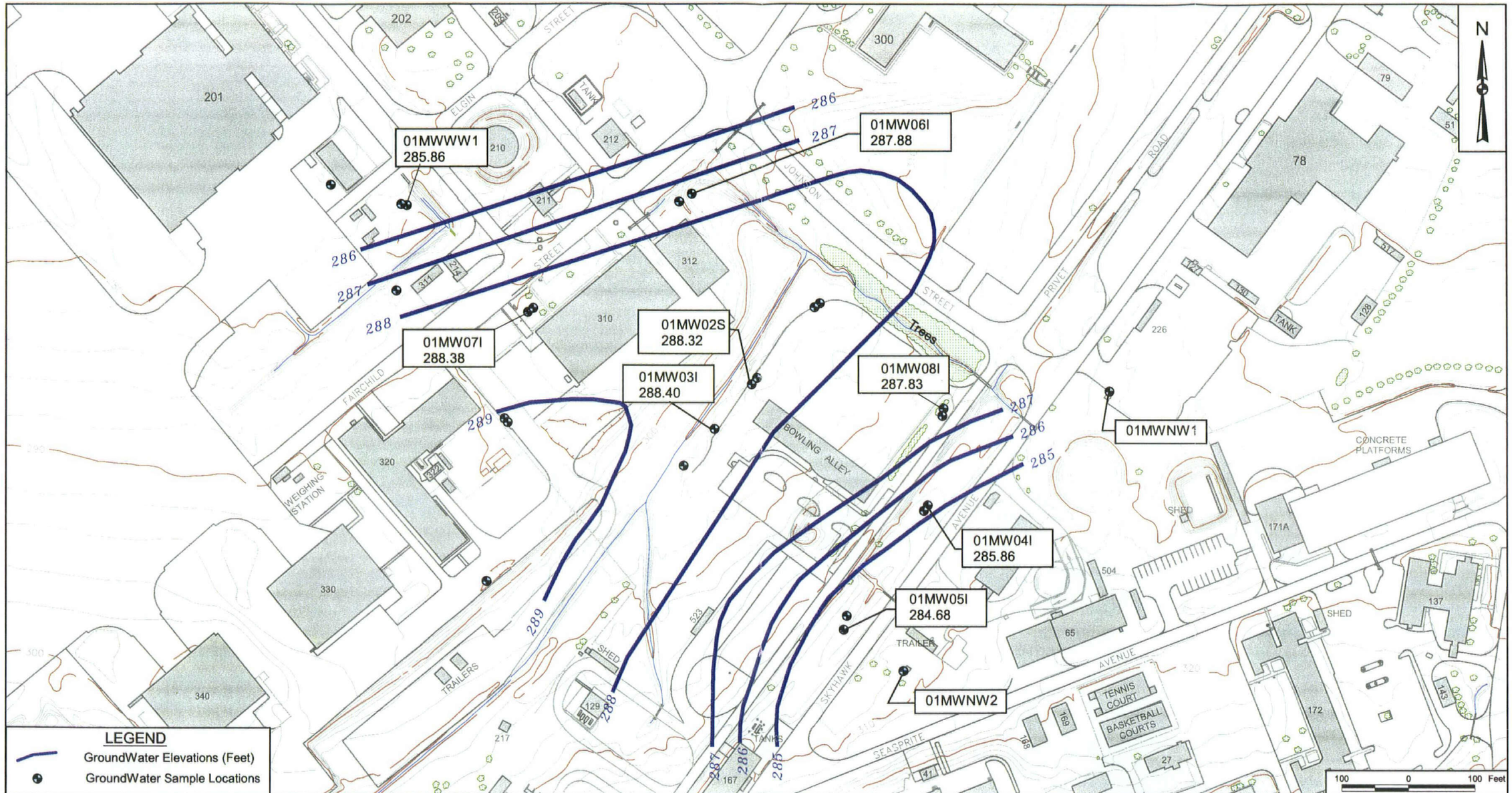
GroundWater Elevations (Feet)

GroundWater Sample Locations

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM	DATE 2/27/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/27/02	HYDRAULIC HEAD ELEVATIONS JULY 2, 1997 (CONFINED AQUIFER) NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY RET / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-16 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1.apr - LAYOUT: FIGURE 4-16
DATE: 2/12/02 BY: CM



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/27/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/27/02	HYDRAULIC HEAD ELEVATIONS AUGUST 7, 1997 (CONFINED AQUIFER) NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-17 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1.apr - LAYOUT: FIGURE 4-17
DATE: 2/12/02 BY: CM

The revised interpretation of groundwater flow in the unconfined zone under pumping conditions is presented in Figures 4-18 and 4-19. The horizontal hydraulic gradient was very low during each measuring round. These data indicate that, unlike in the long-term water-level study, the groundwater flow directions in the unconfined aquifer are affected by the pumping of the supply wells. A cone of depression has formed in the unconfined aquifer, and some shallow groundwater from beneath the Privet Road Compound is drawn back toward the supply wells.

A pair of hydrogeologic cross-sections were constructed to further investigate the subsurface conditions and to evaluate the vertical components of groundwater flow under pumping and non-pumping conditions (Figures 4-20 and 4-21). The cross-section depicting pumping conditions was constructed with hydraulic head data collected during the August 1997 round of water-level measurements. The cross-section depicting non-pumping conditions was constructed with hydraulic head data collected by the Air Force in January 1998, for their Washrack investigation. These data were selected because they contain hydraulic head values from additional monitoring wells installed by the Air Force subsequent to the Phase II fieldwork performed by the Navy (the locations of these wells are illustrated in Figure 4-2).

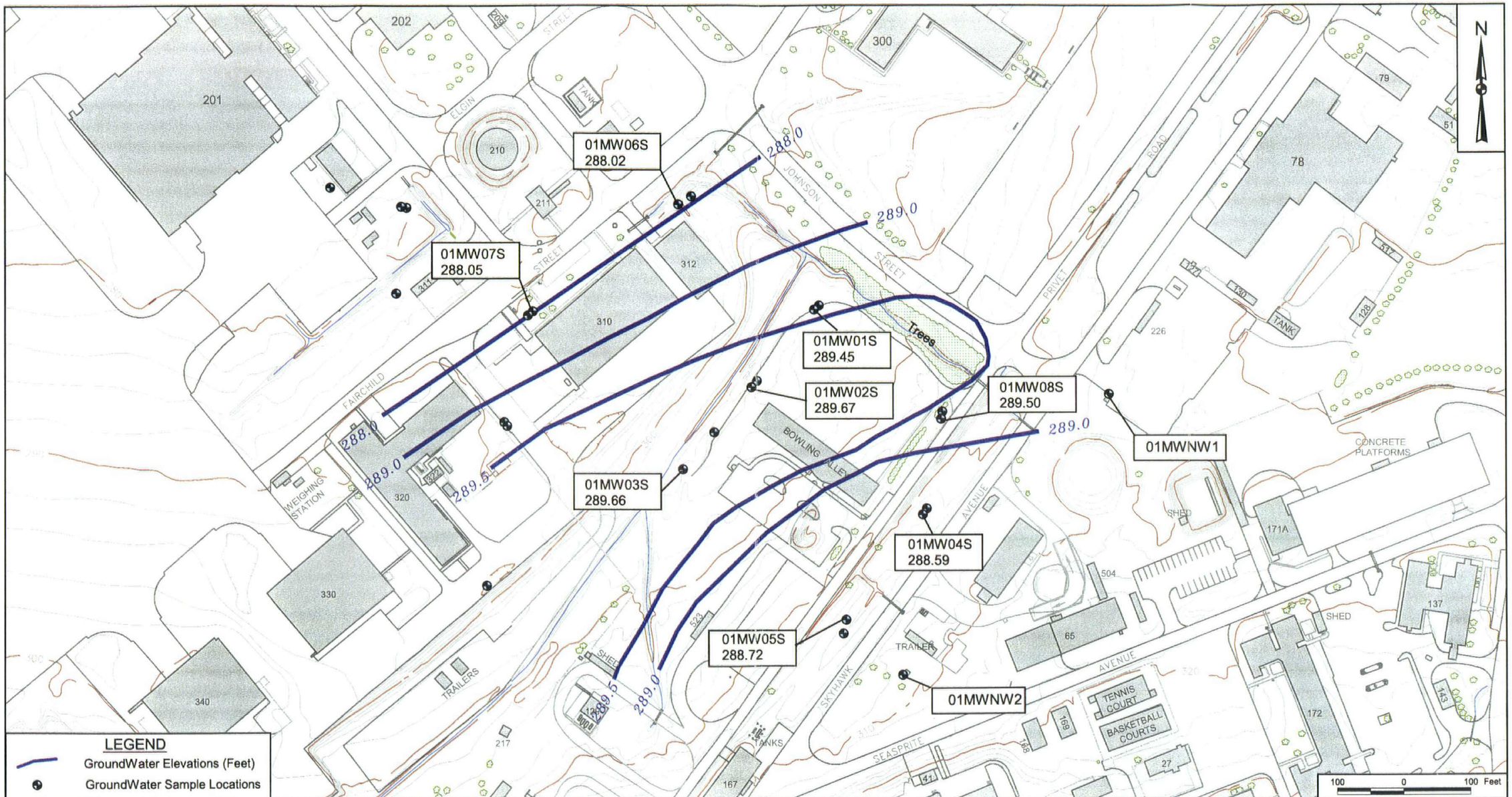
The hydrogeologic cross-sections indicate that the transition from semi-confined to confined conditions occurs between subsurface depths of approximately 40 to 70 feet. The confined conditions do not appear to be a result of a single, laterally extensive aquiclude or aquitard, because there is no relation or correlation between the transition zone and any particular lithologic unit or the structural dip of the strata. Rather, it is believed that the confined conditions are created (at least in part) by the weathering and resultant lower permeability of the shallower, fine-grained units. In this respect, and combined with the irregular distribution of the major water-bearing units within the supply wells as determined by the USGS, the conceptual site model for the Privet Road Site closely resembles the leaky, multi-unit aquifer system (LMAS) interpretation of the Triassic Basin defined by Michalski (1990) and Michalski and Britton (1997).

4.5 NATURE AND EXTENT OF CONTAMINATION

This section evaluates all sampling data from the 1991 Phase I RI and the 1997 Phase II RI. Details of the samples collected (number of samples, location, sample identifier) during each phase are presented. Data were compared to ARARs and TBCs and background as detailed in Section 2.2.

4.5.1 Surface Soil

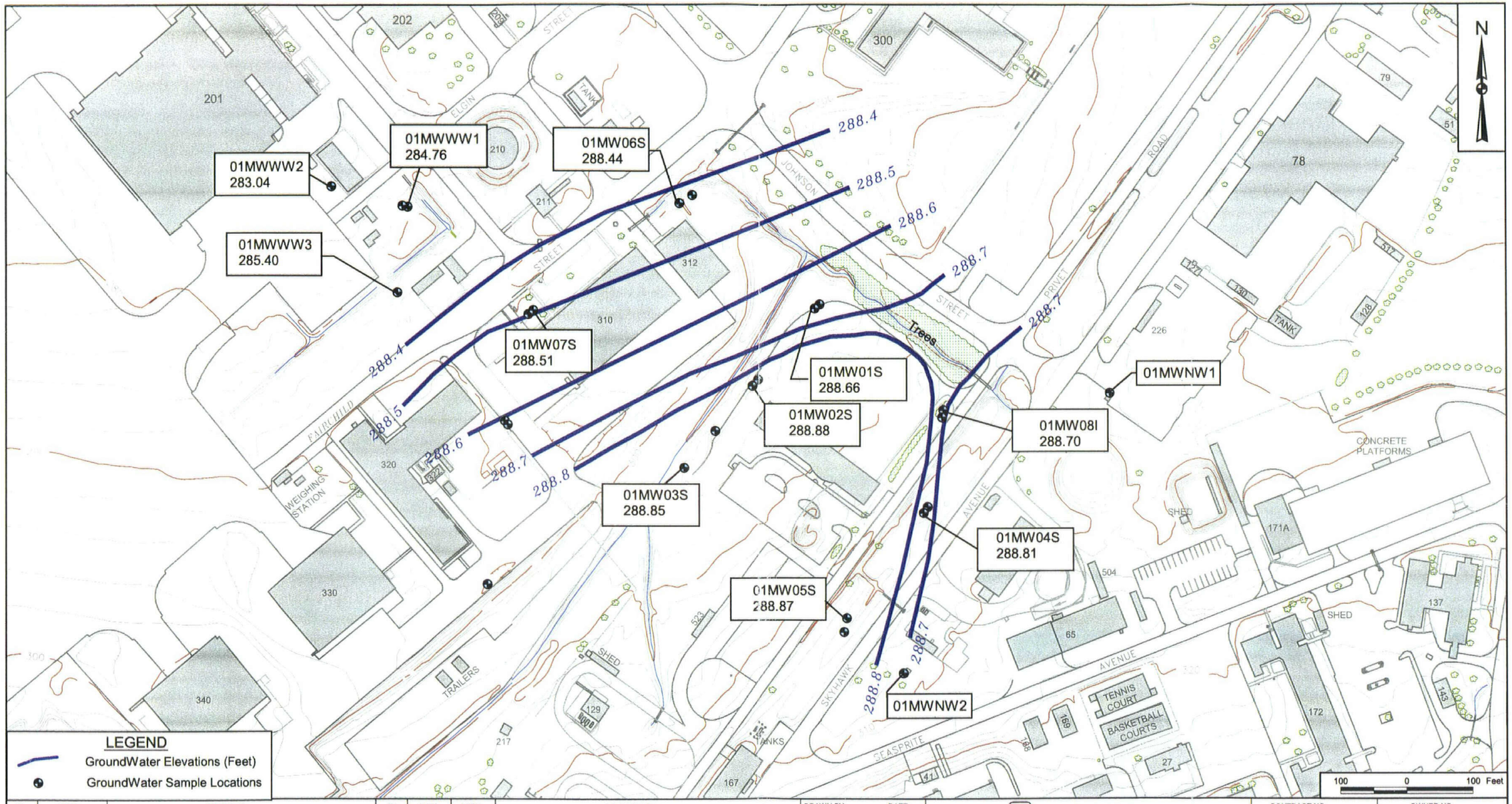
During Phase I RI sampling (1991), 16 soil borings were completed at Site 1. The soil samples taken during the 1991 soil boring program, designated as 0 to 2 feet, are believed to have been obtained from the first 6 inches of soil and for that reason are being considered surface soil for nature and extent and



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/27/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/27/02	HYDRAULIC HEAD ELEVATIONS JULY 2, 1997 (UNCONFINED AQUIFER) NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-18 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1.apr - LAYOUT: FIGURE 4-18
DATE: 2/12/02 BY: CM



LEGEND

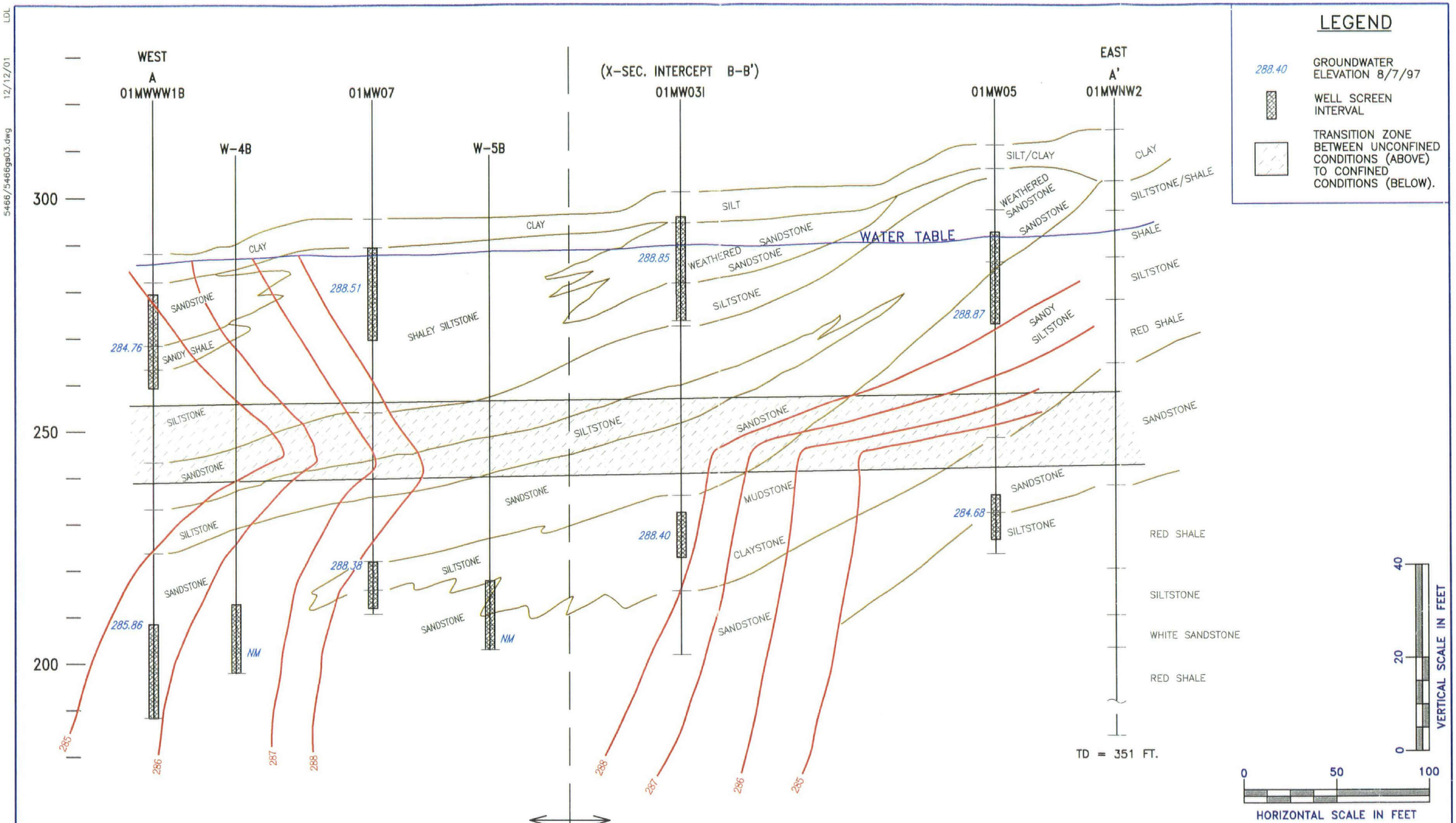
GroundWater Elevations (Feet)

GroundWater Sample Locations

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/27/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/27/02	HYDRAULIC HEAD ELEVATIONS AUGUST 7, 1997 (UNCONFINED AQUIFER) NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-19 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1.apr - LAYOUT: FIGURE 4-19
DATE: 2/12/02 BY: CM



LEGEND

288.40 GROUNDWATER ELEVATION 8/7/97

WELL SCREEN INTERVAL

TRANSITION ZONE BETWEEN UNCONFINED CONDITIONS (ABOVE) TO CONFINED CONDITIONS (BELOW).

DRAWN BY LDL DATE 1/25/02	Tetra Tech NUS, Inc.	CROSS--SECTION A–A'	CONTRACT NO. 5466
CHECKED BY DATE		SITE 1 – PRIVET ROAD COMPOUND	OWNER NO. 2007
REVISED BY DATE		PUMPING CONDITIONS: SUPPLY WELLS OFF	APPROVED BY DATE
SCALE AS NOTED		NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DRAWING NO. FIGURE 4–21 REV.

LDL 12/12/01 5466/5466ga03.dwg

5466ga03.dwg

risk assessment applications. During Phase I activities, 13 surface soil samples were collected from boring locations 01SB03, 01SB04, 01SB06 through 01SB13, and 01SB15 through 01SB17. The depth identifier for these samples in Table 4-4 is -0002 (i.e., the surface soil sample from 01SB03 is identified as 01SB03-0002). These samples were analyzed for TAL inorganics, TCL VOCs, and TCL pesticide/PCBs.

During the Phase II RI field activities (1997), samples from 28 surface soil locations (01SS19 through 01SS26 and 01SS28 through 01SS47) were collected to determine contaminants of concern. One sample, 01SS37, was submitted for TCL PCB analysis. Three samples, 01SS19, 01SS20, and 01SS24, were submitted for dioxin/dibenzofuran analysis, and samples 01SS24 through 01SS26 were submitted for TCL SVOCs. Fifty samples for PCB immunoassay analysis (field test kits) were obtained from locations 01SS19 through 01SS24 and 01SS28 through 01SS47 (two samples at depths of 0 to 6 inches and 0.5 to 2 feet at each location). PCB immunoassay results were obtained primarily to assist in the delineation of the known PCB "hot spot" at Site 1 and were used to estimate volume for PCB-contaminated soil removal (see Figure 4-22A for the approximate location of the PCB-contaminated soil removal performed in 1992). PCB field screening results are discussed in Section 4.5.1.3 of this nature and extent evaluation.

Table 4-4 presents a comparison of detected compounds to ARARs and TBCs. Table 4-5 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related surface soil samples and compares them to background. Table 4-6 presents the results of the background tests performed. Figures 4-22A, 4-22B, 4-22C, and 4-22D show sample locations and concentrations of compounds that exceed ARARs and TBCs.

4.5.1.1 Inorganics

Inorganic analysis was performed during Phase I RI activities only. Three metals not detected in background samples were detected in Site 1 surface soil samples. Cadmium was detected at five locations at levels ranging from 1.6 to 5.8 mg/kg; mercury was detected at five locations at levels ranging from 0.14 to 0.36 mg/kg; and silver was detected once, at 01SB07-0002, at 3 mg/kg. Metals exceeding background levels, but not reference criteria, in on-site samples include aluminum, barium, cobalt, copper, lead, vanadium, and zinc.

Two inorganics exceeded reference criteria. Arsenic exceeded reference criteria in all background and site samples; however, on-site levels of arsenic are considered statistically greater than background. Iron exceeded reference criteria in 10 of the 13 surface soil samples. Background iron levels were below reference criteria.

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB03-0002	01SB03-0002	01SB04-0002	01SB04-0002	01SB06-0002	ARARS & TBCs			
LOCATION:	01SB03	01SB03	01SB04	01SB04	01SB06	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	08/30/91	08/31/91	08/30/91	08/31/91	08/30/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	17300	n/a	15000	n/a	14900	78000	1000000	-	-
antimony	R	n/a	R	n/a	R	31.0	820	30.0	400
arsenic	7.7 E	n/a	6.1 E	n/a	5.9 E	0.430	3.80	3.00	4.00
barium	129	n/a	94.2	n/a	98.4	5500	140000	5000	70000
beryllium	1.1 B	n/a	1 B	n/a	1.1 B	0.150	1.30	1.00	1.30
calcium	6400	n/a	1990	n/a	4960	-	-	-	-
chromium, total	23.7	n/a	22.8	n/a	21.5	390	10000	-	-
cobalt	9.2	n/a	9.7	n/a	8.1	4700	120000	-	-
copper	26.8	n/a	19.3	n/a	24.8	3100	82000	700	37000
iron	21400	n/a	19100	n/a	19900	23000	610000	-	-
lead	49.4 L	n/a	64.7 J	n/a	44.8 L	400	-	500	1000
magnesium	3570	n/a	2310	n/a	3300	-	-	-	-
manganese	867	n/a	573	n/a	536	1800	47000	-	-
mercury	0.18 K	n/a	0.14 K	n/a	0.09 U	23.0	610	20.0	300
nickel	14.9	n/a	12.3	n/a	13.8	1600	41000	200	20000
potassium	787	n/a	779	n/a	1170	-	-	-	-
selenium	R	n/a	R	n/a	R	390	10000	60.0	5000
sodium	704	n/a	508	n/a	695	-	-	-	-
thallium	0.23 UJ	n/a	0.38 J	n/a	0.27 J	6.30	160	6.00	80.0
vanadium	35.6	n/a	30.6	n/a	32.3	550	14000	-	-
zinc	66.5	n/a	65.6	n/a	72.3	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	n/a	5 B	n/a	11 U	n/a	7800000	200000000	8000000	100000000
methylene chloride	n/a	6 U	n/a	4 B	n/a	85000	760000	600000	800000
toluene	n/a	6 U	n/a	2 B	n/a	16000000	410000000	16000000	200000000

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB03-0002	01SB03-0002	01SB04-0002	01SB04-0002	01SB06-0002	ARARS & TBCs			
LOCATION:	01SB03	01SB03	01SB04	01SB04	01SB06	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	08/30/91	08/31/91	08/30/91	08/31/91	08/30/91				
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	n/a	230000 E J	n/a	3700 E	n/a	319	2860	5000	-
PCBs (tot. all)	n/a	230000 E	n/a	3700 E	n/a	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Slt 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB06-0002	01SB07-0002	01SB07-0002	01SB08-0002	01SB08-0002	ARARS & TBCs			
LOCATION:	01SB06	01SB07	01SB07	01SB08	01SB08	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	08/31/91	08/28/91	08/29/91	08/28/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	13100	n/a	17700	n/a	78000	1000000	-	-
antimony	n/a	R	n/a	R	n/a	31.0	820	30.0	400
arsenic	n/a	5.7 E	n/a	6.7 E	n/a	0.430	3.80	3.00	4.00
barium	n/a	90.4	n/a	69 K	n/a	5500	140000	5000	70000
beryllium	n/a	1.2 B	n/a	1.1 B	n/a	0.150	1.30	1.00	1.30
cadmium	n/a	1.6	n/a	0.85 UL	n/a	39.0	1000	20.0	500
calcium	n/a	2130	n/a	10000	n/a	-	-	-	-
chromium, total	n/a	24.2	n/a	32.2	n/a	390	10000	-	-
cobalt	n/a	8.1	n/a	10.2	n/a	4700	120000	-	-
copper	n/a	35.5	n/a	23.3	n/a	3100	82000	700	37000
iron	n/a	18600	n/a	27900 E	n/a	23000	610000	-	-
lead	n/a	59.8 K	n/a	52.9 K	n/a	400	-	500	1000
magnesium	n/a	2300	n/a	5950	n/a	-	-	-	-
manganese	n/a	436	n/a	379 L	n/a	1800	47000	-	-
mercury	n/a	0.36	n/a	0.1 U	n/a	23.0	610	20.0	300
nickel	n/a	14.1	n/a	16.3	n/a	1600	41000	200	20000
potassium	n/a	725	n/a	2140	n/a	-	-	-	-
selenium	n/a	R	n/a	R	n/a	390	10000	60.0	5000
silver	n/a	3	n/a	1.5 U	n/a	390	10000	-	-
sodium	n/a	628	n/a	775 K	n/a	-	-	-	-
thallium	n/a	0.21 UJ	n/a	0.44 B	n/a	6.30	160	6.00	80.0
vanadium	n/a	28.8	n/a	45.1 K	n/a	550	14000	-	-
zinc	n/a	87.4	n/a	179	n/a	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	6 U	n/a	1 B	n/a	1 B	2700000	72000000	7000000	90000000
acetone	12 U	n/a	7 J	n/a	7 J	7800000	200000000	8000000	100000000
chloroform	6 U	n/a	5 U	n/a	1 J	100000	940000	700000	900000
methylene chloride	1 B	n/a	4 B	n/a	3 B	85000	760000	600000	800000

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB06-0002	01SB07-0002	01SB07-0002	01SB08-0002	01SB08-0002	ARARS & TBCs			
LOCATION:	01SB06	01SB07	01SB07	01SB08	01SB08	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	08/31/91	08/28/91	08/29/91	08/28/91	08/29/91				
VOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
toluene	1 B	n/a	5 U	n/a	5 U	16000000	410000000	16000000	200000000
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Aroclor-1260	7200 E	n/a	7100 E	n/a	1500 E	319	2860	5000	-
PCBs (tot. all)	7200 E	n/a	7100 E	n/a	1500 E	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB09-0002	01SB09-0002	01SB10-0002	01SB10-0002	01SB11-0002	ARARS & TBCs			
LOCATION:	01SB09	01SB09	01SB10	01SB10	01SB11	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	08/28/91	08/29/91	08/28/91	08/29/91	08/28/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	19400	n/a	19700	n/a	9470	78000	1000000	-	-
antimony	7.4 U	n/a	6.2 U	n/a	R	31.0	820	30.0	400
arsenic	6.1 E	n/a	5.6 E	n/a	16.2 E	0.430	3.80	3.00	4.00
barium	65.3	n/a	77.2	n/a	79	5500	140000	5000	70000
beryllium	1.2 B	n/a	1.2 B	n/a	1.3 B	0.150	1.30	1.00	1.30
cadmium	0.92 U	n/a	0.78 U	n/a	5.8	39.0	1000	20.0	500
calcium	5330	n/a	1210	n/a	7450	-	-	-	-
chromium, total	32.4	n/a	29.4	n/a	34.5	390	10000	-	-
cobalt	7.4	n/a	6.6	n/a	8	4700	120000	-	-
copper	18.2	n/a	13.4	n/a	39.3	3100	82000	700	37000
iron	30800 E	n/a	26100 E	n/a	20200	23000	610000	-	-
lead	12.7	n/a	10.3	n/a	149 K	400	-	500	1000
magnesium	3360	n/a	2450	n/a	3900	-	-	-	-
manganese	228	n/a	167	n/a	330	1800	47000	-	-
mercury	0.1 U	n/a	0.11 U	n/a	0.23	23.0	610	20.0	300
nickel	13.6	n/a	13.4	n/a	16	1600	41000	200	20000
potassium	1150	n/a	709	n/a	992	-	-	-	-
selenium	0.81 U	n/a	0.94 U	n/a	R	390	10000	60.0	5000
sodium	760	n/a	812	n/a	724	-	-	-	-
thallium	0.16 U	n/a	0.26	n/a	0.22 B	6.30	160	6.00	80.0
vanadium	44.6	n/a	39.9	n/a	27.2	550	14000	-	-
zinc	42.3	n/a	41	n/a	200	23000	610000	-	-
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
dieldrin	n/a	18 U	n/a	77 E	n/a	40.0	360	300	400

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB11-0002	01SB12-0002	01SB12-0002	01SB13-0002	01SB15-0002	ARARS & TBCs			
LOCATION:	01SB11	01SB12	01SB12	01SB13	01SB15	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	08/29/91	08/28/91	08/29/91	08/28/91	08/28/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	15100	n/a	17900	16000	78000	1000000	-	-
antimony	n/a	R	n/a	7.6 U	7.4 U	31.0	820	30.0	400
arsenic	n/a	7.1 E	n/a	2 E	11 E	0.430	3.80	3.00	4.00
barium	n/a	92.6 K	n/a	59.4	116	5500	140000	5000	70000
beryllium	n/a	1.3 B	n/a	0.71 B	1.2 B	0.150	1.30	1.00	1.30
cadmium	n/a	1.7 L	n/a	0.95 U	0.93 U	39.0	1000	20.0	500
calcium	n/a	7490	n/a	991	7870	-	-	-	-
chromium, total	n/a	30.4	n/a	28.2	29.2	390	10000	-	-
cobalt	n/a	12.1	n/a	6.6	10.6	4700	120000	-	-
copper	n/a	44	n/a	12.8	34	3100	82000	700	37000
iron	n/a	24600 E	n/a	29000 E	24800 E	23000	610000	-	-
lead	n/a	65.7 K	n/a	9.2	115	400	-	500	1000
magnesium	n/a	5150	n/a	2400	5400	-	-	-	-
manganese	n/a	434 L	n/a	166	622	1800	47000	-	-
mercury	n/a	0.09 U	n/a	0.1 U	0.17	23.0	610	20.0	300
nickel	n/a	17.1	n/a	12.3	16.7	1600	41000	200	20000
potassium	n/a	1760	n/a	638	1630	-	-	-	-
selenium	n/a	R	n/a	1.2 U	1.1 U	390	10000	60.0	5000
sodium	n/a	899 K	n/a	728	801	-	-	-	-
thallium	n/a	0.43 B	n/a	0.25	0.22 U	6.30	160	6.00	80.0
vanadium	n/a	36 K	n/a	42.4	41	550	14000	-	-
zinc	n/a	137	n/a	39.1	95.8	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	6 U	n/a	6 U	2 B	n/a	2700000	72000000	7000000	90000000
acetone	4 J	n/a	11 U	11 U	n/a	7800000	200000000	8000000	100000000
methylene chloride	6 U	n/a	6 U	7 B	n/a	85000	760000	600000	800000

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB11-0002	01SB12-0002	01SB12-0002	01SB13-0002	01SB15-0002	ARARS & TBCs			
LOCATION:	01SB11	01SB12	01SB12	01SB13	01SB15	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	08/29/91	08/28/91	08/29/91	08/28/91	08/28/91				
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	1100 E J	n/a	920 E	200 U	n/a	319	2860	5000	-
PCBs (tot. all)	1100 E	n/a	920 E	98 U	n/a	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB15-0002	01SB16-0002	01SB17-0002	01SS19	01SS20	ARARS & TBCs			
LOCATION:	01SB15	01SB16	01SB17	01SS19	01SS20	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	08/29/91	08/29/91	08/29/91	04/16/97	04/16/97				
INORGANICS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
aluminum	n/a	18000	22000	n/a	n/a	78000	1000000	-	-
arsenic	n/a	4.7 E	7 E	n/a	n/a	0.430	3.80	3.00	4.00
barium	n/a	97.3	77.6	n/a	n/a	5500	140000	5000	70000
beryllium	n/a	1 B	0.92 B	n/a	n/a	0.150	1.30	1.00	1.30
cadmium	n/a	2.5	1.8	n/a	n/a	39.0	1000	20.0	500
calcium	n/a	13700	3120	n/a	n/a	-	-	-	-
chromium, total	n/a	37.2	30.9	n/a	n/a	390	10000	-	-
cobalt	n/a	12.2	9.2	n/a	n/a	4700	120000	-	-
copper	n/a	25.2	16.2	n/a	n/a	3100	82000	700	37000
iron	n/a	28200 E	33300 E	n/a	n/a	23000	610000	-	-
lead	n/a	14.8	15.1	n/a	n/a	400	-	500	1000
magnesium	n/a	10600	3770	n/a	n/a	-	-	-	-
manganese	n/a	765	267	n/a	n/a	1800	47000	-	-
nickel	n/a	19.6	16.9	n/a	n/a	1600	41000	200	20000
potassium	n/a	1230	1130	n/a	n/a	-	-	-	-
sodium	n/a	949	978	n/a	n/a	-	-	-	-
thallium	n/a	0.26	0.45	n/a	n/a	6.30	160	6.00	80.0
vanadium	n/a	46.9	47.8	n/a	n/a	550	14000	-	-
zinc	n/a	91.7	52.4	n/a	n/a	23000	610000	-	-
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Aroclor-1260	2800 E	180 U	190 U	n/a	n/a	319	2860	5000	-
PCBs (immunoassay)	n/a	n/a	n/a	10000 E	8100 E	319	2860	5000	-
PCBs (tot. all)	2800 E	90 U	95 U	10000 E	8100 E	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SS21	01SS22	01SS23	01SS24	01SS24	ARARS & TBCs			
LOCATION:	01SS21	01SS22	01SS23	01SS24	01SS24	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/16/97	04/16/97	04/16/97	04/16/97	04/22/97				
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
benzo(a)anthracene	n/a	n/a	n/a	n/a	35 J	880	7800	6000	8000
benzo(a)pyrene	n/a	n/a	n/a	n/a	40 J	88.0	780	600	800
bis(2-ethylhexyl)phthalate	n/a	n/a	n/a	n/a	110 B	46000	410000	300000	400000
chrysen	n/a	n/a	n/a	n/a	52 J	88000	780000	600000	800000
fluoranthene	n/a	n/a	n/a	n/a	62 J	3100000	82000000	3000000	40000000
pyrene	n/a	n/a	n/a	n/a	59 J	2300000	61000000	2000000	30000000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	21000 E	6400 E	25000 E L	15400 E	n/a	319	2860	5000	-
PCBs (tot. all)	21000 E	6400 E	25000 E L	15400 E	n/a	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SS24-DUP	01SS25	01SS26	01SS28	01SS29	ARARS & TBCs			
LOCATION:	01SS24	01SS25	01SS26	01SS28	01SS29	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	04/22/97	04/22/97	04/22/97	05/05/97	05/05/97				
SEMIVOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
1,2,4-trichlorobenzene	360 U	120 J	400 U	n/a	n/a	780000	20000000	800000	10000000
2-methylnaphthalene	360 U	130 J	400 U	n/a	n/a	-	-	-	-
acenaphthene	360 U	66 J	400 U	n/a	n/a	4700000	120000000	5000000	60000000
anthracene	360 U	250 J	400 U	n/a	n/a	23000000	610000000	23000000	300000000
benzo(a)anthracene	27 J	1300 E	250 J	n/a	n/a	880	7800	6000	8000
benzo(a)pyrene	32 J	1200 E	280 E J	n/a	n/a	88.0	780	600	800
benzo(b)fluoranthene	360 U	1500 E	440	n/a	n/a	880	7800	6000	8000
benzo(g,h,i)perylene	360 U	960 J	140 J	n/a	n/a	-	-	-	-
benzo(k)fluoranthene	360 U	770 J	260 J	n/a	n/a	8800	78000	60000	80000
bis(2-ethylhexyl)phthalate	140 B	480 B	610 B	n/a	n/a	46000	410000	300000	400000
butylbenzylphthalate	360 U	220 J	270 J	n/a	n/a	16000000	410000000	16000000	200000000
chrys ne	42 J	1400	390 J	n/a	n/a	88000	780000	600000	800000
di-n-butylphthalate	360 U	110 J	91 J	n/a	n/a	7800000	200000000	-	-
dibenz(a,h)anthracene	360 U	290 E J	43 J	n/a	n/a	88.0	780	600	800
fluoranthene	44 J	1800	570	n/a	n/a	3100000	82000000	3000000	40000000
fluorene	360 U	65 J	400 U	n/a	n/a	3100000	82000000	3000000	40000000
indeno(1,2,3-cd)pyrene	360 U	1100 E J	160 J	n/a	n/a	880	7800	6000	8000
naphthalene	360 U	92 J	400 U	n/a	n/a	3100000	82000000	3000000	40000000
phenanthrene	360 U	1100	370 J	n/a	n/a	-	-	-	-
pyrene	42 J	2500	600	n/a	n/a	2300000	61000000	2000000	30000000
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PCBs (immunoassay)	n/a	n/a	n/a	25000 E L	20000 E	319	2860	5000	-
PCBs (tot. all)	n/a	n/a	n/a	25000 E L	20000 E	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SS30	01SS31	01SS32	01SS33	01SS34	ARARS & TBCs			
LOCATION:	01SS30	01SS31	01SS32	01SS33	01SS34	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	05/05/97	05/05/97	05/05/97	05/05/97	06/03/97				
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	16000 E	23000 E	500 U	3900 E	25000 E L	319	2860	5000	-
PCBs (tot. all)	16000 E	23000 E	500 U	3900 E	25000 E L	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SS35	01SS36	01SS37	01SS38	01SS39	ARARS & TBCs			
LOCATION:	01SS35	01SS36	01SS37	01SS38	01SS39	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	06/03/97	06/04/97	06/04/97	06/04/97	06/04/97				
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	n/a	n/a	6700 E	n/a	n/a	319	2860	5000	-
PCBs (immunoassay)	1000 E	25000 E L	25000 E L	25000 E L	25000 E L	319	2860	5000	-
PCBs (tot. all)	1000 E	25000 E L	6700 E	25000 E L	25000 E L	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SS40	01SS41	01SS42	01SS43	01SS44	ARARS & TBCs			
LOCATION:	01SS40	01SS41	01SS42	01SS43	01SS44	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil				
SAMPLE DATE:	06/25/97	06/25/97	06/25/97	07/01/97	07/01/97				
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PCBs (immunoassay)	2300 E	1700 E	1000 E	6400 E	3900 E	319	2860	5000	-
PCBs (tot. all)	2300 E	1700 E	1000 E	6400 E	3900 E	319	2860	5000	-

TABLE 4-4

COMPARISON OF SURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SS45	01SS46	01SS47	---	---	ARARS & TBCs			
LOCATION:	01SS45	01SS46	01SS47	---	---	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Surface Soil	Surface Soil	Surface Soil						
SAMPLE DATE:	07/01/97	07/10/97	07/10/97						
PESTICIDES	ug/kg	ug/kg	ug/kg			ug/kg	ug/kg	ug/kg	ug/kg
PCBs (immunoassay)	18000 E	8100 E	8100 E			319	2860	5000	-
PCBs (tot. all)	18000 E	8100 E	8100 E			319	2860	5000	-

F tnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).

UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.

UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.

No Value - Constituent was not analyzed for in this sample.

UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.

J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.

L - Value is considered biased low because of exceedance of data validation quality control criteria.

K - Value is considered biased high because of exceedance of data validation quality control criteria.

R - Positive result is considered rejected based on exceedance of data validation quality control criteria.

E - Result exceeds one or more of the selected ARARs.

Footnotes to PADEP Criteria:

MSC - Medium-Specific Concentration.

Table 4-5
Occurrence and Distribution of Organics and In rganics in Surface S ils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative C ncentrati n
arsenic	12/12	3.7	10.6	6.61	04/07/97 BGSS03	13/13	2	16.2	7.06	01SB11-0002 08/28/91	9.52
barium	12/12	77.8	111	96	04/07/97 BGSS04	13/13	59.4	129	88.1	01SB03-0002 08/30/91	99.4
cadmium	0/12	-			NA	5/13	1.6	5.8	1.3	01SB11-0002 08/28/91	2.55
calcium	12/12	614	1600	1020	04/07/97 BGSS12	13/13	991	13700	5590	01SB16-0002 08/29/91	7450
chromium	12/12	12.4	20.8	15.4	04/07/97 BGSS02	13/13	21.5	37.2	29	01SB16-0002 08/29/91	31.3
cobalt	12/12	6.8	9.3	7.9	04/07/97 BGSS02	13/13	6.6	12.2	9.08	01SB16-0002 08/29/91	10.1
copper	12/12	8	13.4	10.7	04/07/97 BGSS09	13/13	12.8	44	25.6	01SB12-0002 08/28/91	32.5
iron	12/12	12800	17600	14900	04/07/97 BGSS06	13/13	18600	33300	24900	01SB17-0002 08/29/91	27300
lead	12/12	16.3	64.7	31	04/07/97 BGSS04	13/13	9.2	149	51	01SB11-0002 08/28/91	117
magnesium	12/12	1300	1940	1510	04/07/97 BGSS06	13/13	2300	10600	4190	01SB16-0002 08/29/91	5450
manganese	12/12	429	1190	641	04/07/97 BGSS04	13/13	166	867	444	01SB03-0002 08/30/91	634
mercury	0/12	-			NA	5/13	0.14	0.36	0.114	01SB07-0002 08/28/91	0.191
nickel	12/12	7.4	11.2	9.78	04/07/97 BGSS04	13/13	12.3	19.6	15.2	01SB16-0002 08/29/91	16.3
potassium	7/12	436	771	434	04/07/97 BGSS05	13/13	638	2140	1140	01SB08-0002 08/28/91	1420
silver	0/12	-			NA	1/13	3	3	0.931	01SB07-0002 08/28/91	1.13
sodium	2/12	112	120	63.9	04/07/97 BGSS09	13/13	508	978	766	01SB17-0002 08/29/91	830
thallium	7/12	0.25	0.34	0.226	04/07/97 BGSS07	6/10	0.25	0.45	0.228	01SB17-0002 08/29/91	0.3
vanadium	12/12	20.9	28.2	25	04/07/97 BGSS02	13/13	27.2	47.8	38.3	01SB17-0002 08/29/91	41.8
zinc	12/12	21.7	597	90.5	04/07/97 BGSS04	13/13	39.1	200	90	01SB11-0002 08/28/91	126
1,2,3,4,6,7,8-HPCDD	0/0	-				6/6	0.0647	0.136	0.108	01SS24 04/15/97	0.13
1,2,3,4,6,7,8-HPCDF	0/0	-				6/6	0.0048	0.321	0.134	01SB19-0002 04/15/97	0.236
1,2,3,4,7,8,9-HPCDF	0/0	-				5/6	0.0063	0.19	0.0737	01SB19-0002 04/15/97	0.19
1,2,3,4,7,8-HXCDD	0/0	-				4/6	0.0015	0.0021	0.00144	01SS19 04/15/97	0.0019
1,2,3,4,7,8-HXCDF	0/0	-				6/6	0.0026	0.374	0.148	01SB19-0002 04/15/97	0.374
1,2,3,6,7,8-HXCDD	0/0	-				5/6	0.0017	0.0051	0.00309	01SS20 04/15/97	0.00505
1,2,3,6,7,8-HXCDF	0/0	-				5/6	0.0017	0.0248	0.0101	01SB19-0002 04/15/97	0.0179
1,2,3,7,8,9-HXCDD	0/0	-				6/6	0.0027	0.0129	0.00553	01SB24-0002 04/15/97	0.0109

Tabl 4-5
Occurrence and Distribution f Organics and Inorganics in Surface Soils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative C ncentration
1,2,3,7,8,9-HXCDF	0/0	-				3/6	0.00055	0.009	0.00298	01SB19-0002 04/15/97	0.009
1,2,3,7,8-PECDF	0/0	-				4/6	0.003	0.0049	0.00273	01SB19-0002 04/15/97	0.00431
2,3,4,6,7,8-HXCDF	0/0	-				6/6	0.0011	0.0136	0.007	01SB19-0002 04/15/97	0.011
2,3,4,7,8-PECDF	0/0	-				5/6	0.0023	0.0142	0.00736	01SB19-0002 04/15/97	0.0116
2,3,7,8-tetrachlorodibenzofuran	0/0	-				5/6	0.0015	0.0076	0.00435	01SS20 04/15/97	0.00677
octachlorodibenzo-p-dioxin	0/0	-				6/6	4.58	15.59	7.3	01SB24-0002 04/15/97	12.2
octachlorodibenzofuran	0/0	-				6/6	0.009	0.815	0.359	01SB19-0002 04/15/97	0.636
TOTAL HPCDD	0/0	-				6/6	0.162	0.289	0.236	01SS24 04/15/97	0.277
TOTAL HPCDF	0/0	-				6/6	0.0089	0.798	0.345	01SB19-0002 04/15/97	0.607
TOTAL HXCDD	0/0	-				6/6	0.0276	0.0522	0.0397	01SS20 04/15/97	0.0466
TOTAL HXCDF	0/0	-				6/6	0.0078	0.676	0.278	01SB19-0002 04/15/97	0.496
TOTAL PECDF	0/0	-				5/6	0.0272	0.315	0.141	01SB19-0002 04/15/97	0.24
total tetrachlorodibenzo-p-dioxi	0/0	-				3/6	0.0011	0.0045	0.00188	01SS19 04/15/97	0.0045
total tetrachlorodibenzofuran	0/0	-				6/6	0.0017	0.0688	0.0425	01SS20 04/15/97	0.0663
Aroclor-1260	0/12	-			NA	11/16	51	230000	26300	01SB03-0002 08/31/91	230000
dieldrin	9/12	13	760	179	04/07/97 BGSS03	1/13	77	77	56.5	01SB10-0002 08/29/91	77
pcbs (immunoassay)	0/0	-				46/51	550	25000	10700	01SS23 04/16/97	25000
pcbs (tot. all)	0/0	-				54/64	550	230000	14400	01SB03-0002 08/31/91	52700
1,2,4-trichlorobenzene	0/12	-			NA	1/6	120	120	184	01SS25 04/22/97	120
2-methylnaphthalene	0/12	-			NA	1/6	130	130	186	01SS25 04/22/97	130
acenaphthene	3/12	55	64	178	04/07/97 BGSS10	1/6	66	66	175	01SS25 04/22/97	66
anthracene	6/12	46	160	155	04/07/97 BGSS12	1/6	250	250	206	01SS25 04/22/97	225
benz(a)anthracene	9/12	33	940	307	04/07/97 BGSS12	3/6	35	1300	364	01SS25 04/22/97	1300
benzo(a)pyrene	8/12	110	1100	395	04/07/97 BGSS12	3/6	40	1200	353	01SS25 04/22/97	1200
benzo(b)fluoranthene	8/12	160	1500	508	04/07/97 BGSS12	2/6	440	1500	454	01SS25 04/22/97	1500
benzo(g,h,i)perylene	7/12	52	490	225	04/07/97 BGSS12	2/6	140	960	314	01SS25 04/22/97	808
benzo(k)fluoranthene	7/12	98	920	371	04/07/97 BGSS12	2/6	260	770	303	01SS25 04/22/97	589

Table 4-5
Occurrence and Distribution of Organics and In rganics in Surface S ils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
butylbenzylphthalate	3/12	83	280	209	04/07/97 BGSS02	2/6	220	270	213	01SS26 04/22/97	239
chrysene	9/12	43	1200	420	04/07/97 BGSS12	3/6	52	1400	407	01SS25 04/22/97	1400
di-n-butylphthalate	0/2	-			NA	2/6	91	110	164	01SS25 04/22/97	110
dibenz(a,h)anthracene	5/12	52	160	162	04/07/97 BGSS12	2/6	43	290	186	01SS25 04/22/97	252
fluoranthene	10/12	49	2600	903	04/07/97 BGSS12	3/6	62	1800	505	01SS25 04/22/97	1800
fluorene	4/12	59	160	185	04/07/97 BGSS08	1/6	65	65	175	01SS25 04/22/97	65
indeno(1,2,3-cd)pyrene	8/12	49	640	252	04/07/97 BGSS12	2/6	160	1100	341	01SS25 04/22/97	944
naphthalene	0/12	-			NA	1/6	92	92	180	01SS25 04/22/97	92
phenanthrene	8/12	110	1700	668	04/07/97 BGSS12	2/6	370	1100	376	01SS25 04/22/97	1000
pyrene	10/12	51	2100	723	04/07/97 BGSS12	3/6	59	2500	627	01SS25 04/22/97	2500
acetone	0/0	-				3/12	4	7	5.75	01SB07-0002 08/29/91	6.22
chloroform	0/0	-				1/13	1	1	2.81	01SB08-0002 08/29/91	1

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

Table 4-6
Background Comparison Tests - Surface Soil Data for Site 1
NASJRB Will w Gr ve, Pennsylvania

Name of Test: Question Posed:	Detection Freq: Z or Fisher Site Freq > Back Freq ?				95 % Upper Tolerance Limit (UTL) Site Maximum > UTL for Background Data ?							Upper Ranks Majority are site?				Mann-Whitney/Gehan Ranks of Site > Back?				Student's or Satterthwaite T-test Site Mean > Back. Mean ?					Bartlett's Test for Equal Standard Deviations Site Standard Deviation =Background Std Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN Substance	Back. Freq.	Site Freq.	P Value	YN	Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL	Site Max.	YN	r	k	P Value	YN	P Value	Test	Used	YN	Back. Mean@	Site Mean@	t Value	t Table	YN	Back. Distrib.	Site Distrib.	Std.Dev. Back.@	Std.Dev. Site@	F Value	F Table	YN
1,2,3,4,6,7,8-HPCDD NA	0/0	6/6		NA						0.136	NA				NA				NA		0.108			NA							NA
1,2,3,4,6,7,8-HPCDF NA	0/0	6/6		NA						0.321	NA				NA				NA		0.134			NA							NA
1,2,3,4,7,8,9-HPCDF NA	0/0	5/6		NA						0.19	NA				NA				NA		0.0737			NA							NA
1,2,3,4,7,8-HXCDD NA	0/0	4/6		NA						0.0021	NA				NA				NA		0.0014			NA							NA
1,2,3,4,7,8-HXCDF NA	0/0	6/6		NA						0.374	NA				NA				NA		0.148			NA							NA
1,2,3,6,7,8-HXCDD NA	0/0	5/6		NA						0.0051	NA				NA				NA		0.0031			NA							NA
1,2,3,6,7,8-HXCDF NA	0/0	5/6		NA						0.0248	NA				NA				NA		0.0101			NA							NA
1,2,3,7,8,9-HXCDD NA	0/0	6/6		NA						0.0129	NA				NA				NA		0.0055			NA							NA
1,2,3,7,8,9-HXCDF NA	0/0	3/6		NA						0.009	NA				NA				NA		0.003			NA							NA
1,2,3,7,8-PECDF NA	0/0	4/6		NA						0.0049	NA				NA				NA		0.0027			NA							NA
2,3,4,6,7,8-HXCDF NA	0/0	6/6		NA						0.0136	NA				NA				NA		0.007			NA							NA
2,3,4,7,8-PECDF NA	0/0	5/6		NA						0.0142	NA				NA				NA		0.0074			NA							NA
2,3,7,8-tetrachlorodibenzofur NA	0/0	5/6		NA						0.0076	NA				NA				NA		0.0044			NA							NA
octachlorodibenzo-p-dioxin NA	0/0	6/6		NA						15.59	NA				NA				NA		7.3			NA							NA
octachlorodibenzofuran NA	0/0	6/6		NA						0.815	NA				NA				NA		0.359			NA							NA
aluminum Y	12/12	13/13		NA	9.33	0.142	1.7959	L	14700	22000	Y	13	12	<.0001	Y	0.0002			Y	11400	16600			NA	lognor.	normal					NA
arsenic Y	12/12	13/13		NA	1.85	0.283	1.7959	L	10.8	16.2	Y	2	2	0.2600	N	0.5326			N	1.85	1.86	0.0227	1.7139	N	lognor.	lognor.	0.283	0.474	2.7770	3.8461	Y
barium Y	12/12	13/13		NA	4.56	0.129	1.7959	L	121	129	Y	2	2	0.2600	N	0.8996			N	4.56	4.46	-1.3697	1.7139	N	lognor.	lognor.	0.129	0.223	3.0480	3.8461	Y
cadmium Y	0/12	5/13	0.0242	Y						5.8	NA	5	5	0.0242	Y				NA		1.3			NA							NA
calcium Y	12/12	13/13		NA	6.88	0.329	1.7959	L	1790	13700	Y	11	11	<.0001	Y	0.0001			Y	1020	5590			NA	lognor.	normal					NA
chromium Y	12/12	13/13		NA	2.73	0.142	1.7959	L	20	37.2	Y	13	13	<.0001	Y	<.0001			Y	15.4	29			NA	lognor.	normal					NA
cobalt Y	12/12	13/13		NA	7.9	0.786	1.7959	N	9.37	12.2	Y	8	7	0.0202	Y	0.1003			N	2.06	2.19	1.9650	1.7396	Y	lognor.	lognor.	0.1	0.203	4.9700	3.8461	N
copper Y	12/12	13/13		NA	10.7	1.55	1.7959	N	13.6	44	Y	14	13	<.0001	Y	<.0001			Y	2.36	3.17	6.7975	1.7531	Y	lognor.	lognor.	0.147	0.399	9.3939	3.8461	N
iron Y	12/12	13/13		NA	9.6	0.111	1.7959	L	18200	33300	Y	13	13	<.0001	Y	<.0001			Y	14900	24900			NA	lognor.	normal					NA
lead Y	12/12	13/13		NA	3.34	0.433	1.7959	L	63.3	149	Y	10	8	0.0287	Y	0.2932			N	3.34	3.57	0.7844	1.7396	N	lognor.	lognor.	0.433	0.943	5.9941	3.8461	N
magnesium Y	12/12	13/13		NA	7.31	0.102	1.7959	L	1820	10600	Y	13	13	<.0001	Y	<.0001			Y	7.31	8.24	7.2174	1.7709	Y	lognor.	lognor.	0.102	0.448	18.004	3.8461	N
manganese N	12/12	13/13		NA	6.42	0.277	1.7959	L	1040	867	N	4	2	0.7348	N	0.9819			N	6.42	5.97	-2.6821	1.7341	N	lognor.	lognor.	0.277	0.539	4.4761	3.8461	N
mercury N	0/12	5/13	0.0242	Y						0.36	NA	4	4	0.0565	N				NA		0.114			NA							NA
nickel Y	12/12	13/13		NA	9.78	0.961	1.7959	N	11.6	19.6	Y	13	13	<.0001	Y	<.0001			Y	9.78	15.2			NA	normal	lognor.					NA
potassium Y	7/12	13/13	0.0149	Y	434					2140	NA	15	13	<.0001	Y	<.0001	Gehan	Test	Y	434	1140			NA	normal	lognor.					NA
silver N	0/12	1/13	0.5200	N						3	NA	1	1	0.5200	N				NA		0.931			NA							NA
sodium Y	2/12	13/13	<.0001	Y	63.9					978	NA	13	13	<.0001	Y	<.0001	Gehan	Test	Y	63.9	766			NA	nonpar.	normal					NA
thallium N	7/12	6/10	0.6393	N	0.226					0.45	NA	2	2	0.1948	N	0.8541	Gehan	Test	N	0.226	0.228			NA	nonpar.	normal					NA

Table 4-6
Background Comparis n Tests - Surface Soil Data for Site 1
NASJRB Will w Gr ve, Pennsylvania

Name of Test:		Detection Freq. Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:		Site Freq. > Back Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:		#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:		P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back?	YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance		Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
vanadium	Y	12/12	13/13		NA	25	2.1	1.7959	N	29	47.8	Y	12	12	<.0001	Y	<.0001			Y	25	38.3			NA	normal	normal					NA
zinc	Y	12/12	13/13		NA	90.5					200	NA	10	9	0.0027	Y	0.0207			Y	90.5	90			NA	nonpar.	lognor.					NA
Aroclor-1260	Y	0/12	11/16		NA						230000	NA	10	10	0.0006	Y				NA		26300			NA							NA
dieldrin	N	9/12	1/13		NA	179					77	NA				NA	0.9979	Gehan	Test	N	179	56.5			NA	lognor.	nonpar.					NA
pcbs (immunoassay)	NA	0/0	46/51		NA						25000	NA				NA				NA		10700			NA							NA
pcbs (tot. all)	NA	0/0	54/84		NA						230000	NA				NA				NA		14400			NA							NA
1,2,4-trichlorobenzene	N	0/12	1/6	0.3333	N						120	NA				NA				NA		184			NA							NA
2-methylnaphthalene	N	0/12	1/6	0.3333	N						130	NA				NA				NA		186			NA							NA
acenaphthene	N	3/12	1/6	0.8382	N	178					66	NA				NA	0.1814	Gehan	Test	N	178	175			NA	nonpar.	nonpar.					NA
anthracene	N	6/12	1/6	0.9751	N	155					250	NA	1	1	0.3333	N	0.3476	Gehan	Test	N	155	206			NA	normal	nonpar.					NA
benz(a)anthracene	N	9/12	3/6	0.9427	N	307					1300	NA	1	1	0.3333	N	0.7107	Gehan	Test	N	307	364			NA	lognor.	lognor.					NA
benzo(a)pyrene	N	8/12	3/6	0.8835	N	395					1200	NA	1	1	0.3333	N	0.7311	Gehan	Test	N	395	353			NA	lognor.	lognor.					NA
benzo(b)fluoranthene	N	8/12	2/6	0.9683	N	508					1500	NA	2	1	0.5686	N	0.8235	Gehan	Test	N	508	454			NA	lognor.	nonpar.					NA
benzo(g,h,i)perylene	N	7/12	2/6	0.9344	N	225					960	NA	1	1	0.3333	N	0.6988	Gehan	Test	N	225	314			NA	normal	nonpar.					NA
benzo(k)fluoranthene	N	7/12	2/6	0.9344	N	371					770	NA	3	1	0.7304	N	0.8122	Gehan	Test	N	371	303			NA	lognor.	nonpar.					NA
butylbenzylphthalate	N	3/12	2/6	0.5609	N	209					270	NA	3	2	0.2451	N	0.2990	Gehan	Test	N	209	213			NA	nonpar.	lognor.					NA
chrysene	N	9/12	3/6	0.9427	N	420					1400	NA	1	1	0.3333	N	0.7042	Gehan	Test	N	420	407			NA	lognor.	lognor.					NA
di-n-butylphthalate	N	0/2	2/6	0.5357	N						110	NA				NA				NA		164			NA							NA
dibenz(a,h)anthracene	N	5/12	2/6	0.8009	N	162					290	NA	1	1	0.3333	N	0.5029	Gehan	Test	N	162	186			NA	nonpar.	normal					NA
fluoranthene	N	10/12	3/6	0.9783	N	903					1800	NA	4	1	0.8382	N	0.8923	Gehan	Test	N	903	505			NA	lognor.	lognor.					NA
fluorene	N	4/12	1/6	0.9076	N	185					65	NA	2		1.0000	N	0.8922	Gehan	Test	N	185	175			NA	nonpar.	nonpar.					NA
indeno(1,2,3-cd)pyrene	N	8/12	2/6	0.9683	N	252					1100	NA	1	1	0.3333	N	0.7062	Gehan	Test	N	252	341			NA	lognor.	nonpar.					NA
naphthalene	N	0/12	1/6	0.3333	N						92	NA				NA				NA		180			NA							NA
phenanthrene	N	8/12	2/6	0.9683	N	668					1100	NA	4	1	0.8382	N	0.8288	Gehan	Test	N	668	376			NA	lognor.	nonpar.					NA
pyrene	N	10/12	3/6	0.9783	N	723					2500	NA	1	1	0.3333	N	0.8110	Gehan	Test	N	723	627			NA	lognor.	lognor.					NA
acetone	NA	0/0	3/12		NA						7	NA				NA				NA		5.75			NA							NA
chloroform	NA	0/0	1/13		NA						1	NA				NA				NA		2.81			NA							NA

Notes: Units are mg/kg for inorganics, ug/kg for organics.
A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.
For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:
(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.

Table 4-6
Background Comparison Tests - Surface Soil Data for Site 1
NASJRB Willow Grove, Pennsylvania

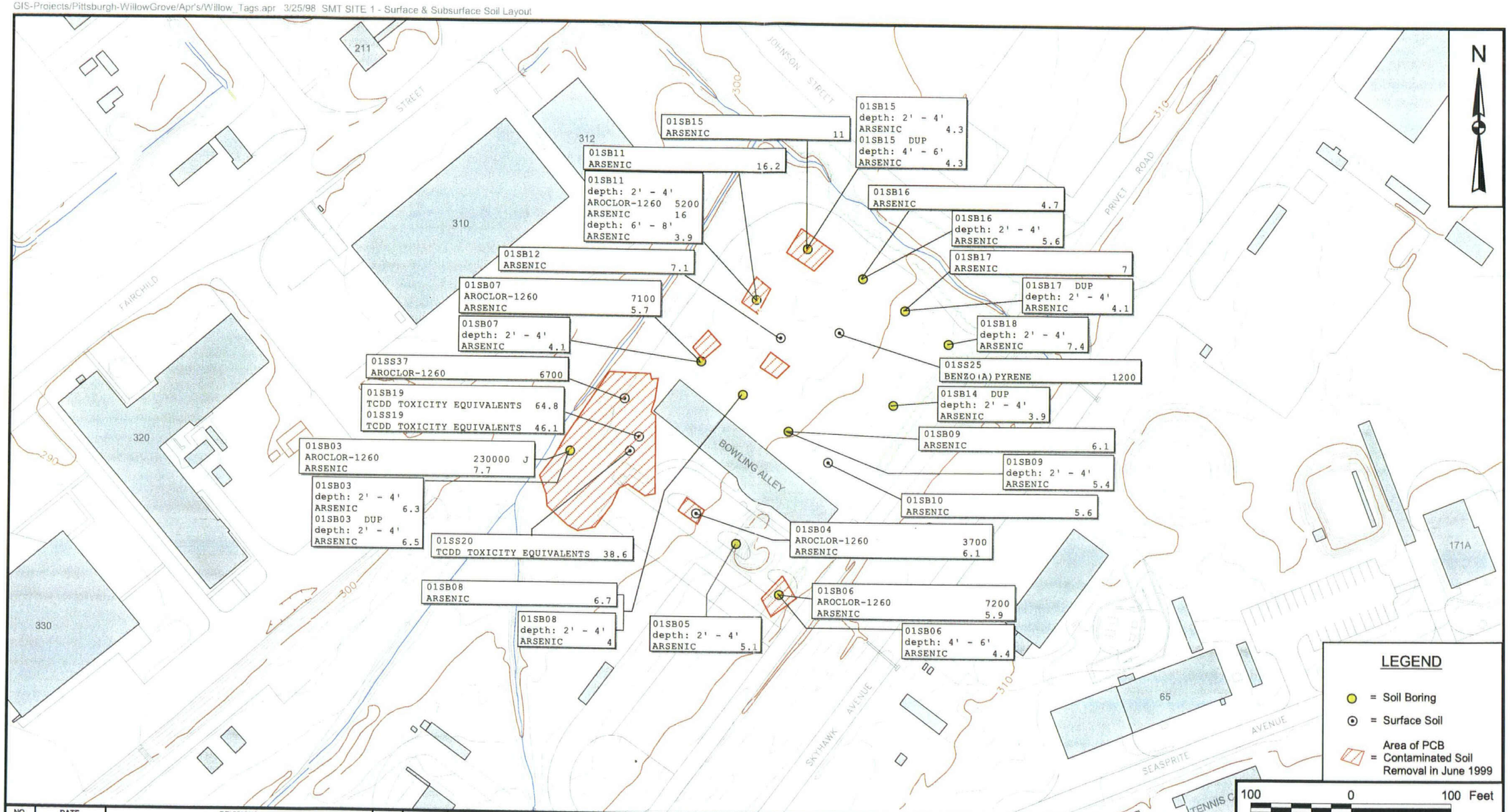
Name of Test: Question Posed	Detection Freq: Z or Fisher Site Freq > Back Freq.?				95 % Upper Tolerance Limit (UTL) Site Maximum > UTL for Background Data?							Upper Ranks Majority are site?				Mann-Whitney/Gehan: Ranks of Site > Back?				Student's or Satterthwaite T-test: Site Mean > Back. Mean ?					Bartlett's Test for Equal Standard Deviations: Site Standard Deviation = Background Std. Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	

(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.
(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.
(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

GIS-Projects/Pittsburgh-WillowGrove/Apr's/Willow_Tags.apr 3/25/98 SMT SITE 1 - Surface & Subsurface Soil Layout



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES
1	4/24/02	ROADS NAMES AND PCB CONTAMINATED AREAS ADDED.	LDL			

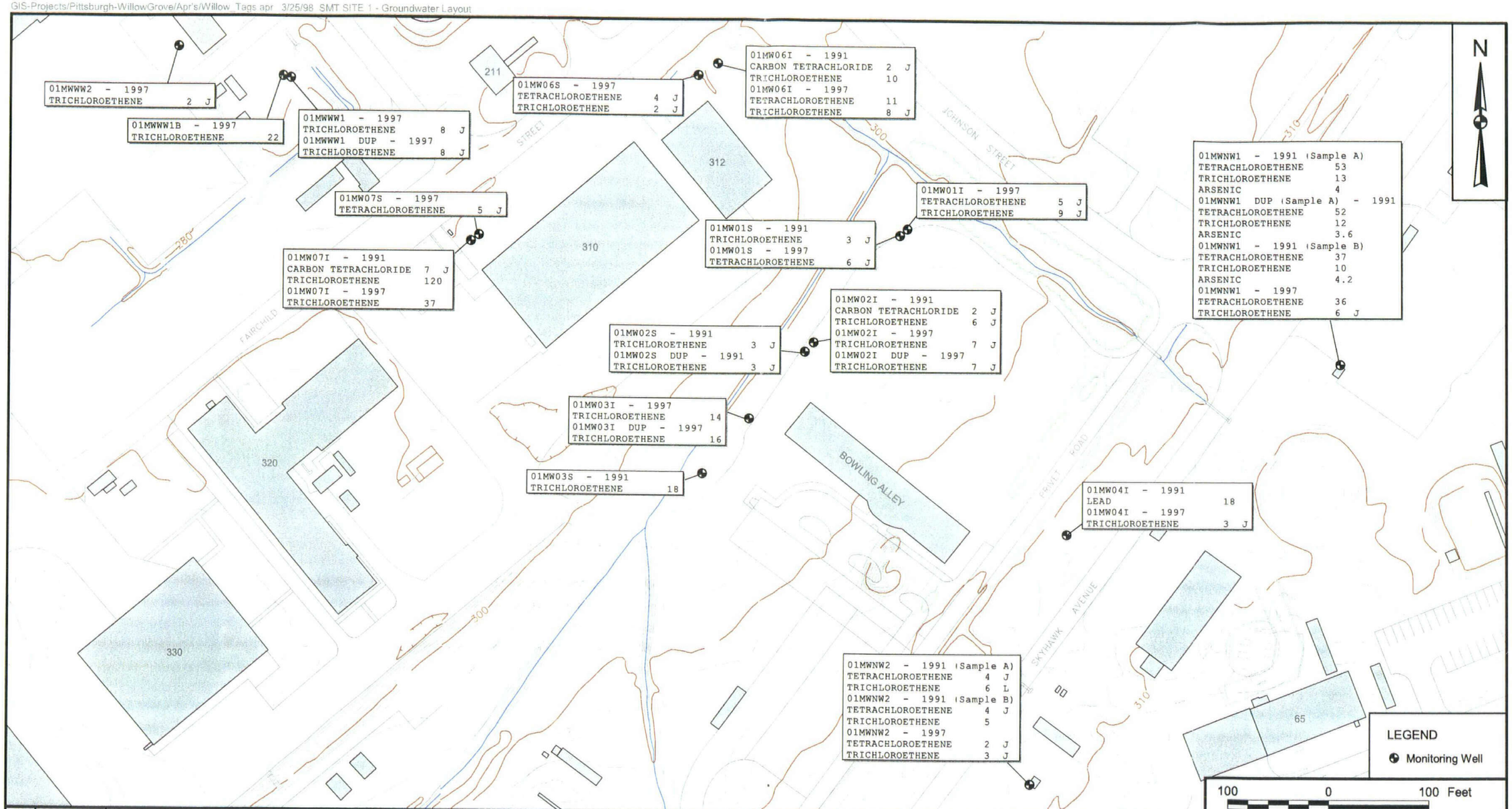
DRAWN BY S. TABLER DATE 3/25/98
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

CONCENTRATION ABOVE SCREENING LEVELS
HUMAN HEALTH RISK CRITERIA
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466
OWNER NUMBER
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-22A
REV 1

GIS-Projects/Pittsburgh-WillowGrove/Apr's/Willow_Tags apr 3/25/98 SMT SITE 1 - Groundwater Layout



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES
1	4/24/02	FIGURE NUMBER REVISED AND DRAWING UPDATED.	LDL			

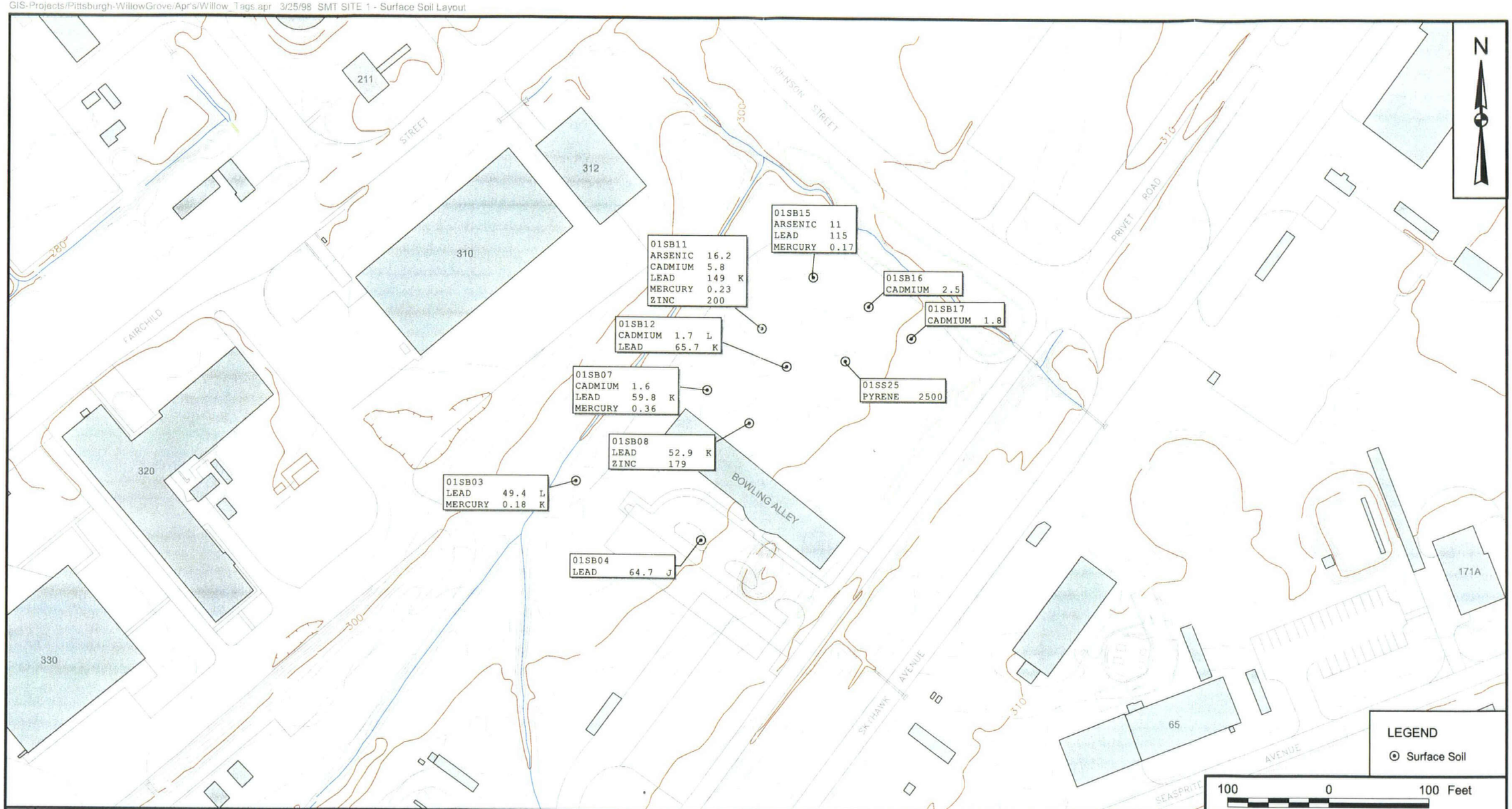
DRAWN BY S. TABLER DATE 3/25/98
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

CONCENTRATION ABOVE SCREENING LEVELS
HUMAN HEALTH RISK CRITERIA
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466
OWNER NUMBER 2207
APPROVED BY — DATE —
APPROVED BY — DATE —
DRAWING NO. FIGURE 4-22B
REV 1

GIS-Projects/Pittsburgh-WillowGrove/Apr's/Willow_Tags.apr 3/25/98 SMT SITE 1 - Surface Soil Layout



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES
1	4/24/02	DRAWING UPDATED.	LDL			

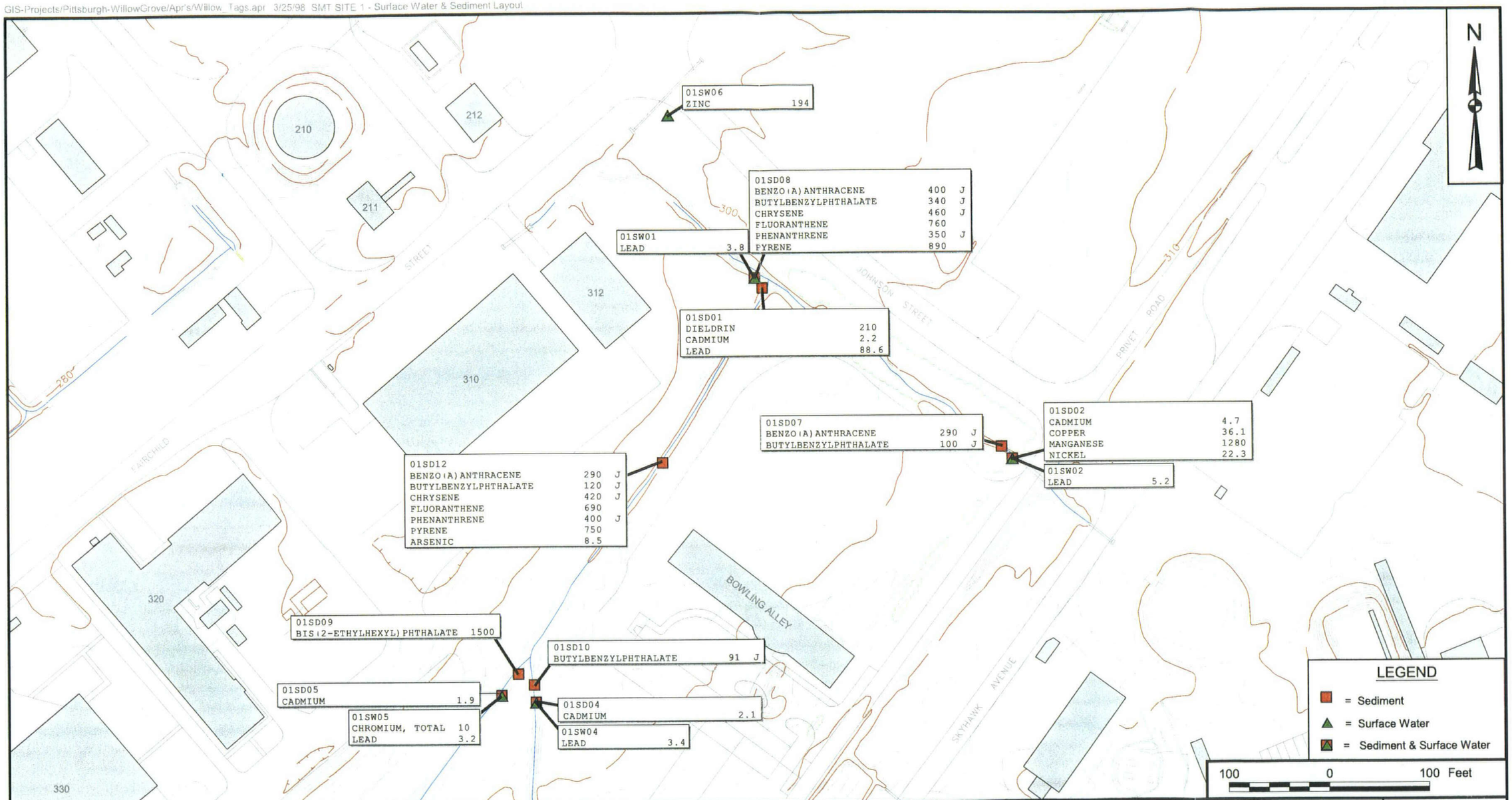
DRAWN BY S. TABLER DATE 3/25/98
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

CONCENTRATION ABOVE SCREENING LEVELS
ECOLOGICAL RISK CRITERIA
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466
OWNER NUMBER
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-22C
REV 1

GIS-Projects/Pittsburgh-WillowGrove/Apr's/Willow_Tags.apr 3/25/98 SMT SITE 1 - Surface Water & Sediment Layout



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES
1	4/26/02	FIGURE NUMBER REVISED AND DRAWING UPDATED.	LDL			

DRAWN BY S. TABLER DATE 3/25/98
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

CONCENTRATION ABOVE SCREENING LEVELS
ECOLOGICAL RISK CRITERIA
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466
OWNER NUMBER 2207
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4-22D
REV 1

4.5.1.2 Organics

VOC results showed the presence of two compounds not found in background samples. Chloroform was found in one sample (01SB08-0002) at 1 J ug/kg. Acetone was found in three samples (01SB07-0002, 01SB08-0002, and 01SB11-0002) at levels ranging from 4 J ug/kg to 7 J ug/kg. No other VOCs were detected.

One pesticide, dieldrin, was found at a level exceeding reference criteria in 01SB10-0002; however, this result was within background levels. Aroclor 1260 was detected in nine samples at levels ranging from 920 ug/kg to 230,000 ug/kg. The highest level was recorded at 01SB03-0002. Aroclor 1260 was not found in background samples. All PCB-contaminated soil above the state action level was removed in June 1999 (see Appendix D).

Two locations (01SS24 and 01SS25) showed several PAHs exceeding reference criteria; however, concentrations were generally within background levels. Two semivolatile compounds, 1,2,4-trichlorobenzene and 2-methylnaphthalene, were detected at 01SS25 at relatively low levels but were not detected in background samples.

Low levels of dibenzodioxin and dibenzofuran compounds were detected in Site 1 surface soil samples. No background samples were analyzed for these compounds. The three samples exceeded the most stringent reference criteria for total TCDD equivalents; however, the levels were below the PADEP non-residential soil direct contact standard at two locations and slightly above it for one location.

4.5.1.3 PCB Immunoassay Results

PCBs were detected in 46 of the 50 samples at levels ranging from 550 ug/kg to 25,000 ug/kg. These results exceed reference criteria; however, the analytical technique used is considered a field screening method that provides an approximation of concentrations detected. The method provides four ranges of results: (greater than 500 ug/kg but less than 3,000 ug/kg; greater than 3,000 ug/kg but less than 5,000 ug/kg; greater than 5,000 ug/kg but less than 22,000 ug/kg; and greater than 22,000 ug/kg. The results were used in planning for potential removal actions.

4.5.2 Subsurface Soils

During the 1991 RI, 54 subsurface samples were obtained at approximately 2-foot intervals from 16 locations (01SB03 through 01SB18). The samples designated as the 0- to 2-foot interval are considered

to be surface soil samples. Samples were analyzed for inorganics, VOCs, and pesticides/PCBs. Phase II RI activities included the collection of 67 samples at various depths from 28 borings (01SB19 through 01SB26 and 01SB28 through 01SB47). Phase II RI subsurface soil samples were analyzed for organic parameters only. During the Phase II investigation, in addition to PCB immunoassay sampling (see Section 4.5.1.3), six subsurface soil samples were submitted for TCL PCB laboratory confirmation analysis, 14 samples were submitted for TCL SVOC analysis, and two samples were submitted for dibenzodioxin/dibenzofuran analysis.

Table 4-7 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related subsurface soil samples and compares them to background. Table 4-8 presents results of the background comparison tests. Table 4-9 presents a comparison of detected compounds to ARARs and TBCs. Figures 4-22A through D show sample locations and concentrations of compounds that exceeded ARARs and TBCs.

4.5.2.1 Inorganics

Arsenic was detected at levels exceeding reference criteria in 41 of the 54 subsurface sampling locations. Iron, at levels exceeding reference criteria and greater than background levels, was found in 40 samples ranging from 23,100 mg/kg to 35,400 mg/kg. Iron was detected at all locations, with the exception of 01SB06, and was found at all depths in soil borings. Mercury was detected in one sample (01SB09-0204) at 0.11 mg/kg. Manganese was detected in two samples (01SB15-0810; 1,930 mg/kg and 01SB16-1012; 2,310 mg/kg) at levels above background and exceeding reference criteria. Both of these samples were taken at depths greater than 8 feet. Other metals detected above background but below regulatory criteria include aluminum, chromium, cobalt, copper, lead, nickel, and vanadium.

4.5.2.2 Organics

Aroclor 1260 was found in eight samples at levels above background before the soil removal in 1966. Also detected at levels below reference criteria, but not detected in background samples, were heptachlor (9.7 ug/kg at 01SB03-0204), carbon disulfide (1 J ug/kg at 01SB07-06075), and acetone in 11 samples at levels ranging from 4 J ug/kg to 21 ug/kg. Acetone was detected in samples from borings 01SB07, 01SB08, 01SB11, and 01SB12.

No SVOCs were detected and dioxin results indicated low concentrations. The three dioxin samples exceeded the most stringent reference criteria for total TCDD equivalents; however, the levels were below the PADEP non-residential soil direct contact standard at two locations and slightly above it for one location. These results correlate with the surface soil sampling; the 0- to 2-foot interval associated with

Table 4-7
Occurrence and Distribution of Organics and Inorganics in Subsurface S ils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative C ncentrati n
aluminum	12/12	9090	15000	11400	04/07/97 BGSS06	59/59	5910	24500	14800	01SB15-0204 08/28/91	16000
arsenic	12/12	3.7	10.6	6.61	04/07/97 BGSS03	45/59	0.9	16	2.44	01SB11-0204 08/28/91	5.29
barium	12/12	77.8	111	96	04/07/97 BGSS04	59/59	45.6	422	100	01SB16-1012 08/29/91	109
cadmium	0/12	-			NA	26/59	0.79	4.5	0.972	01SB11-0204 08/28/91	1.12
calcium	12/12	614	1600	1020	04/07/97 BGSS12	58/59	154	13100	1290	01SB07-0204 08/28/91	1400
chromium	12/12	12.4	20.8	15.4	04/07/97 BGSS02	59/59	10.6	33.7	24.1	01SB07-0204 08/28/91	25.5
cobalt	12/12	6.8	9.3	7.9	04/07/97 BGSS02	59/59	5.1	30.2	11.2	01SB16-1012 08/29/91	12.1
copper	12/12	8	13.4	10.7	04/07/97 BGSS09	58/59	4.1	39.2	15.8	01SB11-0204 08/28/91	18.5
cyanide	2/12	0.7	3.8	0.65	04/07/97 BGSS09	1/59	3.2	3.2	1.11	01SB13-1214 08/28/91	1.17
iron	12/12	12800	17600	14900	04/07/97 BGSS06	59/59	12900	35400	24300	01SB14-1012 08/29/91	25400
lead	12/12	16.3	64.7	31	04/07/97 BGSS04	59/59	1.9	164	10.7	01SB11-0204 08/28/91	11.1
magnesium	12/12	1300	1940	1510	04/07/97 BGSS06	59/59	261	7830	1890	01SB07-0204 08/28/91	2350
manganese	12/12	429	1190	641	04/07/97 BGSS04	59/59	70.3	2310	647	01SB16-1012 08/29/91	779
mercury	0/12	-			NA	2/59	0.11	0.24	0.0551	01SB11-0204 08/28/91	0.0574
nickel	12/12	7.4	11.2	9.78	04/07/97 BGSS04	57/59	5.9	38.2	13.4	01SB16-1012 08/29/91	14.8
potassium	7/12	436	771	434	04/07/97 BGSS05	59/59	184	2840	975	01SB15-0810 08/28/91	1170
selenium	0/12	-			NA	0/34	-		0.618	NA	
sodium	2/12	112	120	63.9	04/07/97 BGSS09	59/59	387	1250	736	01SB14-1012 08/29/91	773
thallium	7/12	0.25	0.34	0.226	04/07/97 BGSS07	21/53	0.18	0.41	0.168	01SB16-0204 08/29/91	0.191
vanadium	12/12	20.9	28.2	25	04/07/97 BGSS02	59/59	19.5	48.8	33.9	01SB18-0406 08/29/91	35.3
zinc	12/12	21.7	597	90.5	04/07/97 BGSS04	59/59	10.7	237	34.8	01SB11-0204 08/28/91	37.8
Aroclor-1260	0/12	-			NA	8/63	11	5200	187	01SB11-0204 08/29/91	150
heptachlor	0/12	-			NA	1/59	9.7	9.7	5.7	01SB03-0204 08/31/91	5.84
pcbs (immunoassay)	0/0	-				12/25	500	23000	1710	01SB31-0204 05/05/97	2120
pcbs (tot. all)	0/0	-				19/84	11	5800	334	01SB33-0204 05/05/97	302
acetone	0/0	-				12/42	4	21	7.14	01SB07-06075 08/29/91	7.76
carbon disulfide	0/0	-				1/60	1	1	2.92	01SB07-06075 08/29/91	1

Table 4-7
Occurrence and Distribution f Organics and Inorganics in Subsurface S ils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data					
	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Representative C ncentration
		Min.	Max.				Min.	Max.			

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

Table 4-8
Background Comparis n Tests - Subsurface Soil Data for Sit 1
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq. Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
aluminum Y	12/12	59/59		NA	9.33	0.142	1.7959	L	14700	24500	Y	40	39	0.0003	Y	0.0029			Y	11400	14800			NA	lognor.	nonpar.					NA
arsenic Y	12/12	45/59	1.0000	N	1.85	0.283	1.7959	L	10.8	16	Y	1	1	0.8310	N	1.0000	Gehan	Test	N	6.61	2.44			NA	lognor.	nonpar.					NA
barium Y	12/12	59/59		NA	4.56	0.129	1.7959	L	121	422	Y	12	12	0.0874	N	0.9920			N	96	100			NA	lognor.	nonpar.					NA
cadmium N	0/12	26/59	0.0022	Y						4.5	NA	10	10	0.1361	N				NA		0.972			NA							NA
calcium Y	12/12	58/59	1.0000	N	6.88	0.329	1.7959	L	1790	13100	Y	5	5	0.3845	N	0.9956			N	1020	1290			NA	lognor.	nonpar.					NA
chromium Y	12/12	59/59		NA	2.73	0.142	1.7959	L	20	33.7	Y	46	46	<.0001	Y	<.0001			Y	15.4	24.1			NA	lognor.	nonpar.					NA
cobalt Y	12/12	59/59		NA	7.9	0.786	1.7959	N	9.37	30.2	Y	40	40	<.0001	Y	0.0005			Y	7.9	11.2			NA	normal	nonpar.					NA
copper Y	12/12	58/59	1.0000	N	10.7	1.55	1.7959	N	13.6	39.2	Y	32	32	0.0003	Y	0.0146			Y	10.7	15.8			NA	normal	nonpar.					NA
cyanide N	2/12	1/59		NA	0.65					3.2	NA	2	1	0.9734	N	0.9046	Gehan	Test	N	0.65	1.11			NA	nonpar.	nonpar.					NA
iron Y	12/12	59/59		NA	9.6	0.111	1.7959	L	18200	35400	Y	49	49	<.0001	Y	<.0001			Y	14900	24300			NA	lognor.	normal					NA
lead Y	12/12	59/59		NA	3.34	0.433	1.7959	L	63.3	164	Y	1	1	0.8310	N	1.0000			N	31	10.7			NA	lognor.	nonpar.					NA
magnesium Y	12/12	59/59		NA	7.31	0.102	1.7959	L	1820	7830	Y	31	30	0.0060	Y	0.3882			N	7.31	7.28	-0.2930	1.6683	N	lognor.	lognor.	0.102	0.747	31.305	3.8431	N
manganese Y	12/12	59/59		NA	6.42	0.277	1.7959	L	1040	2310	Y	7	7	0.2565	N	0.9052			N	641	647			NA	lognor.	nonpar.					NA
mercury N	0/12	2/59	0.6885	N						0.24	NA	1	1	0.8310	N				NA		0.0551			NA							NA
nickel Y	12/12	57/59	1.0000	N	9.78	0.961	1.7959	N	11.6	38.2	Y	11	11	0.1093	N	0.0008			Y	9.78	13.4			NA	normal	nonpar.					NA
potassium Y	7/12	59/59	0.0001	Y	434					2840	NA	33	33	0.0002	Y	0.0003	Gehan	Test	Y	434	975			NA	normal	nonpar.					NA
selenium NA	0/12	0/34		NA							NA				NA				NA		0.618			NA							NA
sodium Y	2/12	59/59	<.0001	Y	63.9					1250	NA	49	49	<.0001	Y	<.0001	Gehan	Test	Y	63.9	736			NA	nonpar.	nonpar.					NA
thallium N	7/12	21/53	0.9338	N	0.226					0.41	NA	3	3	0.5363	N	0.9992	Gehan	Test	N	0.226	0.168			NA	nonpar.	nonpar.					NA
vanadium Y	12/12	59/59		NA	25	2.1	1.7959	N	29	48.8	Y	46	46	<.0001	Y	<.0001			Y	25	33.9			NA	normal	normal					NA
zinc N	12/12	59/59		NA	90.5					237	NA	4	3	0.8699	N	0.9998			N	90.5	34.8			NA	nonpar.	nonpar.					NA
heptachlor NA	0/12	1/59		NA						9.7	NA				NA				NA		5.7			NA							NA
pcbs (tot. all) NA	0/0	19/84		NA						5800	NA				NA				NA		334			NA							NA
acetone NA	0/0	12/42		NA						21	NA				NA				NA		7.14			NA							NA
carbon disulfide NA	0/0	1/60		NA						1	NA				NA				NA		2.92			NA							NA

Notes: Units are mg/kg for inorganics, ug/kg for organics.

A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.

UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:

(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.

(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.

(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.

Table 4-8
Background Comparison Tests - Subsurface Soil Data for Sit 1
NASJRB Willow Grove, Pennsylvania

Name of Test: Question Posed	Detection Freq. Z or Fisher Site Freq. > Back Freq.?				95 % Upper Tolerance Limit (UTL) Site Maximum > UTL for Background Data?							Upper Ranks Majority are site?				Mann-Whitney/Gehan Ranks of Site > Back?				Student's or Satterthwaite T-test Site Mean > Back. Mean?					Bartlett's Test for Equal Standard Deviations Site Standard Deviation = Background Std. Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN Substance	Back. Freq.	Site Freq.	P Value	YN	Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL	Site Max.	YN	r	k	P Value	YN	P Value	Test	Used	YN	Back. Mean@	Site Mean@	t Value	t Table	YN	Back. Distrib.	Site Distrib.	Std.Dev. Back.@	Std.Dev. Site@	F Value	F Table	YN

(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB03-0204	01SB03-0204	01SB03-0204-DU	01SB03-0204-DU	01SB03-0406	ARARS & TBCs			
LOCATION:	01SB03	01SB03	01SB03	01SB03	01SB03	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/30/91	08/31/91	08/30/91	08/31/91	08/30/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	18600	n/a	16900	n/a	13100	78000	1000000	-	-
antimony	R	n/a	R	n/a	R	31.0	820	30.0	400
arsenic	6.3 E	n/a	6.5 E	n/a	1.9 E	0.430	3.80	3.00	4.00
barium	51.3 K	n/a	46.7 K	n/a	72 K	5500	140000	5000	70000
beryllium	1.2 B	n/a	1.2 B	n/a	1.1 B	0.150	1.30	1.00	1.30
calcium	1020	n/a	971	n/a	390	-	-	-	-
chromium, total	26.6	n/a	24.6	n/a	24.6	390	10000	-	-
cobalt	6.8	n/a	7.2	n/a	12.6	4700	120000	-	-
copper	13.8	n/a	14.7 K	n/a	9 K	3100	82000	700	37000
iron	29400 E	n/a	27500 E	n/a	24200 E	23000	610000	-	-
lead	10.8 J	n/a	14.1 J	n/a	5.6 J	400	-	500	1000
magnesium	2430	n/a	2150	n/a	746	-	-	-	-
manganese	155 K	n/a	170 K	n/a	664 K	1800	47000	-	-
nickel	11.7	n/a	12	n/a	12	1600	41000	200	20000
potassium	960	n/a	757	n/a	568	-	-	-	-
selenium	R	n/a	R	n/a	R	390	10000	60.0	5000
sodium	931 K	n/a	895 K	n/a	729 K	-	-	-	-
vanadium	42 K	n/a	39 K	n/a	36.6 K	550	14000	-	-
zinc	42	n/a	38.8	n/a	20.9	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	n/a	7 B	n/a	12 U	n/a	7800000	200000000	8000000	100000000
methylene chloride	n/a	2 B	n/a	6 U	n/a	85000	760000	600000	800000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	n/a	300	n/a	1200 E	n/a	319	2860	5000	-
PCBs (tot. all)	n/a	300	n/a	1200 E	n/a	319	2860	5000	-
heptachlor	n/a	9.7	n/a	9.6 U	n/a	140	1300	1000	1300

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB03-0406	01SB03-0608	01SB03-0608	01SB04-0204	01SB04-0204	ARARS & TBCs			
LOCATION:	01SB03	01SB03	01SB03	01SB04	01SB04	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/31/91	08/30/91	08/31/91	08/30/91	08/31/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	14200	n/a	19100	n/a	78000	1000000	-	-
antimony	n/a	R	n/a	R	n/a	31.0	820	30.0	400
arsenic	n/a	1.2 E	n/a	3.5 E	n/a	0.430	3.80	3.00	4.00
barium	n/a	67 K	n/a	49.2 K	n/a	5500	140000	5000	70000
beryllium	n/a	1 B	n/a	1.1 B	n/a	0.150	1.30	1.00	1.30
calcium	n/a	703	n/a	1040	n/a	-	-	-	-
chromium, total	n/a	23	n/a	26.2	n/a	390	10000	-	-
cobalt	n/a	12.9	n/a	9.7	n/a	4700	120000	-	-
copper	n/a	8.4 K	n/a	17 K	n/a	3100	82000	700	37000
iron	n/a	23900 E	n/a	23300 E	n/a	23000	610000	-	-
lead	n/a	5.5 J	n/a	8.4 J	n/a	400	-	500	1000
magnesium	n/a	1110	n/a	2660	n/a	-	-	-	-
manganese	n/a	456 K	n/a	306 K	n/a	1800	47000	-	-
nickel	n/a	9.9	n/a	13.9	n/a	1600	41000	200	20000
potassium	n/a	736	n/a	945	n/a	-	-	-	-
selenium	n/a	R	n/a	R	n/a	390	10000	60.0	5000
sodium	n/a	648 K	n/a	624 K	n/a	-	-	-	-
thallium	n/a	0.22 UJ	n/a	0.32 J	n/a	6.30	160	6.00	80.0
vanadium	n/a	35.1 K	n/a	40.4 K	n/a	550	14000	-	-
zinc	n/a	21.2	n/a	39.7	n/a	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
methylene chloride	4 B	n/a	3 B	n/a	4 B	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB04-0406	01SB04-0406	01SB04-0608	01SB04-0608	01SB05-0204	ARARS & TBCs			
LOCATION:	01SB04	01SB04	01SB04	01SB04	01SB05	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/30/91	08/31/91	08/30/91	08/31/91	08/30/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	12600	n/a	10400	n/a	24100	78000	1000000	-	-
antimony	R	n/a	R	n/a	R	31.0	820	30.0	400
arsenic	3.3 E	n/a	2.3 E	n/a	5.1 E	0.430	3.80	3.00	4.00
barium	90.7 K	n/a	59.6	n/a	75.3 K	5500	140000	5000	70000
beryllium	1.1 B	n/a	1 B	n/a	1.2 B	0.150	1.30	1.00	1.30
calcium	443	n/a	234	n/a	1100	-	-	-	-
chromium, total	10.6	n/a	17	n/a	27.2	390	10000	-	-
cobalt	12	n/a	8.4	n/a	9.7	4700	120000	-	-
copper	30.7 K	n/a	35.6	n/a	22.8 K	3100	82000	700	37000
iron	24500 E	n/a	18300	n/a	26200 E	23000	610000	-	-
lead	4.8 J	n/a	4 J	n/a	21.2 J	400	-	500	1000
magnesium	1200	n/a	656	n/a	2200	-	-	-	-
manganese	881 K	n/a	545	n/a	742 K	1800	47000	-	-
nickel	11.4	n/a	9.8	n/a	15.9	1600	41000	200	20000
potassium	576	n/a	348	n/a	768	-	-	-	-
selenium	R	n/a	R	n/a	R	390	10000	60.0	5000
sodium	809 K	n/a	635	n/a	872 K	-	-	-	-
thallium	0.22 J	n/a	0.2 UJ	n/a	0.32 J	6.30	160	6.00	80.0
vanadium	32.5 K	n/a	30	n/a	43.5 K	550	14000	-	-
zinc	30.3	n/a	22.4	n/a	50.9	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1-dichloroethene	n/a	2 B	n/a	6 U	n/a	1100	9500	700000	9000000
acetone	n/a	4 B	n/a	4 B	n/a	7800000	200000000	8000000	100000000
methylene chloride	n/a	3 B	n/a	2 B	n/a	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB05-0204	01SB05-0204-DU	01SB05-0204-DU	01SB05-0406	01SB05-0406	ARARS & TBCs			
LOCATION:	01SB05	01SB05	01SB05	01SB05	01SB05	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/31/91	08/30/91	08/31/91	08/30/91	08/31/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	20000	n/a	17000	n/a	78000	1000000	-	-
antimony	n/a	R	n/a	R	n/a	31.0	820	30.0	400
arsenic	n/a	1.6 E	n/a	1.5 E	n/a	0.430	3.80	3.00	4.00
barium	n/a	70.7 K	n/a	68.5	n/a	5500	140000	5000	70000
beryllium	n/a	1 B	n/a	1.1 B	n/a	0.150	1.30	1.00	1.30
calcium	n/a	1090	n/a	438	n/a	-	-	-	-
chromium, total	n/a	22.7	n/a	23.6	n/a	390	10000	-	-
cobalt	n/a	10.2	n/a	7.7	n/a	4700	120000	-	-
copper	n/a	26 K	n/a	22.5	n/a	3100	82000	700	37000
iron	n/a	24100 E	n/a	19300	n/a	23000	610000	-	-
lead	n/a	17.1 J	n/a	4.3 J	n/a	400	-	500	1000
magnesium	n/a	1750	n/a	593	n/a	-	-	-	-
manganese	n/a	743 K	n/a	330	n/a	1800	47000	-	-
nickel	n/a	12.9	n/a	9.6	n/a	1600	41000	200	20000
potassium	n/a	583	n/a	439	n/a	-	-	-	-
selenium	n/a	1.2 J	n/a	R	n/a	390	10000	60.0	5000
sodium	n/a	821 K	n/a	682	n/a	-	-	-	-
thallium	n/a	0.22 J	n/a	0.22 UJ	n/a	6.30	160	6.00	80.0
vanadium	n/a	37.6 K	n/a	35.7	n/a	550	14000	-	-
zinc	n/a	44.4	n/a	17.5	n/a	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	12 U	n/a	6 B	n/a	3 B	7800000	200000000	8000000	100000000
methylene chloride	1 B	n/a	3 B	n/a	3 B	85000	760000	600000	800000
toluene	6 U	n/a	2 B	n/a	6 U	16000000	410000000	16000000	200000000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB05-0608	01SB05-0608	01SB06-0204	01SB06-0204	01SB06-0406	ARARS & TBCs			
LOCATION:	01SB05	01SB05	01SB06	01SB06	01SB06	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/30/91	08/31/91	08/30/91	08/31/91	08/30/91				
INORGANICS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
aluminum	11500	n/a	20400	n/a	19700	78000	1000000	-	-
antimony	R	n/a	R	n/a	R	31.0	820	30.0	400
arsenic	1.4 E	n/a	3.2 E	n/a	4.4 E	0.430	3.80	3.00	4.00
barium	73.2	n/a	76.8	n/a	72.1	5500	140000	5000	70000
beryllium	1.1 B	n/a	1 B	n/a	1 B	0.150	1.30	1.00	1.30
calcium	165	n/a	914	n/a	944	-	-	-	-
chromium, total	18.4	n/a	23.6	n/a	20.1	390	10000	-	-
cobalt	5.9	n/a	6.6	n/a	8.8	4700	120000	-	-
copper	16.8	n/a	24.2	n/a	37.8	3100	82000	700	37000
iron	14700	n/a	16800	n/a	18100	23000	610000	-	-
lead	2.4 J	n/a	8.4 J	n/a	17 J	400	-	500	1000
magnesium	261	n/a	2200	n/a	1230	-	-	-	-
manganese	404	n/a	238	n/a	475	1800	47000	-	-
nickel	8.7	n/a	12.5	n/a	11.1	1600	41000	200	20000
potassium	191	n/a	673	n/a	518	-	-	-	-
selenium	R	n/a	R	n/a	R	390	10000	60.0	5000
sodium	554	n/a	567	n/a	605	-	-	-	-
thallium	0.2 UJ	n/a	0.2 UJ	n/a	0.23 J	6.30	160	6.00	80.0
vanadium	28.2	n/a	36.1	n/a	29.6	550	14000	-	-
zinc	15.1	n/a	34.9	n/a	38	23000	610000	-	-
VOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
acetone	n/a	11 U	n/a	6 B	n/a	7800000	200000000	8000000	100000000
methylene chloride	n/a	3 B	n/a	1 B	n/a	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB06-0406	01SB06-0608	01SB06-0608	01SB07-0204	01SB07-0204	ARARS & TBCs			
LOCATION:	01SB06	01SB06	01SB06	01SB07	01SB07	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/31/91	08/30/91	08/31/91	08/28/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	9690	n/a	16800	n/a	78000	1000000	-	-
antimony	n/a	R	n/a	R	n/a	31.0	820	30.0	400
arsenic	n/a	2.7 E	n/a	4.1 E	n/a	0.430	3.80	3.00	4.00
barium	n/a	103	n/a	66.7 K	n/a	5500	140000	5000	70000
beryllium	n/a	1.3 B	n/a	1.2 B	n/a	0.150	1.30	1.00	1.30
cadmium	n/a	0.84 U	n/a	1 L	n/a	39.0	1000	20.0	500
calcium	n/a	259	n/a	13100	n/a	-	-	-	-
chromium, total	n/a	11.3	n/a	33.7	n/a	390	10000	-	-
cobalt	n/a	9.6	n/a	10.5	n/a	4700	120000	-	-
copper	n/a	29.7	n/a	25	n/a	3100	82000	700	37000
iron	n/a	16900	n/a	29800 E	n/a	23000	610000	-	-
lead	n/a	3.2 J	n/a	10.4 K	n/a	400	-	500	1000
magnesium	n/a	462	n/a	7830	n/a	-	-	-	-
manganese	n/a	769	n/a	471 L	n/a	1800	47000	-	-
nickel	n/a	10.9	n/a	17.6	n/a	1600	41000	200	20000
potassium	n/a	184	n/a	2590	n/a	-	-	-	-
selenium	n/a	R	n/a	R	n/a	390	10000	60.0	5000
sodium	n/a	571	n/a	996 K	n/a	-	-	-	-
thallium	n/a	0.22 UJ	n/a	0.33 B	n/a	6.30	160	6.00	80.0
vanadium	n/a	19.5	n/a	46.4 K	n/a	550	14000	-	-
zinc	n/a	30.4	n/a	59.5	n/a	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	6 U	n/a	6 U	n/a	1 B	2700000	72000000	7000000	90000000
1,1-dichloroethene	2 B	n/a	6 U	n/a	6 U	1100	9500	700000	9000000
acetone	3 B	n/a	11 U	n/a	15	7800000	200000000	8000000	100000000
methylene chloride	4 B	n/a	6 UJ	n/a	4 B	85000	760000	600000	800000
toluene	1 B	n/a	6 U	n/a	6 U	16000000	410000000	16000000	200000000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB07-0406	01SB07-0406	01SB07-0406-DU	01SB07-0406-DU	01SB07-06075	ARARS & TBCs			
LOCATION:	01SB07	01SB07	01SB07	01SB07	01SB07	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/28/91	08/29/91	08/28/91	08/29/91	08/28/91				
INORGANICS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
aluminum	12500	n/a	14600	n/a	9280	78000	1000000	-	-
antimony	R	n/a	R	n/a	R	31.0	820	30.0	400
arsenic	1.8 E	n/a	1.8 E	n/a	0.71 U	0.430	3.80	3.00	4.00
barium	89.5 K	n/a	72.5	n/a	63.7	5500	140000	5000	70000
beryllium	1.3 B	n/a	1.2 B	n/a	0.98 B	0.150	1.30	1.00	1.30
cadmium	0.87 L	n/a	0.93 U	n/a	0.98	39.0	1000	20.0	500
calcium	447	n/a	489	n/a	457	-	-	-	-
chromium, total	25.3	n/a	21	n/a	21.7	390	10000	-	-
cobalt	6.9	n/a	8.6	n/a	9.8	4700	120000	-	-
copper	14.9	n/a	17.3	n/a	12.1	3100	82000	700	37000
iron	23200 E	n/a	20200	n/a	17400	23000	610000	-	-
lead	6.7 K	n/a	9.2 K	n/a	2.6 K	400	-	500	1000
magnesium	1460	n/a	1320	n/a	1010	-	-	-	-
manganese	138 L	n/a	191	n/a	500	1800	47000	-	-
nickel	7.8	n/a	8.4	n/a	6.7	1600	41000	200	20000
potassium	701	n/a	989	n/a	597	-	-	-	-
selenium	R	n/a	R	n/a	R	390	10000	60.0	5000
sodium	716 K	n/a	619	n/a	564	-	-	-	-
thallium	0.18 UJ	n/a	0.21 B	n/a	0.18 UJ	6.30	160	6.00	80.0
vanadium	34.2 K	n/a	29.8	n/a	28.8	550	14000	-	-
zinc	23.2	n/a	22.1	n/a	22.3	23000	610000	-	-
VOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
1,1,1-trichloroethane	n/a	1 B	n/a	2 B	n/a	2700000	72000000	7000000	90000000
acetone	n/a	12 U	n/a	11 J	n/a	7800000	200000000	8000000	100000000
methylene chloride	n/a	6 B	n/a	4 B	n/a	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB07-06075	01SB07-07508	01SB08-0204	01SB08-0204	01SB08-0406	ARARS & TBCs			
LOCATION:	01SB07	01SB07	01SB08	01SB08	01SB08	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/29/91	08/28/91	08/29/91	08/28/91				
INORGANICS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
aluminum	n/a	n/a	14000	n/a	15100	78000	1000000	-	-
antimony	n/a	n/a	R	n/a	R	31.0	820	30.0	400
arsenic	n/a	n/a	4 E	n/a	0.89 U	0.430	3.80	3.00	4.00
barium	n/a	n/a	53.4 K	n/a	104 K	5500	140000	5000	70000
beryllium	n/a	n/a	1.1 B	n/a	1.1 B	0.150	1.30	1.00	1.30
cadmium	n/a	n/a	0.88 UL	n/a	1.1 L	39.0	1000	20.0	500
calcium	n/a	n/a	1500	n/a	579	-	-	-	-
chromium, total	n/a	n/a	21.9	n/a	27.6	390	10000	-	-
cobalt	n/a	n/a	12.7	n/a	13.9	4700	120000	-	-
copper	n/a	n/a	14.4	n/a	13.5	3100	82000	700	37000
iron	n/a	n/a	23900 E	n/a	29200 E	23000	610000	-	-
lead	n/a	n/a	9.6 K	n/a	8.8 K	400	-	500	1000
magnesium	n/a	n/a	3260	n/a	1990	-	-	-	-
manganese	n/a	n/a	524 L	n/a	465 L	1800	47000	-	-
nickel	n/a	n/a	12.9	n/a	11.7	1600	41000	200	20000
potassium	n/a	n/a	967	n/a	1580	-	-	-	-
selenium	n/a	n/a	R	n/a	R	390	10000	60.0	5000
sodium	n/a	n/a	579 K	n/a	747 K	-	-	-	-
thallium	n/a	n/a	0.34 B	n/a	0.23 B	6.30	160	6.00	80.0
vanadium	n/a	n/a	40.1 K	n/a	26 K	550	14000	-	-
zinc	n/a	n/a	38.3	n/a	31.3	23000	610000	-	-
VOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
1,1,1-trichloroethane	3 B	2 B	n/a	1 B	n/a	2700000	72000000	7000000	90000000
acetone	21	21	n/a	11	n/a	7800000	200000000	8000000	100000000
carbon disulfide	1 J	6 U	n/a	6 U	n/a	7800000	200000000	7000000	100000000
methylene chloride	6 B	6 B	n/a	3 B	n/a	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB07-06075	01SB07-07508	01SB08-0204	01SB08-0204	01SB08-0406	ARARS & TBCs			
LOCATION:	01SB07	01SB07	01SB08	01SB08	01SB08	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/29/91	08/28/91	08/29/91	08/28/91				
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	220	n/a	n/a	190 U	n/a	319	2860	5000	-
PCBs (tot. all)	220	n/a	n/a	93 U	n/a	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB08-0406	01SB08-0608	01SB08-0608	01SB08-0810	01SB08-0810	ARARS & TBCs			
LOCATION:	01SB08	01SB08	01SB08	01SB08	01SB08	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-resid ntial Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/28/91	08/29/91	08/28/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	10500	n/a	9170	n/a	78000	1000000	-	-
antimony	n/a	R	n/a	R	n/a	31.0	820	30.0	400
barium	n/a	80.7	n/a	90.4	n/a	5500	140000	5000	70000
beryllium	n/a	1.3 B	n/a	1.2 B	n/a	0.150	1.30	1.00	1.30
cadmium	n/a	0.88 U	n/a	0.79	n/a	39.0	1000	20.0	500
calcium	n/a	352	n/a	309	n/a	-	-	-	-
chromium, total	n/a	24	n/a	20.4	n/a	390	10000	-	-
cobalt	n/a	6.6	n/a	7.5	n/a	4700	120000	-	-
copper	n/a	9.5	n/a	10.4	n/a	3100	82000	700	37000
iron	n/a	19800	n/a	17600	n/a	23000	610000	-	-
lead	n/a	3.3 K	n/a	3.5 K	n/a	400	-	500	1000
magnesium	n/a	722	n/a	634	n/a	-	-	-	-
manganese	n/a	238	n/a	462	n/a	1800	47000	-	-
nickel	n/a	5.9 U	n/a	7.9	n/a	1600	41000	200	20000
potassium	n/a	716	n/a	711	n/a	-	-	-	-
selenium	n/a	R	n/a	R	n/a	390	10000	60.0	5000
sodium	n/a	582	n/a	616	n/a	-	-	-	-
vanadium	n/a	30.4	n/a	25.7	n/a	550	14000	-	-
zinc	n/a	13.4	n/a	14.1	n/a	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	1 B	n/a	6 U	n/a	5 U	2700000	72000000	7000000	90000000
acetone	9 J	n/a	4 J	n/a	6 J	7800000	200000000	8000000	100000000
methylene chloride	6 B	n/a	6 U	n/a	5 U	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB09-0608	01SB09-0810	01SB09-0810	01SB10-0204	01SB10-0204	ARARS & TBCs			
LOCATION:	01SB09	01SB09	01SB09	01SB10	01SB10	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/28/91	08/29/91	08/28/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	12900	n/a	20900	n/a	78000	1000000	-	-
arsenic	n/a	0.76 U	n/a	2.8 E	n/a	0.430	3.80	3.00	4.00
barium	n/a	138	n/a	71.5	n/a	5500	140000	5000	70000
beryllium	n/a	1.5 B	n/a	1.3 B	n/a	0.150	1.30	1.00	1.30
calcium	n/a	676	n/a	1250	n/a	-	-	-	-
chromium, total	n/a	26.2	n/a	24.2	n/a	390	10000	-	-
cobalt	n/a	8.9	n/a	12.1	n/a	4700	120000	-	-
copper	n/a	28	n/a	24.8	n/a	3100	82000	700	37000
iron	n/a	26600 E	n/a	25200 E	n/a	23000	610000	-	-
lead	n/a	6.3	n/a	7.8	n/a	400	-	500	1000
magnesium	n/a	1180	n/a	2170	n/a	-	-	-	-
manganese	n/a	617	n/a	565	n/a	1800	47000	-	-
nickel	n/a	10.4	n/a	13.9	n/a	1600	41000	200	20000
potassium	n/a	1320	n/a	928	n/a	-	-	-	-
sodium	n/a	819	n/a	817	n/a	-	-	-	-
thallium	n/a	0.19 U	n/a	0.18	n/a	6.30	160	6.00	80.0
vanadium	n/a	39.6	n/a	37.8	n/a	550	14000	-	-
zinc	n/a	18.6	n/a	37.2	n/a	23000	610000	-	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB09-0204	01SB09-0204	01SB09-0406	01SB09-0406	01SB09-0608	ARARS & TBCs			
LOCATION:	01SB09	01SB09	01SB09	01SB09	01SB09	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/28/91	08/29/91	08/28/91	08/29/91	08/28/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	17100	n/a	15200	n/a	18100	78000	1000000	-	-
arsenic	5.4 E	n/a	1.2 E	n/a	0.91 E	0.430	3.80	3.00	4.00
barium	70.7	n/a	69.9	n/a	143	5500	140000	5000	70000
beryllium	1.3 B	n/a	1.1 B	n/a	1.8 B	0.150	1.30	1.00	1.30
calcium	6340	n/a	309	n/a	594	-	-	-	-
chromium, total	30.8	n/a	25.7	n/a	27	390	10000	-	-
cobalt	9	n/a	17.5	n/a	9.9	4700	120000	-	-
copper	22.6	n/a	17.5	n/a	21.8	3100	82000	700	37000
iron	26100 E	n/a	23600 E	n/a	32400 E	23000	610000	-	-
lead	20	n/a	6.8	n/a	18.4	400	-	500	1000
magnesium	6020	n/a	701	n/a	1480	-	-	-	-
manganese	410	n/a	518	n/a	318	1800	47000	-	-
mercury	0.11	n/a	0.1 U	n/a	0.1 U	23.0	610	20.0	300
nickel	16.2 U	n/a	7.6	n/a	16.2	1600	41000	200	20000
potassium	2700	n/a	584	n/a	1480	-	-	-	-
sodium	742	n/a	744	n/a	1000	-	-	-	-
thallium	0.27	n/a	0.22 U	n/a	0.21 U	6.30	160	6.00	80.0
vanadium	42.3	n/a	30.1	n/a	30.8	550	14000	-	-
zinc	48.1	n/a	14.7	n/a	24.7	23000	610000	-	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB10-0406	01SB10-0406	01SB10-0406-DU	01SB10-0406-DU	01SB10-0608	ARARS & TBCs			
LOCATION:	01SB10	01SB10	01SB10	01SB10	01SB10	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/28/91	08/29/91	08/28/91	08/29/91	08/28/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	18900	n/a	17900	n/a	11000	78000	1000000	-	-
arsenic	1.9 E	n/a	2 E	n/a	1.1 E	0.430	3.80	3.00	4.00
barium	73.8	n/a	74.7	n/a	71.3	5500	140000	5000	70000
beryllium	1.4 B	n/a	1.3 B	n/a	1.2 B	0.150	1.30	1.00	1.30
calcium	360	n/a	341	n/a	154	-	-	-	-
chromium, total	27.2	n/a	22.8	n/a	17	390	10000	-	-
cobalt	9.7	n/a	10.2	n/a	8.7	4700	120000	-	-
copper	25.9	n/a	23.7	n/a	19	3100	82000	700	37000
iron	24800 E	n/a	23600 E	n/a	16600	23000	610000	-	-
lead	8.2	n/a	7	n/a	4	400	-	500	1000
magnesium	1830	n/a	1590	n/a	479	-	-	-	-
manganese	383	n/a	432	n/a	474	1800	47000	-	-
nickel	14	n/a	11.9	n/a	8.3	1600	41000	200	20000
potassium	1230	n/a	886	n/a	409	-	-	-	-
sodium	768	n/a	737	n/a	542	-	-	-	-
thallium	0.26	n/a	0.2 U	n/a	0.21 U	6.30	160	6.00	80.0
vanadium	35.3	n/a	34.1	n/a	28.7	550	14000	-	-
zinc	29.7	n/a	28.2	n/a	17.2	23000	610000	-	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB10-0608	01SB11-0204	01SB11-0204	01SB11-0406	01SB11-0406	ARARS & TBCs			
LOCATION:	01SB10	01SB11	01SB11	01SB11	01SB11	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/28/91	08/29/91	08/28/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	11700	n/a	17300	n/a	78000	1000000	-	-
antimony	n/a	R	n/a	6.6 U	n/a	31.0	820	30.0	400
arsenic	n/a	16 E	n/a	3.4 E	n/a	0.430	3.80	3.00	4.00
barium	n/a	108	n/a	50.1	n/a	5500	140000	5000	70000
beryllium	n/a	1.3 B	n/a	0.41 B	n/a	0.150	1.30	1.00	1.30
cadmium	n/a	4.5	n/a	1.4	n/a	39.0	1000	20.0	500
calcium	n/a	8370	n/a	756	n/a	-	-	-	-
chromium, total	n/a	29.4	n/a	26.6	n/a	390	10000	-	-
cobalt	n/a	9.2	n/a	11.3	n/a	4700	120000	-	-
copper	n/a	39.2	n/a	14.4	n/a	3100	82000	700	37000
iron	n/a	23100 E	n/a	24300 E	n/a	23000	610000	-	-
lead	n/a	164 K	n/a	8	n/a	400	-	500	1000
magnesium	n/a	3980	n/a	2570	n/a	-	-	-	-
manganese	n/a	352	n/a	382	n/a	1800	47000	-	-
mercury	n/a	0.24	n/a	0.1 U	n/a	23.0	610	20.0	300
nickel	n/a	20.7	n/a	15.3	n/a	1600	41000	200	20000
potassium	n/a	1020	n/a	1020	n/a	-	-	-	-
selenium	n/a	R	n/a	1.1 U	n/a	390	10000	60.0	5000
sodium	n/a	858	n/a	796	n/a	-	-	-	-
thallium	n/a	0.37 B	n/a	0.22 U	n/a	6.30	160	6.00	80.0
vanadium	n/a	27.9	n/a	38.3	n/a	550	14000	-	-
zinc	n/a	237	n/a	33	n/a	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	11 U	n/a	5 J	n/a	7 B	7800000	200000000	8000000	100000000
methylene chloride	6 U	n/a	6 U	n/a	4 B	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB10-0608		01SB11-0204	01SB11-0204		01SB11-0406		01SB11-0406	ARARS & TBCs			
LOCATION:	01SB10		01SB11	01SB11		01SB11		01SB11	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil	Subsurface Soil		Subsurface Soil		Subsurface Soil				
SAMPLE DATE:	08/29/91		08/28/91	08/29/91		08/28/91		08/29/91				
PESTICIDES	**ug/kg**		**ug/kg**	**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	180	U	n/a	5200	E	190	U	n/a	319	2860	5000	-
PCBs (tot. all)	88	U	n/a	5200	E	97	U	n/a	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB11-0608	01SB11-0608	01SB11-0810	01SB11-0810	01SB12-0406	ARARS & TBCs			
LOCATION:	01SB11	01SB11	01SB11	01SB11	01SB12	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/28/91	08/29/91	08/28/91	08/29/91	08/28/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	15100	n/a	14600	n/a	18800	78000	1000000	-	-
antimony	R	n/a	R	n/a	R	31.0	820	30.0	400
arsenic	3.9 E	n/a	1.8 E	n/a	1.6 E	0.430	3.80	3.00	4.00
barium	71.3 K	n/a	84.9 K	n/a	72.9 K	5500	140000	5000	70000
beryllium	1.4 B	n/a	1.4 B	n/a	1.4 B	0.150	1.30	1.00	1.30
cadmium	0.91 L	n/a	2 L	n/a	0.92 L	39.0	1000	20.0	500
calcium	692	n/a	854	n/a	734	-	-	-	-
chromium, total	24.8	n/a	29.9	n/a	27.9	390	10000	-	-
cobalt	12.9	n/a	8.3	n/a	13.1	4700	120000	-	-
copper	17.7	n/a	12.6	n/a	18	3100	82000	700	37000
iron	24300 E	n/a	29800 E	n/a	26900 E	23000	610000	-	-
lead	6.8 K	n/a	7.6 K	n/a	8.8 K	400	-	500	1000
magnesium	2270	n/a	1750	n/a	1640	-	-	-	-
manganese	530 L	n/a	272 L	n/a	580 L	1800	47000	-	-
nickel	12	n/a	11.9	n/a	12.5	1600	41000	200	20000
potassium	1060	n/a	1300	n/a	1240	-	-	-	-
selenium	R	n/a	R	n/a	R	390	10000	60.0	5000
sodium	852 K	n/a	1030 K	n/a	960 K	-	-	-	-
thallium	0.3 B	n/a	0.29 B	n/a	0.19 UJ	6.30	160	6.00	80.0
vanadium	35.9 K	n/a	39.6 K	n/a	35.5 K	550	14000	-	-
zinc	31.3	n/a	29.9	n/a	42	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	n/a	7 J	n/a	12 U	n/a	7800000	200000000	8000000	100000000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB12-0406	01SB12-0608	01SB12-0608	01SB12-0608-DU	01SB12-0608-DU	ARARS & TBCs			
LOCATION:	01SB12	01SB12	01SB12	01SB12	01SB12	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/28/91	08/29/91	08/28/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	9460	n/a	12900	n/a	78000	1000000	-	-
antimony	n/a	R	n/a	R	n/a	31.0	820	30.0	400
barium	n/a	64 K	n/a	87.6 K	n/a	5500	140000	5000	70000
beryllium	n/a	1.3 B	n/a	1.3 B	n/a	0.150	1.30	1.00	1.30
cadmium	n/a	2 L	n/a	1.7 L	n/a	39.0	1000	20.0	500
calcium	n/a	545	n/a	727	n/a	-	-	-	-
chromium, total	n/a	22.7	n/a	25.1	n/a	390	10000	-	-
cobalt	n/a	6.8	n/a	8.2	n/a	4700	120000	-	-
copper	n/a	8.1	n/a	10.6	n/a	3100	82000	700	37000
iron	n/a	24400 E	n/a	28100 E	n/a	23000	610000	-	-
lead	n/a	4.7 K	n/a	6.6 K	n/a	400	-	500	1000
magnesium	n/a	1250	n/a	2170	n/a	-	-	-	-
manganese	n/a	165 L	n/a	196 L	n/a	1800	47000	-	-
nickel	n/a	8.7	n/a	12.5	n/a	1600	41000	200	20000
potassium	n/a	1040	n/a	1840	n/a	-	-	-	-
selenium	n/a	R	n/a	R	n/a	390	10000	60.0	5000
sodium	n/a	846 K	n/a	986 K	n/a	-	-	-	-
vanadium	n/a	39.6 K	n/a	29.8 K	n/a	550	14000	-	-
zinc	n/a	22.3	n/a	33.6	n/a	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	7 J	n/a	11 J	n/a	3 J	7800000	200000000	8000000	100000000
methylene chloride	6 U	n/a	6 U	n/a	3 B	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB12-0810	01SB12-0810	01SB12-1012	01SB13-0204	01SB13-0608	ARARS & TBCs			
LOCATION:	01SB12	01SB12	01SB12	01SB13	01SB13	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/28/91	08/29/91	08/28/91	08/28/91	08/28/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	8610	n/a	5910	19500	16300	78000	1000000	-	-
antimony	R	n/a	6.9 U	7.6 U	7.8 U	31.0	820	30.0	400
arsenic	0.81 U	n/a	0.82 U	3.4 E	0.92 U	0.430	3.80	3.00	4.00
barium	68.4	n/a	128	73.4	139	5500	140000	5000	70000
beryllium	1.2 B	n/a	0.86 B	0.71 B	0.97 B	0.150	1.30	1.00	1.30
cadmium	0.82	n/a	0.86 U	0.95 U	0.97 U	39.0	1000	20.0	500
calcium	563	n/a	323	343	1130 U	-	-	-	-
chromium, total	24.7	n/a	18.1	26	32.2	390	10000	-	-
cobalt	7.8	n/a	15.1	13.7	6.5	4700	120000	-	-
copper	9.9	n/a	13.1	15.4	11.4	3100	82000	700	37000
iron	19100	n/a	17200	25000 E	33500 E	23000	610000	-	-
lead	3.7 K	n/a	1.9	6.2	11.5	400	-	500	1000
magnesium	707	n/a	531	1820	2530	-	-	-	-
manganese	468	n/a	1110	727	70.3	1800	47000	-	-
nickel	9.3	n/a	20	16.6	15.3	1600	41000	200	20000
potassium	688	n/a	212	925	2210	-	-	-	-
selenium	R	n/a	1 U	1.2 U	1.1 U	390	10000	60.0	5000
sodium	721	n/a	549	643	830	-	-	-	-
thallium	0.2 UJ	n/a	0.23	0.33	0.38	6.30	160	6.00	80.0
vanadium	26.2	n/a	25.4	37.7	33.2	550	14000	-	-
zinc	19.4	n/a	32.5	34.1	37.6	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1,1-trichloroethane	n/a	2 B	2 B	6 U	1 B	2700000	72000000	7000000	90000000
acetone	n/a	9 J	11 U	11 U	11 B	7800000	200000000	8000000	100000000
methylene chloride	n/a	6 U	6 B	3 B	5 B	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB13-1012	01SB13-1214	01SB14-0204	01SB14-0204	01SB14-0204-DU	ARARS & TBCs			
LOCATION:	01SB13	01SB13	01SB14	01SB14	01SB14	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/28/91	08/28/91	08/28/91	08/29/91	08/28/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	12200	9090	16700	n/a	18800	78000	1000000	-	-
arsenic	0.91 U	0.9 E	3.2 E	n/a	3.9 E	0.430	3.80	3.00	4.00
barium	105	195	60.1	n/a	53.3	5500	140000	5000	70000
beryllium	0.44 B	0.63 B	1 B	n/a	1.1 B	0.150	1.30	1.00	1.30
calcium	692	487	1230	n/a	1290	-	-	-	-
chromium, total	29	33.4	22.9	n/a	24.2	390	10000	-	-
cobalt	9.8	12.4	12.2	n/a	10.1	4700	120000	-	-
copper	9	6.3	16.2	n/a	16.3	3100	82000	700	37000
cyanide	2.8 U	3.2	1.4 U	n/a	1.8 U	1600	41000	1000	20000
iron	34400 E	28500 E	23900 E	n/a	24200 E	23000	610000	-	-
lead	7.4	7.5	8.4	n/a	8.5	400	-	500	1000
magnesium	1760	691	2760	n/a	2990	-	-	-	-
manganese	308	1420	570	n/a	477	1800	47000	-	-
nickel	13.3	13.7	12.4	n/a	14.7	1600	41000	200	20000
potassium	1830	747	1030	n/a	1170	-	-	-	-
sodium	892	756	763	n/a	790	-	-	-	-
thallium	0.3	0.19	0.2	n/a	0.2 U	6.30	160	6.00	80.0
vanadium	22.7	25.8	37.6	n/a	37.4	550	14000	-	-
zinc	30.8	27.3	40.2	n/a	39	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1-dichloroethene	6 U	1 B	n/a	6 U	n/a	1100	9500	700000	9000000
acetone	5 B	6 B	n/a	29 B	n/a	7800000	200000000	8000000	100000000
methylene chloride	5 B	2 B	n/a	6 U	n/a	85000	760000	600000	800000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	180 U	180 U	n/a	300	n/a	319	2860	5000	-
PCBs (tot. all)	91 U	89 U	n/a	300	n/a	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB14-0204-DU	01SB14-0406	01SB14-0406	01SB14-0608	01SB14-0810	ARARS & TBCs			
LOCATION:	01SB14	01SB14	01SB14	01SB14	01SB14	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/28/91	08/29/91	08/29/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	18800	n/a	14100	16400	78000	1000000	-	-
arsenic	n/a	1.4 E	n/a	1.6 E	0.66 U	0.430	3.80	3.00	4.00
barium	n/a	69.9	n/a	180	120	5500	140000	5000	70000
beryllium	n/a	1.3 B	n/a	1.1 B	0.94 B	0.150	1.30	1.00	1.30
cadmium	n/a	0.84 U	n/a	2.4	2.6	39.0	1000	20.0	500
calcium	n/a	375	n/a	258	486	-	-	-	-
chromium, total	n/a	24.8	n/a	24	24.6	390	10000	-	-
cobalt	n/a	10.1	n/a	19.6	11.7	4700	120000	-	-
copper	n/a	9.9	n/a	7.7	8.7	3100	82000	700	37000
iron	n/a	23500 E	n/a	24700 E	27900 E	23000	610000	-	-
lead	n/a	6.3	n/a	4.7	8.4	400	-	500	1000
magnesium	n/a	911	n/a	307	1280	-	-	-	-
manganese	n/a	499	n/a	1330	812	1800	47000	-	-
nickel	n/a	10.7	n/a	24.9	15	1600	41000	200	20000
potassium	n/a	634	n/a	262	959	-	-	-	-
sodium	n/a	746	n/a	836	708	-	-	-	-
thallium	n/a	0.16 U	n/a	0.19 U	0.2	6.30	160	6.00	80.0
vanadium	n/a	34.9	n/a	30.6	32.6	550	14000	-	-
zinc	n/a	21.2	n/a	29.5	27.2	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
1,1-dichloroethene	6 U	n/a	2 B	6 U	6 U	1100	9500	700000	9000000
acetone	12 U	n/a	5 B	12 U	3 B	7800000	200000000	8000000	100000000
methylene chloride	6 U	n/a	6 U	3 B	6 U	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB14-1012	01SB15-0204	01SB15-0204	01SB15-0406	01SB15-0406	ARARS & TBCs			
LOCATION:	01SB14	01SB15	01SB15	01SB15	01SB15	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/28/91	08/29/91	08/28/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	18100	24500	n/a	18600	n/a	78000	1000000	-	-
arsenic	1 E	4.3 E	n/a	3 E	n/a	0.430	3.80	3.00	4.00
barium	298	112	n/a	61.9	n/a	5500	140000	5000	70000
beryllium	1.8 B	1 B	n/a	0.93 B	n/a	0.150	1.30	1.00	1.30
cadmium	3.2	0.81 U	n/a	0.93 U	n/a	39.0	1000	20.0	500
calcium	668	1090	n/a	969	n/a	-	-	-	-
chromium, total	29.1	25.3	n/a	29.2	n/a	390	10000	-	-
cobalt	19.4	10.8	n/a	5.1	n/a	4700	120000	-	-
copper	14	8.8	n/a	10	n/a	3100	82000	700	37000
iron	35400 E	21100	n/a	21200	n/a	23000	610000	-	-
lead	7.3	11.7	n/a	9.3	n/a	400	-	500	1000
magnesium	1710	2470	n/a	2560	n/a	-	-	-	-
manganese	1660	1610	n/a	179	n/a	1800	47000	-	-
nickel	22.1	17.5	n/a	11.9	n/a	1600	41000	200	20000
potassium	1790	766	n/a	977	n/a	-	-	-	-
sodium	1250	641	n/a	652	n/a	-	-	-	-
thallium	0.19 U	0.22 U	n/a	0.27	n/a	6.30	160	6.00	80.0
vanadium	30	40.3	n/a	37.6	n/a	550	14000	-	-
zinc	43.4	47.1	n/a	33.1	n/a	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	6 B	n/a	12 U	n/a	13 U	7800000	200000000	8000000	100000000
methylene chloride	6 U	n/a	3 B	n/a	6 U	85000	760000	600000	800000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB15-0406-DU	01SB15-0406-DU	01SB15-0810	01SB15-0810	01SB15-1214	ARARS & TBCs			
LOCATION:	01SB15	01SB15	01SB15	01SB15	01SB15	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/28/91	08/29/91	08/28/91	08/29/91	08/28/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	17300	n/a	13000	n/a	9740	78000	1000000	-	-
arsenic	4.3 E	n/a	0.81 U	n/a	0.79 U	0.430	3.80	3.00	4.00
barium	57	n/a	383	n/a	301	5500	140000	5000	70000
beryllium	0.97 B	n/a	1 B	n/a	1.2 B	0.150	1.30	1.00	1.30
cadmium	0.97 U	n/a	0.81 U	n/a	0.92	39.0	1000	20.0	500
calcium	850	n/a	1060	n/a	823	-	-	-	-
chromium, total	26.2	n/a	25.8	n/a	29.5	390	10000	-	-
cobalt	7.5	n/a	13.8	n/a	9.7	4700	120000	-	-
copper	10.7	n/a	4.1	n/a	5.3	3100	82000	700	37000
iron	23200 E	n/a	32000 E	n/a	29100 E	23000	610000	-	-
lead	7.1	n/a	15.8	n/a	11.8	400	-	500	1000
magnesium	2560	n/a	3010	n/a	1820	-	-	-	-
manganese	341	n/a	1930 E	n/a	1530	1800	47000	-	-
nickel	13.1	n/a	21.9	n/a	12.2	1600	41000	200	20000
potassium	904	n/a	2840	n/a	1570	-	-	-	-
sodium	704	n/a	960	n/a	843	-	-	-	-
thallium	0.21	n/a	0.34	n/a	0.22	6.30	160	6.00	80.0
vanadium	38.5	n/a	23	n/a	31.8	550	14000	-	-
zinc	36.1	n/a	44.7	n/a	34.4	23000	610000	-	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB15-1214	01SB16-0204	01SB16-0406	01SB16-0810	01SB16-1012	ARARS & TBCs			
LOCATION:	01SB15	01SB16	01SB16	01SB16	01SB16	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91				
INORGANICS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
aluminum	n/a	18100	15000	12000	9050	78000	1000000	-	-
arsenic	n/a	5.6 E	2.9 E	1.5 E	2.6 E	0.430	3.80	3.00	4.00
barium	n/a	52.7	45.6	75.2	422	5500	140000	5000	70000
beryllium	n/a	0.48 B	0.22 B	0.62 B	1.5 B	0.150	1.30	1.00	1.30
cadmium	n/a	3.1	2.6	1.2	2.4	39.0	1000	20.0	500
calcium	n/a	11200	545	469	576	-	-	-	-
chromium, total	n/a	27.7	22.2	19.6	13.8	390	10000	-	-
cobalt	n/a	17.2	9.9	12.4	30.2	4700	120000	-	-
copper	n/a	18.6	13.4	7.6	12.5	3100	82000	700	37000
Iron	n/a	26800 E	24100 E	21400	25600 E	23000	610000	-	-
lead	n/a	16.4	7.8	6.9	4.8	400	-	500	1000
magnesium	n/a	7250	2310	1200	1090	-	-	-	-
manganese	n/a	482	608	750	2310 E	1800	47000	-	-
nickel	n/a	17.2	13.2	12.2	38.2	1600	41000	200	20000
potassium	n/a	1540	947	914	374	-	-	-	-
sodium	n/a	833	728	601	734	-	-	-	-
thallium	n/a	0.41	0.26	0.15 U	0.23 U	6.30	160	6.00	80.0
vanadium	n/a	39.8	34.1	31.2	27.4	550	14000	-	-
zinc	n/a	43.9	38	23.8	55	23000	610000	-	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB17-0204	01SB17-0204-DU	01SB17-0406	01SB17-0608	01SB18-0204	ARARS & TBCs			
LOCATION:	01SB17	01SB17	01SB17	01SB17	01SB18	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/29/91	08/29/91	08/29/91	08/29/91				
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	18600	18200	18000	14200	18400	78000	1000000	-	-
arsenic	3.5 E	4.1 E	1.7 E	1.9 E	7.4 E	0.430	3.80	3.00	4.00
barium	60.1	56.6	68.8	68.6	59.9	5500	140000	5000	70000
beryllium	0.87 B	0.89 B	0.83 B	0.9 B	0.88 B	0.150	1.30	1.00	1:30
cadmium	1.5	1.1	1.2	0.9	1.3	39.0	1000	20.0	500
calcium	1150	910	717	577	2960	-	-	-	-
chromium, total	25.2	23.6	22.9	21.7	23.7	390	10000	-	-
cobalt	14.1	15.2	13.3	14	11.2	4700	120000	-	-
copper	16.3	14.7	12.9	10.9	17.1	3100	82000	700	37000
iron	28600 E	28000 E	27900 E	23400 E	29800 E	23000	610000	-	-
lead	8.5	8.4	8.4	6.6	15.7	400	-	500	1000
magnesium	3350	2990	1790	1780	3140	-	-	-	-
manganes	427	474	567	1060	281	1800	47000	-	-
nickel	17.4	16.5	14.6	15.8	16	1600	41000	200	20000
potassium	1180	941	1060	809	748	-	-	-	-
sodium	782	725	722	649	557	-	-	-	-
thallium	0.23 U	0.2 U	0.21 U	0.19 U	0.36	6.30	160	6.00	80.0
vanadium	46.2	45.5	39.7	34.2	45	550	14000	-	-
zinc	39.9	38.6	28.9	29.6	39.3	23000	610000	-	-
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
aceton	11 U	11 U	20 B	11 U	4 B	7800000	200000000	8000000	100000000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB18-0406	01SB18-0608	01SB18-0810	01SB18-1012	01SB19-0002	ARARS & TBCs			
LOCATION:	01SB18	01SB18	01SB18	01SB18	01SB19	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	08/29/91	08/29/91	08/29/91	08/29/91	04/15/97				
INORGANICS	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
aluminum	17600	17500	10300	6800	n/a	78000	1000000	-	-
arsenic	3 E	0.99 E	1.6 E	0.64 U	n/a	0.430	3.80	3.00	4.00
barium	60.1	75.2	84.2	52.6	n/a	5500	140000	5000	70000
beryllium	0.9 B	1.1 B	0.98 B	0.84 B	n/a	0.150	1.30	1.00	1.30
cadmium	1.4	0.85 U	0.98	0.84 U	n/a	39.0	1000	20.0	500
calcium	802	497	321	188	n/a	-	-	-	-
chromium, total	27.6	18.5	15.9	17	n/a	390	10000	-	-
cobalt	13.6	13	12.5	5.9	n/a	4700	120000	-	-
copper	14.7	11.3	5.5	3.4 U	n/a	3100	82000	700	37000
iron	29200 E	23300 E	20100	12900	n/a	23000	610000	-	-
lead	7.8	6.5	3.8	2.2	n/a	400	-	500	1000
magnesium	2930	1080	720	305	n/a	-	-	-	-
manganese	558	876	1180	511	n/a	1800	47000	-	-
nickel	15.6	13	12.5	5.9	n/a	1600	41000	200	20000
potassium	1090	834	292	199	n/a	-	-	-	-
sodium	775	658	387	413	n/a	-	-	-	-
thallium	0.2	0.22 U	0.2 U	0.16 U	n/a	6.30	160	6.00	80.0
vanadium	48.8	27.9	29.4	24.9	n/a	550	14000	-	-
zinc	35.9	27.9	28.2	10.7	n/a	23000	610000	-	-
VOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
1,1-dichloroethene	6 U	6 U	1 B	6 U	n/a	1100	9500	700000	9000000
acetone	5 B	11 U	11 U	6 B	n/a	7800000	200000000	8000000	100000000
methylene chloride	6 U	6 U	2 B	6 U	n/a	85000	760000	600000	800000
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PCBs (immunoassay)	n/a	n/a	n/a	n/a	1900 E	319	2860	5000	-
PCBs (tot. all)	120 U	94 U	89 U	87 U	1900 E	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB19-0204	01SB19-0406	01SB20-0002	01SB21-0002	01SB21-0204	ARARS & TBCs			
LOCATION:	01SB19	01SB19	01SB20	01SB21	01SB21	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	04/15/97	04/15/97	04/16/97	04/15/97	04/15/97				
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Aroclor-1260	n/a	n/a	n/a	n/a	49 J	319	2860	5000	-
PCBs (immunoassay)	1100 E	500 U	25000 E L	1700 E	500 U	319	2860	5000	-
PCBs (tot. all)	1100 E	500 U	25000 E L	1700 E	49	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB21-0406	01SB22-0002	01SB22-0204	01SB22-0406	01SB23-0002	ARARS & TBCs			
LOCATION:	01SB21	01SB22	01SB22	01SB22	01SB23	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	04/15/97	04/15/97	04/15/97	04/16/97	04/16/97				
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	n/a	n/a	71 J	n/a	n/a	319	2860	5000	-
PCBs (immunoassay)	500 U	2300 E	500 U	500 U	25000 E L	319	2860	5000	-
PCBs (tot. all)	500 U	2300 E	71	500 U	25000 E L	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB23-0204	01SB23-0406	01SB24-0002	01SB24-0204	01SB24-0406	ARARS & TBCs			
LOCATION:	01SB23	01SB23	01SB24	01SB24	01SB24	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	04/16/97	04/16/97	04/15/97	04/15/97	04/15/97				
SEMIVOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
bis(2-ethylhexyl)phthalate	n/a	n/a	550 B	190 B	330 B	46000	410000	300000	400000
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PCBs (immunoassay)	690 E	550 E	n/a	n/a	n/a	319	2860	5000	-
PCBs (tot. all)	690 E	550 E	n/a	n/a	n/a	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB24-0608	01SB25-0002	01SB25-0204	01SB25-0406	01SB25-0608	ARARS & TBCs			
LOCATION:	01SB24	01SB25	01SB25	01SB25	01SB25	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	04/15/97	04/15/97	04/15/97	04/15/97	04/15/97				
SEMIVOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
bis(2-ethylhexyl)phthalate	210 B	240 B	220 B	200 B	130 B	46000	410000	300000	400000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB26-0002	01SB26-0204	01SB26-0406	01SB26-0608	01SB26-0810	ARARS & TBCs			
LOCATION:	01SB26	01SB26	01SB26	01SB26	01SB26	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	04/15/97	04/15/97	04/15/97	04/15/97	04/15/97				
SEMIVOLATILES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
bis(2-ethylhexyl)phthalate	180 B	210 B	160 B	230 B	220 B	46000	410000	300000	400000

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB26-1012	01SB28-0002	01SB28-0002	01SB28-0204	01SB29-0002	ARARS & TBCs			
LOCATION:	01SB26	01SB28	01SB28	01SB28	01SB29	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	04/15/97	05/05/97	05/06/97	05/05/97	05/05/97				
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
bis(2-ethylhexyl)phthalate	250 B	n/a	n/a	n/a	n/a	46000	410000	300000	400000
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	n/a	n/a	160000 E	n/a	n/a	319	2860	5000	-
PCBs (immunoassay)	n/a	25000 E L	n/a	500 U	21000 E	319	2860	5000	-
PCBs (tot. all)	n/a	n/a	160000 E	500 U	21000 E	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB29-0204	01SB30-0002	01SB30-0204	01SB31-0002	01SB31-0204	ARARS & TBCs			
LOCATION:	01SB29	01SB30	01SB30	01SB31	01SB31	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	05/05/97	05/05/97	05/05/97	05/05/97	05/05/97				
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PCBs (immunoassay)	1000 E	550 E	500 U	1900 E	23000 E	319	2860	5000	-
PCBs (tot. all)	1000 E	550 E	500 U	1900 E	n/a	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB31-0204	01SB31-0406	01SB32-0002	01SB32-0204	01SB33-0002	ARARS & TBCs			
LOCATION:	01SB31	01SB31	01SB32	01SB32	01SB33	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	05/06/97	06/03/97	05/05/97	05/05/97	05/05/97				
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
Aroclor-1260	96	n/a	n/a	n/a	n/a	319	2860	5000	-
PCBs (immunoassay)	n/a	3900 E	2200 E	500 E	25000 E L	319	2860	5000	-
PCBs (tot. all)	96	3900 E	2200 E	500 E	25000 E L	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB33-0204		01SB33-0406		01SB34-0002		01SB35-0002		01SB35-0204		ARARS & TBCs			
LOCATION:	01SB33		01SB33		01SB34		01SB35		01SB35		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	05/05/97		06/04/97		06/03/97		06/03/97		06/03/97					
PESTICIDES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	5800	E	500	U	550	E	1900	E	500	U	319	2860	5000	-
PCBs (tot. all)	5800	E	500	U	550	E	1900	E	500	U	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB35-0406	01SB36-0002	01SB36-0204	01SB36-0406	01SB37-0002	ARARS & TBCs			
LOCATION:	01SB35	01SB36	01SB36	01SB36	01SB37	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	06/03/97	06/04/97	06/04/97	06/04/97	06/04/97				
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PCBs (immunoassay)	500 E	25000 E L	850 E	550 E	25000 E L	319	2860	5000	-
PCBs (tot. all)	500 E	25000 E L	850 E	550 E	25000 E L	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB37-0204	01SB37-0406	01SB38-0002	01SB39-0002	01SB40-0002	ARARS & TBCs			
LOCATION:	01SB37	01SB37	01SB38	01SB39	01SB40	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	06/04/97	06/04/97	06/25/97	06/25/97	06/25/97				
PESTICIDES	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Aroclor-1260	n/a	11 J	n/a	51 J	n/a	319	2860	5000	-
PCBs (immunoassay)	1100 E	500 U	500 U	500 U	550 E	319	2860	5000	-
PCBs (tot. all)	1100 E	11	500 U	500 U	550 E	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB41-0002	01SB42-0002	01SB43-0002	01SB43-0204	01SB44-0002	ARARS & TBCs			
LOCATION:	01SB41	01SB42	01SB43	01SB43	01SB44	Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil				
SAMPLE DATE:	06/25/97	06/25/97	07/01/97	07/01/97	07/01/97				
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	500 U	500 U	5800 E	500 U	2200 E	319	2860	5000	-
PCBs (tot. all)	500 U	500 U	5800 E	500 U	2200 E	319	2860	5000	-

TABLE 4-9

COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SB44-0204		01SB45-0002		01SB45-0204		01SB46-0002		01SB47-0002		ARARS & TBCs			
LOCATION:	01SB44		01SB45		01SB45		01SB46		01SB47		Risk-Based Concentration for Residential Soil Ingestion	Risk-Based Concentration for Industrial Soil Ingestion	PADEP Soil Residential Direct Contact MSC	PADEP Soil Non-residential Direct Contact MSC
DATA SOURCE:	Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil		Subsurface Soil					
SAMPLE DATE:	07/01/97		07/01/97		07/01/97		07/10/97		07/10/97					
PESTICIDES	**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**		**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
PCBs (immunoassay)	500	U	1900	E	500	U	2000	E	1100	E	319	2860	5000	-
PCBs (tot. all)	500	U	1900	E	500	U	2000	E	1100	E	319	2860	5000	-

TABLE 4-9
COMPARISON OF SUBSURFACE SOIL ANALYTICAL DATA TO ARARS AND TBCS - SITE 01
NASJRB, WILLOW GROVE, PENNSYLVANIA

Fo tnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).
UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.
UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.
No Value - Constituent was not analyzed for in this sample.
UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.
J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.
L - Value is considered biased low because of exceedance of data validation quality control criteria.
K - Value is considered biased high because of exceedance of data validation quality control criteria.
R - Positive result is considered rejected based on exceedance of data validation quality control criteria.
E - Result exceeds one or more of the selected ARARs.

Footnotes to PADEP Criteria:

MSC - Medium-Specific Concentration.

the surface soil locations (01SS19, 01SS20, 01SS24) showed similar dioxin results.

4.5.3 Surface Water

Five surface water samples (01SW01, 01SW02, and 01SW04 through 01SW06) were collected from Site 1 during Phase I RI activities. These samples were collected from surface water drainage ditches at the Privet Road Compound. Location 01SW05 is considered the upstream sample. Samples were analyzed for TAL metals and TCL VOCs. No surface water samples were obtained during the Phase II investigation. Table 4-10 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related surface water samples and compares them to background. Table 4-11 presents results of the background comparison tests. Table 4-12 presents a comparison of detected compounds to ARARs and TBCs. Figures 4-22A through D show sample locations and concentrations of compounds that exceeded ARARs and TBCs.

4.5.3.1 Inorganics

Lead exceeded reference criteria in all samples except 01SW06; however, lead levels in downstream samples did not greatly exceed the upstream concentration. Zinc levels (194 ug/l) exceeded reference criteria at 01SW06, which is the most downstream sample. Sample 01SW02, which is also a downstream point, showed elevated levels of zinc (45 ug/l). Zinc was not detected at significant levels in other samples. Antimony was detected once (01SW06 at 47 ug/l). This level exceeds reference criteria; however, only the levels of lead and zinc were considered statistically above background.

4.5.3.2 Organics

The highest levels of the two organic compounds detected in Site 1 surface water, acetone (1,300 J ug/l) and 4-methyl-2-pentanone (220 ug/l), were recorded at the upstream location (01SW05). 01SW02 was the only other location with these compounds (acetone, 170 ug/l; 4-methyl-2-pentanone, 92 ug/l).

4.5.4 Sediment

Five sediment samples (01SD01, 01SD02, and 01SD04 through 01SD06) were collected during Phase I RI activities. Phase I RI samples were analyzed for TAL inorganics, TCL VOCs, and TCL pesticide/PCBs. These locations were resampled during Phase II activities (01SD07 through 01SD11) and analyzed for semivolatiles. Location 01SD05/01SD10 is considered upstream. A mid-stream location between 01SD09 and 01SD08, identified as 01SD12, was also sampled for TAL organics and

Table 4-10
Occurrence and Distribution of Organics and Inorganics in Surface Water, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative C ncentration
aluminum	0/0	-				2/2	1260	1440	1350	01SW02 09/25/91	1440
antimony	0/8	-			NA	1/5	47	47	27.4	01SW06 09/25/91	41.3
barium	8/8	87.3	112	101	03/13/97 BGSW05	3/5	5	37	10	01SW05 09/25/91	37
calcium	8/8	15800	34900	24600	03/13/97 BGSW01	5/5	7420	42000	17000	01SW05 09/25/91	42000
chromium	0/8	-			NA	2/5	7	10	5.5	01SW05 09/25/91	8.3
iron	8/8	85.3	519	307	03/13/97 BGSW03	5/5	571	1660	1070	01SW02 09/25/91	1490
lead	0/8	-			NA	5/5	1.5	5.2	3.42	01SW02 09/25/91	4.69
magnesium	8/8	6250	12100	8890	03/13/97 BGSW01	5/5	1950	9040	4010	01SW05 09/25/91	9040
manganese	8/8	26.7	98.5	65.6	03/13/97 BGSW03	3/3	21	41	31.3	01SW02 09/25/91	41
potassium	6/8	1750	2860	1820	03/13/97 BGSW01	4/5	2380	5160	3320	01SW05 09/25/91	4920
sodium	8/8	10700	36200	20400	03/13/97 BGSW02	1/5	16700	16700	5120	01SW05 09/25/91	16700
zinc	3/8	6.8	9.1	4.53	03/13/97 BGSW04	2/2	45	194	120	01SW06 09/25/91	194
4-methyl-2-pentanone	0/8	-			NA	2/5	92	220	65.4	01SW05 09/26/91	220
acetone	0/8	-			NA	2/5	170	1300	297	01SW05 09/26/91	1300

Notes:

Units are ug/L.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

Tabl 4-11
Background Comparison Tests - Surface Water Data for Site 1
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq. Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back Freq.?				Site Maximum > UTL for Background Data?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back. Freq.	Site Freq.	P Value	YN	Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL	Site Max.	YN	r	k	P Value	YN	P Value	Test	Used	YN	Back. Mean@	Site Mean@	t Value	t Table	YN	Back. Distrib.	Site Distrib.	Std.Dev. Back.@	Std.Dev. Site@	F Value	F Table	YN
Substance																															
aluminum NA	0/0	2/2		NA						1440	NA				NA				NA		1350			NA							NA
antimony N	0/8	1/5	0.3846	N						47	NA	1	1	0.3846	N				NA		27.4			NA							NA
barium N	8/8	3/5	1.0000	N	4.61	0.0937	1.8946	L	121	37	N	9	1	1.0000	N	1.0000			N	101	10			NA	lognor.	lognor.					NA
calcium N	8/8	5/5		NA	10.1	0.322	1.8946	L	44900	42000	N	1	1	0.3846	N	0.8834			N	10.1	9.52	-1.9507	1.7959	N	lognor.	lognor.	0.322	0.699	2.9336	3.8724	Y
chromium N	0/8	2/5	0.1282	N						10	NA	1	1	0.3846	N				NA		5.5			NA							NA
iron Y	8/8	5/5		NA	307	124	1.8946	N	557	1660	Y	5	5	0.0008	Y	0.0008			Y	307	1070			NA	normal	normal					NA
lead Y	0/8	5/5	0.0008	Y						5.2	NA	5	5	0.0008	Y				NA		3.42			NA							NA
magnesium N	8/8	5/5		NA	9.06	0.266	1.8946	L	14700	9040	N	5	1	0.9565	N	0.9961			N	9.06	8.13	-3.8663	1.7959	N	lognor.	lognor.	0.266	0.608	3.3198	3.8724	Y
manganese N	8/8	3/3		NA	65.6	23.6	1.8946	N	113	41	N	9	2	0.9455	N	0.9818			N	65.6	31.3			NA	normal	normal					NA
potassium Y	6/8	4/5	0.6853	N	1820					5160	NA	3	3	0.0350	Y	0.0326			Y	1820	3320			NA	normal	normal					NA
sodium N	8/8	1/5	1.0000	N	9.81	0.501	1.8946	L	50000	16700	N	5	1	0.9565	N	0.9938	Gehan	Test	N	20400	5120			NA	lognor.	nonpar.					NA
zinc Y	3/8	2/2	0.2222	N	4.53					194	NA	2	2	0.0222	Y	0.0222	Gehan	Test	Y	4.53	120			NA	nonpar.	unknow.					NA
4-methyl-2-pentanone N	0/8	2/5	0.1282	N						220	NA	2	2	0.1282	N				NA		65.4			NA							NA
acetone N	0/8	2/5	0.1282	N						1300	NA	2	2	0.1282	N				NA		297			NA							NA

Notes: Units are ug/L.
A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.
For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:
(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.
(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.
(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.
(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)

Tabl 4-11
Background Comparison Tests - Surface Water Data for Site 1
NASJRB Willow Gr ve, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	

r,k The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-12

COMPARISON OF SURFACE WATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SW01 09/25/91	01SW01 09/26/91	01SW02 09/25/91	01SW02 09/26/91	ARARS & TBCs				
LOCATION:	01SW01	01SW01	01SW02	01SW02	AWQC Freshwater Chronic Aquatic Life	AWQC Ingestion of Water and Fish	AWQC Ingestion of Fish Only	PADEP WQC Criteria Continuous Concentrations	PADEP WQC Human Health Criteria
DATA SOURCE:	Surface Water	Surface Water	Surface Water	Surface Water					
SAMPLE DATE:	09/25/91	09/26/91	09/25/91	09/26/91					
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	590 B	n/a	1440	n/a	-	-	-	-	-
barium	3 U	n/a	5	n/a	-	-	-	4100	1000
beryllium	3 B	n/a	4 B	n/a	-	-	-	0.0100	-
calcium	8520	n/a	10600	n/a	-	-	-	-	-
copper	10 B	n/a	9 B	n/a	11.0 +	-	-	11.0 +	1000
iron	709	n/a	1660	n/a	-	-	-	-	-
lead	3.8 E	n/a	5.2 E	n/a	3.20 +	-	-	2.50 +	50.0
magnesium	1950	n/a	2600	n/a	-	-	-	-	-
manganese	16 B	n/a	41	n/a	-	-	-	-	-
potassium	2140 U	n/a	2380	n/a	-	-	-	-	-
vanadium	4 B	n/a	4 B	n/a	-	-	-	103	2.00
zinc	45	n/a	18 B	n/a	101 +	-	-	100 +	5000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
4-methyl-2-pentanone	n/a	10 U	n/a	92	-	-	-	-	-
acetone	n/a	10 U	n/a	170	-	-	-	86000	4000
methylene chloride	n/a	4 B	n/a	5 U	-	4.70	1600	2370	5.00

TABLE 4-12

COMPARISON OF SURFACE WATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SW04 09/25/91	01SW04 09/26/91	01SW05 09/25/91	01SW05 09/26/91	ARARS & TBCs				
LOCATION:	01SW04	01SW04	01SW05	01SW05	AWQC Freshwater Chronic Aquatic Life	AWQC Ingestion of Water and Fish	AWQC Ingestion of Fish Only	PADEP WQC Criteria Continuous Concentrations	PADEP WQC Human Health Criteria
DATA SOURCE:	Surface Water	Surface Water	Surface Water	Surface Water					
SAMPLE DATE:	09/25/91	09/26/91	09/25/91	09/26/91					
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	887 B	n/a	1260	n/a	-	-	-	-	-
barium	5	n/a	37	n/a	-	-	-	4100	1000
beryllium	4 B	n/a	4 B	n/a	-	-	-	0.0100	-
calcium	16400	n/a	42000	n/a	-	-	-	-	-
chromium, total	7	n/a	10	n/a	209 +	-	-	10.0	-
copper	9 B	n/a	6 B	n/a	11.0 +	-	-	11.0 +	1000
iron	1100	n/a	1290	n/a	-	-	-	-	-
lead	3.4 E	n/a	3.2 E	n/a	3.20 +	-	-	2.50 +	50.0
magnesium	4020	n/a	9040	n/a	-	-	-	-	-
manganese	21	n/a	32	n/a	-	-	-	-	-
nickel	15 B	n/a	15 B	n/a	160 +	610	4600	160 +	600
potassium	4740	n/a	5160	n/a	-	-	-	-	-
sodium	4450 U	n/a	16700	n/a	-	-	-	-	-
vanadium	4 B	n/a	7 B	n/a	-	-	-	103	2.00
zinc	21 B	n/a	9 B	n/a	101 +	-	-	100 +	5000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
4-methyl-2-pentanone	n/a	10 U	n/a	220	-	-	-	-	-
acetone	n/a	10 U	n/a	1300 J	-	-	-	86000	4000
methylene chloride	n/a	3 B	n/a	14 B	-	4.70	1600	2370	5.00

TABLE 4-12

COMPARISON OF SURFACE WATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SW06 09/25/91	01SW06 09/26/91	---	---	ARARS & TBCs				
LOCATION:	01SW06	01SW06	---	---	AWQC Freshwater Chronic Aquatic Life	AWQC Ingestion of Water and Fish	AWQC Ingestion of Fish Only	PADEP WQC Criteria Continuous Concentrations	PADEP WQC Human Health Criteria
DATA SOURCE:	Surface Water	Surface Water							
SAMPLE DATE:	09/25/91	09/26/91							
INORGANICS	ug/L	ug/L			ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	415 B	n/a			-	-	-	-	-
antimony	47 E	n/a			-	14.0	4300	219	10.0
beryllium	4 B	n/a			-	-	-	0.0100	-
calcium	7420	n/a			-	-	-	-	-
copper	8 B	n/a			11.0 +	-	-	11.0 +	1000
iron	571	n/a			-	-	-	-	-
lead	1.5	n/a			3.20 +	-	-	2.50 +	50.0
magnesium	2430	n/a			-	-	-	-	-
manganese	12 B	n/a			-	-	-	-	-
nickel	18 B	n/a			160 +	610	4600	160 +	600
potassium	3230	n/a			-	-	-	-	-
vanadium	5 B	n/a			-	-	-	103	2.00
zinc	194 E	n/a			101 +	-	-	100 +	5000
VOLATILES	ug/L	ug/L			ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	n/a	3 B			-	4.70	1600	2370	5.00

TABLE 4-12
COMPARISON OF SURFACE WATER ANALYTICAL DATA TO ARARS AND TBCS - SITE 01
NASJRB, WILLOW GROVE, PENNSYLVANIA

F otnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).
UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.
UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.
No Value - Constituent was not analyzed for in this sample.
UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.
J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.
L - Value is considered biased low because of exceedance of data validation quality control criteria.
K - Value is considered biased high because of exceedance of data validation quality control criteria.
R - Positive result is considered rejected based on exceedance of data validation quality control criteria.
E - Result exceeds one or more of the selected ARARs.

Fo tnotes to Ambient Water Quality Criteria:

- - No standard is available for this chemical in this classification.
+ - Criterion is hardness dependent and is generated based upon an assumed hardness of 100 mg/L.

TCL organic parameters (Figure 4-1). Table 4-13 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related sediment samples and compares them to background. Table 4-14 presents results of the background comparison tests. Table 4-15 presents a comparison of detected compounds to ARARs and TBCs. Figures 4-22 (A through D) show sample locations and concentrations of compounds that exceed ARARs and TBCs.

4.5.4.1 Inorganics

Arsenic and barium were detected in several samples at levels exceeding reference criteria. The on-site levels of these inorganics did exceed facility-wide background; however, they were not significantly greater than upstream concentrations.

Cadmium exceeded reference criteria at 01SD02 (4.7 mg/kg) and was detected at levels greater than concentrations found in the upstream sample (01SD05, 1.9 mg/kg), which also exceeds reference criteria. Cadmium was not detected in background samples. Lead concentrations found in 01SD01 (88.6 mg/kg) exceeded reference criteria and were greater than background and upstream samples. Manganese exceeded reference criteria in all samples except 01SD06; location 01SD02 showed levels (1,280 mg/kg) greater than background and upstream (571 mg/kg).

4.5.4.2 Organics

The pesticide dieldrin was detected in one sample, 01SD01, at 210 ug/kg. This level exceeds reference criteria but does not exceed background levels. Aroclor 1260 was detected in one sediment sample (01SD12) at 980 ug/kg. This compound was not detected in background samples. Several PAHs [benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and pyrene] were detected at concentrations exceeding reference criteria and upstream results but were not significantly above facility-wide background levels.

4.5.5 Groundwater

During the Phase I RI, 12 monitoring wells and four supply wells were sampled for TAL inorganics and TCL VOCs. During Phase II, 23 total wells (21 monitoring wells and two production wells) were sampled for TCL VOCs only (see Figure 4-1 for sample locations). Phase II sampling included a resampling of all available Phase I wells, newly installed wells, and four monitoring wells at the Air Force Reserve portion

Table 4-13
Occurrence and Distribution f Organics and Inorganics in Sediments, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
aluminum	8/8	3610	8950	6300	03/13/97 BGSD01	6/6	8060	18700	13500	01SD05 09/09/91	18700
antimony	0/5	-			NA	1/3	7.4	7.4	6	01SD12 03/17/97	7.4
arsenic	8/8	3.2	7.2	4.51	03/13/97 BGSD01	6/6	3.6	8.5	6.57	01SD12 03/17/97	7.97
barium	8/8	54.6	142	95.9	03/13/97 BGSD03	6/6	39.7	167	91.9	01SD02 09/09/91	159
beryllium	8/8	0.52	1.2	0.865	03/13/97 BGSD01	3/3	0.78	1.4	1.09	01SD02 09/09/91	1.4
cadmium	0/8	-			NA	5/6	0.87	4.7	2.09	01SD02 09/09/91	4.7
calcium	8/8	744	18200	4970	03/13/97 BGSD06	6/6	1510	9220	3660	01SD01 09/09/91	8450
chromium	8/8	6.8	34.5	15.3	03/13/97 BGSD01	6/6	14.7	31.8	24.4	01SD05 09/09/91	29.2
cobalt	8/8	4.5	12.4	7.08	03/13/97 BGSD01	6/6	5.2	17.1	9.55	01SD02 09/09/91	14.9
copper	8/8	5.8	27.8	13.3	03/13/97 BGSD01	6/6	8.8	36.1	21.1	01SD02 09/09/91	28.6
iron	8/8	9540	35400	16200	03/13/97 BGSD01	6/6	12800	33500	22600	01SD02 09/09/91	28300
lead	8/8	6.4	26.8	15.2	03/13/97 BGSD03	6/6	23.4	88.6	42.4	01SD01 09/09/91	75.1
magnesium	8/8	999	10600	3400	03/13/97 BGSD06	6/6	1910	5400	3130	01SD01 09/09/91	4840
manganese	8/8	376	759	505	03/13/97 BGSD01	6/6	243	1280	580	01SD02 09/09/91	1160
nickel	8/8	6.8	22.7	12.2	03/13/97 BGSD01	6/6	7.6	22.3	14.2	01SD02 09/09/91	21.3
potassium	6/8	514	2330	1010	03/13/97 BGSD01	6/6	692	1550	1100	01SD02 09/09/91	1380
selenium	2/8	0.36	0.44	0.193	03/13/97 BGSD03	1/6	0.32	0.32	0.471	01SD12 03/17/97	0.32
sodium	2/8	240	560	143	03/13/97 BGSD01	1/6	188	188	468	01SD12 03/17/97	188
vanadium	8/8	7.9	52.6	22.3	03/13/97 BGSD01	6/6	21	41.7	34.4	01SD05 09/09/91	40.7
zinc	8/8	25.4	97.6	50.2	03/13/97 BGSD01	6/6	67.2	124	91	01SD05 09/09/91	109
Aroclor-1260	0/8	-			NA	1/6	980	980	338	01SD12 03/17/97	835
dieldrin	1/8	3.1	3.1	2.26	03/13/97 BGSD03	1/6	210	210	49.7	01SD01 09/09/91	210
benz(a)anthracene	1/8	580	580	275	03/13/97 BGSD01	4/6	140	400	259	01SD08 03/17/97	381
benzo(a)pyrene	1/8	530	530	269	03/13/97 BGSD01	4/6	180	320	248	01SD08 03/17/97	307
benzo(b)fluoranthene	1/8	670	670	286	03/13/97 BGSD01	4/6	250	590	354	01SD08 03/17/97	576
benzo(g,h,i)perylene	0/8	-			NA	2/6	89	150	195	01SD12 03/17/97	150
benzo(k)fluoranthene	1/8	300	300	240	03/13/97 BGSD01	4/6	170	250	214	01SD08 03/17/97	237

Table 4-13
Occurrence and Distribution of Organics and In rganics in Sediments, Site 1
NASJRB Willow Gr ve, Pennsylvania

	Background Data					Site-Related Data				
Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative C ncentrati n
bis(2-ethylhexyl)phthalate	0/8	-			NA	3/6	330	1500	505	01SD09 03/17/97	1500
butylbenzylphthalate	0/8	-			NA	4/6	91	340	181	01SD08 03/17/97	340
chrysene	3/8	110	640	240	03/13/97 BGSD01	4/6	200	460	299	01SD08 03/17/97	441
fluoranthene	4/8	100	510	226	03/13/97 BGSD01	6/6	65	760	414	01SD08 03/17/97	655
indeno(1,2,3-cd)pyrene	0/8	-			NA	2/6	140	200	207	01SD12 03/17/97	200
phenanthrene	1/8	260	260	235	03/13/97 BGSD01	4/6	130	400	248	01SD12 03/17/97	400
pyrene	4/8	100	1300	319	03/13/97 BGSD01	6/6	49	890	438	01SD08 03/17/97	728

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

Table 4-14
Background Comparison T sts - Sediment Data for Site 1
NASJRB Willow Grove, Pennsylvania

Name of Test: Question Posed:	Detection Freq: Z or Fisher Site Freq > Back Freq ?				95 % Upper Tolerance Limit (UTL) Site Maximum > UTL for Background Data ?							Upper Ranks Majority are site?				Mann-Whitney/Gehan Ranks of Site > Back?				Student's or Satterthwaite T-test Site Mean > Back. Mean ?					Bartlett's Test for Equal Standard Deviations Site Standard Deviation =Background Std Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back. Freq.	Site Freq.	P Value	YN	Back. Mean@	Std.Dev. Back.@	t Value	L,N Q	Back. UTL	Site Max.	YN	r	k	P Value	YN	P Value	Test	Used	YN	Back. Mean@	Site Mean@	t Value	t Table	YN	Back. Distrib.	Site Distrib.	Std.Dev. Back.@	Std.Dev. Site@	F Value	F Table	YN
Substance																															
aluminum Y	8/8	6/6		NA	8.71	0.304	1.8946	L	11200	18700	Y	5	5	0.0030	Y	0.0010			Y	8.71	9.47	4.4550	1.7823	Y	lognor.	lognor.	0.304	0.327	0.0296	3.8639	Y
antimony N	0/5	1/3	0.3750	N						7.4	NA				NA				NA		6			NA							NA
arsenic Y	8/8	6/6		NA	1.48	0.246	1.8946	L	7.2	8.5	Y	6	5	0.0163	Y	0.0153			Y	4.51	6.57			NA	lognor.	normal					NA
barium Y	8/8	6/6		NA	95.9	27.7	1.8946	N	152	167	Y	1	1	0.4286	N	0.5791			N	4.53	4.43	-0.4486	1.7823	N	lognor.	lognor.	0.3	0.463	1.0239	3.8639	Y
beryllium Y	8/8	3/3		NA	0.865	0.265	1.8946	N	1.4	1.4	Y	1	1	0.2727	N	0.1515			N	0.865	1.09			NA	normal	normal					NA
cadmium N	0/8	5/6	0.0030	Y						4.7	NA	3	3	0.0549	N				NA		2.09			NA							NA
calcium Y	8/8	6/6		NA	4970					9220	NA	9	6	0.0280	Y	0.6667			N	4970	3660			NA	nonpar.	lognor.					NA
chromium Y	8/8	6/6		NA	2.56	0.589	1.8946	L	42.3	31.8	N	8	6	0.0093	Y	0.0420			Y	2.56	3.17	2.3243	1.7823	Y	lognor.	lognor.	0.589	0.269	2.8051	3.8639	Y
cobalt Y	8/8	6/6		NA	1.9	0.347	1.8946	L	13.4	17.1	Y	6	4	0.1562	N	0.1092			N	1.9	2.19	1.4360	1.7823	N	lognor.	lognor.	0.347	0.4	0.1127	3.8639	Y
copper Y	8/8	6/6		NA	2.46	0.527	1.8946	L	33.6	36.1	Y	7	5	0.0513	N	0.0553			N	13.3	21.1			NA	lognor.	normal					NA
iron N	8/8	6/6		NA	9.58	0.481	1.8946	L	38100	33500	N	7	5	0.0513	N	0.0956			N	9.58	10	1.7744	1.7823	N	lognor.	lognor.	0.481	0.322	0.8099	3.8639	Y
lead Y	8/8	6/6		NA	2.61	0.503	1.8946	L	37.6	88.6	Y	7	6	0.0023	Y	0.0010			Y	2.61	3.64	3.8275	1.7823	Y	lognor.	lognor.	0.503	0.484	0.0077	3.8639	Y
magnesium Y	8/8	6/6		NA	3400					5400	NA	8	6	0.0093	Y	0.5754			N	3400	3130			NA	nonpar.	lognor.					NA
manganese Y	8/8	6/6		NA	6.19	0.264	1.8946	L	832	1280	Y	1	1	0.4286	N	0.3357			N	6.19	6.23	0.1586	1.7823	N	lognor.	lognor.	0.264	0.549	2.8931	3.8639	Y
nickel N	8/8	6/6		NA	2.42	0.423	1.8946	L	26.3	22.3	N	8	5	0.1212	N	0.2594			N	2.42	2.59	0.7990	1.7823	N	lognor.	lognor.	0.423	0.375	0.0765	3.8639	Y
potassium N	6/8	6/6	0.3077	N	1010					1550	NA	11	6	0.1538	N	0.4016			N	1010	1100			NA	lognor.	normal					NA
selenium N	2/8	1/6		NA	0.193					0.32	NA				NA	0.3140	Gehan	Test	N	0.193	0.471			NA	nonpar.	lognor.					NA
sodium N	2/8	1/6		NA	143					188	NA				NA	0.3140	Gehan	Test	N	143	468			NA	nonpar.	normal					NA
vanadium Y	8/8	6/6		NA	2.9	0.664	1.8946	L	68.9	41.7	N	8	6	0.0093	Y	0.0566			N	2.9	3.51	2.3945	1.8331	Y	lognor.	lognor.	0.664	0.253	4.0395	3.8639	N
zinc Y	8/8	6/6		NA	3.81	0.475	1.8946	L	117	124	Y	8	6	0.0093	Y	0.0060			Y	50.2	91			NA	lognor.	normal					NA
Aroclor-1260 N	0/8	1/6		NA						980	NA	1	1	0.4286	N				NA		338			NA							NA
dieldrin N	1/8	1/6		NA	2.26					210	NA	1	1	0.4286	N	0.1675	Gehan	Test	N	2.26	49.7			NA	lognor.	lognor.					NA
benz(a)anthracene N	1/8	4/6	0.0629	N	275					400	NA	4	3	0.1748	N	0.1052	Gehan	Test	N	275	259			NA	nonpar.	lognor.					NA
benzo(a)pyrene N	1/8	4/6	0.0629	N	269					320	NA	4	3	0.1748	N	0.0629	Gehan	Test	N	269	248			NA	nonpar.	lognor.					NA
benzo(b)fluoranthene N	1/8	4/6	0.0629	N	286					590	NA	5	4	0.0629	N	0.0629	Gehan	Test	N	286	354			NA	nonpar.	lognor.					NA
benzo(g,h,i)perylene N	0/8	2/6	0.1648	N						150	NA				NA				NA		195			NA							NA
benzo(k)fluoranthene N	1/8	4/6	0.0629	N	240					250	NA	3	2	0.3846	N	0.0723	Gehan	Test	N	240	214			NA	lognor.	normal					NA
bis(2-ethylhexyl)phthalate N	0/8	3/6	0.0549	N						1500	NA	3	3	0.0549	N				NA		505			NA							NA
butylbenzylphthalate N	0/8	4/6	0.0150	Y						340	NA	1	1	0.4286	N				NA		181			NA							NA
chrysene N	3/8	4/6	0.2960	N	240					460	NA	5	4	0.0629	N	0.0569	Gehan	Test	N	240	299			NA	lognor.	lognor.					NA
fluoranthene N	4/8	6/6	0.0699	N	226					760	NA	3	3	0.0549	N	0.0576	Gehan	Test	N	226	414			NA	lognor.	normal					NA
indeno(1,2,3-cd)pyrene N	0/8	2/6	0.1648	N						200	NA				NA				NA		207			NA							NA
phenanthrene N	1/8	4/6	0.0629	N	235					400	NA	2	2	0.1648	N	0.0606	Gehan	Test	N	235	248			NA	lognor.	lognor.					NA

Tabl 4-14
Background Comparis n Tests - Sediment Data f r Sit 1
NASJRB Will w Grove, P nnsylvania

Name of Test: 1 - Question Posed:	Detection Freq. Z or Fisher Site Freq > Back Freq ?				95 % Upper Tolerance Limit (UTL) Site Maximum > UTL for Background Data ?							Upper Ranks Majority are site?				Mann-Whitney/Gehan Ranks of Site > Back?				Student's or Satterthwaite T-test Site Mean > Back. Mean ?					Bartlett's Test for Equal Standard Deviations Site Standard Deviation = Background Std Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
pyrene N	4/8	6/6	0.0699	N	319					890	NA	5	4	0.0629	N	0.1505	Gehan	Test	N	319	438			NA	nonpar.	normal					NA

Notes: Units are mg/kg for inorganics, ug/kg for organics.
A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.
For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:
(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.
(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.
(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.
(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-15

COMPARISON OF SEDIMENT ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SD01 09/09/91	01SD01 09/10/91	01SD02 09/09/91	01SD02 09/10/91	01SD04 09/09/91	01SD04 09/10/91	01SD05 09/09/91	Sediment Ecological Toxicity Threshold Values
LOCATION:	01SD01	01SD01	01SD02	01SD02	01SD04	01SD04	01SD05	
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	
SAMPLE DATE:	09/09/91	09/10/91	09/09/91	09/10/91	09/09/91	09/10/91	09/09/91	
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	13300	n/a	10300	n/a	18300	n/a	18700	-
antimony	11.5 B	n/a	10.6 U	n/a	10.6 U	n/a	15.9 B	150 A
arsenic	7.1	n/a	6.2	n/a	6.2	n/a	7.8	8.20 L
barium	85	n/a	167	n/a	87.3	n/a	97.7	-
beryllium	1.1	n/a	1.4	n/a	0.95 B	n/a	1.3 B	-
cadmium	2.2 E	n/a	4.7 E	n/a	2.1 E	n/a	1.9 E	1.20 L
calcium	9220	n/a	3990	n/a	2380	n/a	2360	-
chromium, total	26.8	n/a	24.9	n/a	27	n/a	31.8	81.0 L
cobalt	9.3	n/a	17.1	n/a	9	n/a	9.9	-
copper	21.6	n/a	36.1 E	n/a	21.5	n/a	22.9	34.0 L
iron	21900	n/a	33500	n/a	24400	n/a	24400	-
lead	88.6 E	n/a	29.7	n/a	41.6	n/a	44.5	47.0 L
magnesium	5400	n/a	3970	n/a	2610	n/a	2820	-
manganese	545	n/a	1280 E	n/a	463	n/a	571	1110 O
nickel	13.8	n/a	22.3 E	n/a	14	n/a	16.9	21.0 L
potassium	1390	n/a	1550	n/a	1080	n/a	1160	-
vanadium	36.1	n/a	34.5	n/a	41.4	n/a	41.7	-
zinc	102	n/a	84.3	n/a	101	n/a	124	150 L
PESTICIDES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
dieldrin	210 E	n/a	41 U	n/a	38 U	n/a	59 U	8.00 M

TABLE 4-15

COMPARISON OF SEDIMENT ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SD05 09/10/91	01SD06 09/09/91	01SD07 03/17/97	01SD08 03/17/97	01SD09 03/17/97	01SD10 03/17/97	01SD11 03/17/97	Sediment Ecological Toxicity Threshold Values
LOCATION:	01SD05	01SD06	01SD07	01SD08	01SD09	01SD10	01SD11	
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	
SAMPLE DATE:	09/10/91	09/09/91	03/17/97	03/17/97	03/17/97	03/17/97	03/17/97	
MISCELLANEOUS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
total organic carbon	n/a	n/a	22800	24600	6370	26700	15600	-
INORGANICS	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
aluminum	n/a	8060	n/a	n/a	n/a	n/a	n/a	-
antimony	n/a	7.8 B	n/a	n/a	n/a	n/a	n/a	150 A
arsenic	n/a	3.6	n/a	n/a	n/a	n/a	n/a	8.20 L
barium	n/a	39.7	n/a	n/a	n/a	n/a	n/a	-
beryllium	n/a	0.69 B	n/a	n/a	n/a	n/a	n/a	-
cadmium	n/a	0.87	n/a	n/a	n/a	n/a	n/a	1.20 L
calcium	n/a	2510	n/a	n/a	n/a	n/a	n/a	-
chromium, total	n/a	14.7	n/a	n/a	n/a	n/a	n/a	81.0 L
cobalt	n/a	5.2	n/a	n/a	n/a	n/a	n/a	-
copper	n/a	8.8	n/a	n/a	n/a	n/a	n/a	34.0 L
iron	n/a	12800	n/a	n/a	n/a	n/a	n/a	-
lead	n/a	23.4	n/a	n/a	n/a	n/a	n/a	47.0 L
magnesium	n/a	1910	n/a	n/a	n/a	n/a	n/a	-
manganese	n/a	243	n/a	n/a	n/a	n/a	n/a	1110 O
nickel	n/a	7.6	n/a	n/a	n/a	n/a	n/a	21.0 L
potassium	n/a	692	n/a	n/a	n/a	n/a	n/a	-
vanadium	n/a	21	n/a	n/a	n/a	n/a	n/a	-
zinc	n/a	67.5	n/a	n/a	n/a	n/a	n/a	150 L
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
benzo(a)anthracene	n/a	n/a	290 E J	400 E J	450 U	140 J	420 U	261 L
benzo(a)pyrene	n/a	n/a	240 J	320 J	450 U	180 J	420 U	430 L
benzo(b)fluoranthene	n/a	n/a	380 J	590	450 U	250 J	420 U	3200 A
benzo(g,h,i)perylene	n/a	n/a	89 J	500 U	450 U	490 U	420 U	670 A
benzo(k)fluoranthene	n/a	n/a	170 J	250 J	450 U	200 J	420 U	-
bis(2-ethylhexyl)phthalate	n/a	n/a	430 U	530	1500 E	490 U	420 U	1300 A
butylbenzylphthalate	n/a	n/a	100 E J	340 E J	450 U	91 E J	420 U	63.0 A

TABLE 4-15

COMPARISON OF SEDIMENT ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SD05 09/10/91	01SD06 09/09/91	01SD07 03/17/97	01SD08 03/17/97	01SD09 03/17/97	01SD10 03/17/97	01SD11 03/17/97	Sediment Ecological Toxicity Threshold Values
LOCATION:	01SD05	01SD06	01SD07	01SD08	01SD09	01SD10	01SD11	
DATA SOURCE:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	
SAMPLE DATE:	09/10/91	09/09/91	03/17/97	03/17/97	03/17/97	03/17/97	03/17/97	
SEMIVOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
chrysene	n/a	n/a	280 J	460 E J	450 U	200 J	420 U	384 L
fluoranthene	n/a	n/a	520	760 E	65 J	340 J	110 J	600 L
indeno(1,2,3-cd)pyrene	n/a	n/a	430 U	500 U	450 U	140 J	420 U	600 A
phenanthrene	n/a	n/a	170 J	350 E J	450 U	130 J	420 U	240 L
pyrene	n/a	n/a	580	890 E	49 J	270 J	88 J	660 L
VOLATILES	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**	**ug/kg**
acetone	23 U	4 B	n/a	n/a	n/a	n/a	n/a	-

TABLE 4-15

COMPARISON OF SEDIMENT ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SD12 03/17/97	---	---	---	---	---	---	Sediment Ecological Toxicity Threshold Values
LOCATION:	01SD12	---	---	---	---	---	---	
DATA SOURCE:	Sediment							
SAMPLE DATE:	03/17/97							
MISCELLANEOUS	**mg/kg**							**mg/kg**
total organic carbon	16800							-
INORGANICS	**mg/kg**							**mg/kg**
aluminum	12200							-
antimony	7.4							150 A
arsenic	8.5 E							8.20 L
barium	74.5							-
beryllium	0.78							-
calcium	1510							-
chromium, total	21.1							81.0 L
cobalt	6.8							-
copper	15.9							34.0 L
iron	18700							-
lead	26.6							47.0 L
magnesium	2070							-
manganese	380							1110 O
nickel	10.4							21.0 L
potassium	737							-
selenium	0.32 J							1.00 B
sodium	188							-
vanadium	31.5							-
zinc	67.2							150 L
SEMIVOLATILES	**ug/kg**							**ug/kg**
benzo(a)anthracene	290 E J							261 L
benzo(a)pyrene	310 J							430 L
benzo(b)fluoranthene	470 J							3200 A
benzo(g,h,i)perylene	150 J							670 A
benzo(k)fluoranthene	230 J							-
bis(2-ethylhexyl)phthalate	330 J							1300 A

TABLE 4-15

COMPARISON OF SEDIMENT ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01SD12 03/17/97	---	---	---	---	---	---	Sediment Ecological Toxicity Threshold Values
LOCATION:	01SD12	---	---	---	---	---	---	
DATA SOURCE:	Sediment							
SAMPLE DATE:	03/17/97							
SEMIVOLATILES	ug/kg							ug/kg
butylbenzylphthalate	120 E J							63.0 A
chrysene	420 E J							384 L
fluoranthene	690 E							600 L
indeno(1,2,3-cd)pyrene	200 J							600 A
phenanthrene	400 E J							240 L
pyrene	750 E							660 L
VOLATILES	ug/kg							ug/kg
acetone	25 B							-
PESTICIDES	ug/kg							ug/kg
Aroclor-1260	980							-

TABLE 4-15

COMPARISON OF SEDIMENT ANALYTICAL DATA TO ARARS AND TBCS - SITE 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

Fo tnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).

UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.

UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.

No Value - Constituent was not analyzed for in this sample.

UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.

J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.

L - Value is considered biased low because of exceedance of data validation quality control criteria.

K - Value is considered biased high because of exceedance of data validation quality control criteria.

R - Positive result is considered rejected based on exceedance of data validation quality control criteria.

E - Result exceeds one or more of the selected ARARs.

F otnotes to Sediment Criteria:

- - No standard is available for this chemical in this classification.

A - EPA Region III BTAG Screening Level (EPA, 1995).

B - Wisconsin DNR. 1995. Report of the Technical Subcommittee on Determination of Dredge Material Suitability for In-Water Disposal. Madison, Wisconsin.

L - Effects Range-Low. Source: Long E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environmental Management. 19:81-97.

M - Effects Range-Medium. Source: Long, E. R. and L. G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52, National Oceanic and Atmospheric Administration, Seattle, WA.

O - Ontario screening level. Source: Ontario Ministry of the Environment (OME). 1992. Guidelines for the Protection and Management of the Aquatic Sediment Quality in Ontario. Log 92-2309-067, PIBS

of the facility. Table 4-16 presents the occurrence and distribution of inorganic and organic chemicals detected in site-related groundwater samples and compares them to background. Table 4-17 presents results of the background comparison tests. Table 4-18 presents a comparison of detected compounds to ARARs and TBCs. Figures 4-22A through D show sample locations and concentrations of compounds that exceed ARARs and TBCs.

4.5.5.1 Inorganics

Several unfiltered samples (Phase I) exceeded reference criteria for various metals; unfiltered results were reviewed to determine if these metals concentrations may be due to suspended solids. Filtered groundwater samples from five shallow zone wells and three intermediate zone wells showed beryllium at 3 ug/l to 4 ug/l. These levels exceed reference criteria. One shallow zone well groundwater sample (01MW05S-F) showed manganese at a level above reference criteria (981 ug/l). This level is significantly above the other shallow monitoring wells. The intermediate zone well 01MW04I-F showed arsenic (2 J ug/l) and lead (17 ug/l) at levels exceeding reference criteria. Arsenic and beryllium were also detected in production wells at levels exceeding reference criteria and similar to monitoring well concentrations. Statistical tests do not indicate these inorganics are present at levels above background.

4.5.5.2 Organics

Several VOCs were detected in samples obtained during both phases of the RI; the most frequently detected compounds were PCE, ranging from 2 ug/l to 53 ug/l in 11 samples, and TCE, ranging from 1 ug/l to 120 ug/l in 26 samples. All positive detections of PCE and all TCE concentrations greater than 1 ug/l exceed reference criteria. In general, the TCE and PCE detections are more prevalent and at higher concentrations in the intermediate wells that monitor the semiconfined to confined aquifer.

The VOC detections within the shallow wells (representing the unconfined aquifer conditions of the overburden and shallow, weathered bedrock) were less prevalent and at lower concentrations during the Phase II investigation as compared to the Phase I investigation, although data quality problems during the Phase I investigation (resulting in the rejection or blanking of the PCE detections) make a direct comparison difficult. Therefore, the interpretations and conclusions in this report will focus on the most recent (Phase II) analytical data, which will be supplemented with post-Phase II (2001) analytical data provided by the Air Force and the investigation of the supply wells performed by the USGS (2001).

Table 4-16
Occurrence and Distribution f Organics and Inorganics in Groundwater, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Representativ C ncentrati n
		Min.	Max.				Min.	Max.			
aluminum		-				4/11	85 -	3430	405	01MW05S-F 09/23/91	1760
arsenic		-				2/14	4 -	4.2	1.44	01MWNW1B 10/08/91	1.88
barium		-				13/13	17 -	287	122	01MWNW2B 09/30/91	287
beryllium		-				6/6	3 -	4	3.67	01MW07I-F 09/24/91	4
calcium		-				16/16	12400 -	45400	31400	01MWNW1A 10/08/91	35800
chromium		-				1/10	18 -	18	4.95	01MW05I-F 09/23/91	6.95
cobalt		-				2/16	10 -	17	6.06	01MW05S-F 09/23/91	7.07
copper		-				1/1	37 -	37	37	01MW05S-F 09/23/91	37
iron		-				2/2	247 -	576	412	01MW02I 09/24/91	576
lead		-				11/16	1 -	18	2.92	01MW04I 09/23/91	6.08
magnesium		-				16/16	3780 -	27300	12100	01MWNW1A 10/08/91	15800
manganese		-				12/12	6 -	981	208	01MW05S-F 09/23/91	981
nickel		-				2/6	14 -	26	10.7	01MW04S-F 09/23/91	24.8
potassium		-				9/16	2180 -	38700	5750	01MW05I-F 09/23/91	11200
sodium		-				16/16	9840 -	28500	16100	01MW06S-F 09/24/91	18500
zinc		-				5/5	2 -	65	32	01MW05S-F 09/23/91	59.2
1,1,1-trichloroethane		-				2/39	1 -	3	3.95	01MW06I 09/24/91	3
1,1-dichloroethane		-				1/39	2 -	2	3.96	01MW03S 09/24/91	2
1,2-dichloroethene (total)		-				2/39	2 -	5	3.9	01MW07I 06/27/97	4.35
carbon tetrachloride		-				3/39	2 -	7	4.06	01MW07I 09/24/91	4.56
tetrachloroethene		-				11/33	2 -	53	7.94	01MWNW1A 10/07/91	9.2
toluene		-				5/39	1 -	6	4.04	01MW04I 09/23/91	4.63
trichloroethene		-				26/39	1 -	120	9.59	01MW07I 09/24/91	12

Notes:

Units are mg/kg for inorganics, ug/kg for organics.

Table 4-16
Occurrence and Distributi n of Organics and Inorganics in Groundwater, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection		Mean of All Data	Sampling Round and Location of Maximum	Representative C ncentration
		Min.	Max.				Min.	Max.			

Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

Table 4-17
Background Comparison T sts - Groundwater Data for Site 1
NASJRB Will w Gr ve, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation = Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	
aluminum N	0/0	4/11		NA						3430	NA				NA				NA		405			NA		nonpar.					NA
arsenic N	0/0	2/14		NA						4.2	NA				NA				NA		1.44			NA		nonpar.					NA
barium N	0/0	13/13		NA						287	NA				NA				NA		4.37			NA		lognor.		1.06			NA
beryllium N	0/0	6/6		NA						4	NA				NA				NA		3.67			NA		nonpar.					NA
calcium N	0/0	16/16		NA						45400	NA				NA				NA		31400			NA		normal					NA
chromium N	0/0	1/10		NA						18	NA				NA				NA		4.95			NA		nonpar.					NA
cobalt N	0/0	2/16		NA						17	NA				NA				NA		6.06			NA		nonpar.					NA
copper N	0/0	1/1		NA						37	NA				NA				NA		37			NA		unknow.					NA
iron N	0/0	2/2		NA						576	NA				NA				NA		412			NA		unknow.					NA
ead N	0/0	11/16		NA						18	NA				NA				NA		2.92			NA		lognor.					NA
agnesium Y	0/0	16/16		NA						27300	NA				NA				NA		9.3			NA		lognor.		0.485			NA
anganese N	0/0	12/12		NA						981	NA				NA				NA		4.24			NA		lognor.		1.68			NA
ickel N	0/0	2/6		NA						26	NA				NA				NA		10.7			NA		nonpar.					NA
potassium N	0/0	9/16		NA						38700	NA				NA				NA		5750			NA		nonpar.					NA
sodium Y	0/0	16/16		NA						28500	NA				NA				NA		9.65			NA		lognor.		0.29			NA
zinc N	0/0	5/5		NA						65	NA				NA				NA		32			NA		normal					NA
tetrachloroethene N	0/0	7/23		NA						36	NA				NA				NA		6.48			NA		nonpar.					NA
trichloroethene N	0/0	14/23		NA						37	NA				NA				NA		7.3			NA		lognor.					NA

Notes: Units are ug/L.

A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.

UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.

For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:

(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.

(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.

(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.

(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect. limits uniformly below the range of positive values. If not, the Gehan Test is used.

Table 4-17
Background Comparison T sts - Groundwater Data for Site 1
NASJRB Willow Grove, Pennsylvania

Name of Test: Question Posed:	Detection Freq: Z or Fisher Site Freq > Back Freq ?				95 % Upper Tolerance Limit (UTL) Site Maximum > UTL for Background Data?							Upper Ranks Majority are site?				Mann-Whitney/Gehan Ranks of Site > Back?				Student's or Satterthwaite T-test Site Mean > Back. Mean ?					Bartlett's Test for Equal Standard Deviations Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	

@ Mean and standard deviations are shown of log-transformed data when distributions are of this type; ie., if an (L) code appears for the UTL test or if site and background distributions both match lognormal, and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)

r,k The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set are comprised of site data if both populations are in fact equal.

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW01I	01MW01S	01MW01S	01MW01S-F	01MW01SO	ARARS & TBCs			
LOCATION:	01MW01I	01MW01S	01MW01S	01MW01S	01MW01SO	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Filter.Mon.Well	Monitoring Well				
SAMPLE DATE:	07/07/97	06/27/97	09/24/91	09/24/91	06/27/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	n/a	3870	85	n/a	-	-	-	37000
barium	n/a	n/a	130	19	n/a	2000	2000 a	2000	2600
beryllium	n/a	n/a	5 B	3 E	n/a	4.00	4000 e	4.00	0.0160
cadmium	n/a	n/a	4 U	5 B	n/a	5.00	5.00 e	5.00	18.0
calcium	n/a	n/a	29200	31600	n/a	-	-	-	-
chromium, total	n/a	n/a	12 B	10 B	n/a	100 *	100 a	100	180
cobalt	n/a	n/a	10	10 U	n/a	-	-	-	2200
copper	n/a	n/a	13 B	18 B	n/a	1300	-	1000	1500
iron	n/a	n/a	5120 J	40 B	n/a	-	-	-	11000
lead	n/a	n/a	8.8 E	1 U	n/a	15.0	-	5.00	15.0
magnesium	n/a	n/a	12400	11900	n/a	-	-	-	-
manganese	n/a	n/a	242	16	n/a	-	-	-	840
nickel	n/a	n/a	21 B	13 B	n/a	100	100 a	100	730
potassium	n/a	n/a	3340	2400	n/a	-	-	-	-
silver	n/a	n/a	R	6 U	n/a	-	100	100	180
sodium	n/a	n/a	16600	16400	n/a	-	-	-	-
vanadium	n/a	n/a	10 B	4 U	n/a	-	-	-	260
zinc	n/a	n/a	38 B	33 B	n/a	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	10 U	1 J	n/a	10 U	200	200 a	200	790
methylene chloride	6 B	13 B	3 B	n/a	10 UJ	5.00	2000 d	5.00	4.10
tetrachloroethene	5 E J	6 E J	32 B	n/a	10 U	5.00	1000 e	5.00	1.10
trichloroethene	9 E J	10 U	3 E J	n/a	1 J	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW02I	01MW02I	01MW02I-DUP	01MW02I-F	01MW02S	ARARS & TBCs			
LOCATION:	01MW02I	01MW02I	01MW02I	01MW02I	01MW02S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Filter.Mon.Well	Monitoring Well				
SAMPLE DATE:	06/27/97	09/24/91	06/27/97	09/24/91	06/27/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	95	n/a	72 U	n/a	-	-	-	37000
barium	n/a	65	n/a	59	n/a	2000	2000 a	2000	2600
beryllium	n/a	4 B	n/a	4 E	n/a	4.00	4000 e	4.00	0.0160
cadmium	n/a	4 U	n/a	5 B	n/a	5.00	5.00 e	5.00	18.0
calcium	n/a	43500	n/a	41800	n/a	-	-	-	-
chromium, total	n/a	11 B	n/a	11 B	n/a	100 *	100 a	100	180
copper	n/a	9 B	n/a	15 B	n/a	1300	-	1000	1500
iron	n/a	576 J	n/a	43 B	n/a	-	-	-	11000
lead	n/a	7 E	n/a	1.4	n/a	15.0	-	5.00	15.0
magnesium	n/a	11800	n/a	11600	n/a	-	-	-	-
manganese	n/a	232	n/a	213	n/a	-	-	-	840
nickel	n/a	14 B	n/a	15 B	n/a	100	100 a	100	730
potassium	n/a	11500	n/a	11000	n/a	-	-	-	-
silver	n/a	R	n/a	6 U	n/a	-	100	100	180
sodium	n/a	19600	n/a	18900	n/a	-	-	-	-
zinc	n/a	40 B	n/a	37 B	n/a	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
carbon t trachloride	10 U	2 E J	10 U	n/a	10 U	5.00	70.0	5.00	0.160
methylene chloride	14 B	3 B	5 B	n/a	9 B	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	9 B	10 U	n/a	10 U	5.00	1000 e	5.00	1.10
toluene	10 U	2 J	10 U	n/a	10 U	1000	1000 a	1000	750
trichloroethene	7 E J	6 E J	7 E J	n/a	10 U	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW02S	01MW02S-DUP	01MW02S-DUP-F	01MW02S-F	01MW03I	ARARS & TBCs			
LOCATION:	01MW02S	01MW02S	01MW02S	01MW02S	01MW03I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Filter.Mon.Well	Filter.Mon.Well	Monitoring Well				
SAMPLE DATE:	09/24/91	09/24/91	09/24/91	09/24/91	07/07/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	2930	2870	72 U	72 U	n/a	-	-	-	37000
barium	68	65	15	17	n/a	2000	2000 a	2000	2600
beryllium	5 B	5 B	3 E	3 E	n/a	4.00	4000 e	4.00	0.0160
cadmium	4 U	4 U	4 B	4 U	n/a	5.00	5.00 e	5.00	18.0
calcium	28100	29600	29900	30700	n/a	-	-	-	-
chromium, total	12 B	12 B	11 B	7 UJ	n/a	100 *	100 a	100	180
cobalt	10 U	11	10 U	10 U	n/a	-	-	-	2200
copper	18 B	13 B	19 B	19 B	n/a	1300	-	1000	1500
iron	4050 J	3730 J	45 B	42 B	n/a	-	-	-	11000
lead	10.4 E	9.6 E	1 U	1.3	n/a	15.0	-	5.00	15.0
magnesium	11300	12100	10900	11000	n/a	-	-	-	-
manganese	260	221	44	45	n/a	-	-	-	840
nickel	20 B	17 B	19 B	21 B	n/a	100	100 a	100	730
potassium	3080	3080	2390	2630	n/a	-	-	-	-
silver	R	R	6 U	6 U	n/a	-	100	100	180
sodium	15500	16300	15300	15400	n/a	-	-	-	-
vanadium	6 B	7 B	5 B	5 B	n/a	-	-	-	260
zinc	34 B	32 B	29 B	30 B	n/a	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
m thylene chloride	2 B	2 B	n/a	n/a	7 B	5.00	2000 d	5.00	4.10
tetrachloroethene	37 B	37 B	n/a	n/a	10 U	5.00	1000 e	5.00	1.10
trichloroethene	3 E J	3 E J	n/a	n/a	14 E	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW03I-DUP	01MW03S	01MW03S	01MW03S-F	01MW04I	ARARS & TBCs			
LOCATION:	01MW03I	01MW03S	01MW03S	01MW03S	01MW04I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Filter.Mon.Well	Monitoring Well				
SAMPLE DATE:	07/07/97	06/27/97	09/24/91	09/24/91	06/27/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
barium	n/a	n/a	18	21	n/a	2000	2000 a	2000	2600
beryllium	n/a	n/a	4 B	3 E	n/a	4.00	4000 e	4.00	0.0160
cadmium	n/a	n/a	4 U	4 B	n/a	5.00	5.00 e	5.00	18.0
calcium	n/a	n/a	13900	13900	n/a	-	-	-	-
chromium, total	n/a	n/a	7 U	7 B	n/a	100 *	100 a	100	180
copper	n/a	n/a	7 B	13 B	n/a	1300	-	1000	1500
iron	n/a	n/a	167 B	34 B	n/a	-	-	-	11000
lead	n/a	n/a	1.1	1	n/a	15.0	-	5.00	15.0
magnesium	n/a	n/a	6220	6060	n/a	-	-	-	-
manganese	n/a	n/a	55	44	n/a	-	-	-	840
nickel	n/a	n/a	15 B	12 B	n/a	100	100 a	100	730
potassium	n/a	n/a	2180	2140 U	n/a	-	-	-	-
silver	n/a	n/a	R	6 U	n/a	-	100	100	180
sodium	n/a	n/a	11000	10500	n/a	-	-	-	-
vanadium	n/a	n/a	4 U	5 B	n/a	-	-	-	260
zinc	n/a	n/a	25 B	16 B	n/a	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1-dichloroethane	10 U	10 U	2 J	n/a	10 U	-	-	-	810
methylene chloride	4 B	5 B	3 B	n/a	4 B	5.00	2000 d	5.00	4.10
trichloroethene	16 E	10 U	18 E	n/a	3 E J	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW04I	01MW04I-F	01MW04S	01MW04S	01MW04S-F	ARARS & TBCs			
LOCATION:	01MW04I	01MW04I	01MW04S	01MW04S	01MW04S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Filter.Mon.Well	Monitoring Well	Monitoring Well	Filter.Mon.Well				
SAMPLE DATE:	09/23/91	09/23/91	06/27/97	09/23/91	09/23/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	92 B	119 B	n/a	27800 J	593	-	-	-	37000
arsenic	2 UJ	2 E J	n/a	8.8 E J	2 UJ	50.0	-	50.0	0.0450
barium	130	181	n/a	1160	20 B	2000	2000 a	2000	2600
beryllium	3 B	5 B	n/a	10 B	5 B	4.00	4000 e	4.00	0.0160
calcium	40000	53200	n/a	36400	40600	-	-	-	-
chromium, total	10 B	18	n/a	32 B	7 U	100 *	100 a	100	180
cobalt	10 U	10 U	n/a	54	10	-	-	-	2200
copper	7 B	12 B	n/a	120	18 B	1300	-	1000	1500
iron	19 B	117 B	n/a	46400 E	43 B	-	-	-	11000
lead	18 E	17 E	n/a	22.2 E	1 U	15.0	-	5.00	15.0
magnesium	12200	16400	n/a	15400	14500	-	-	-	-
manganese	243	350	n/a	4040 E	668	-	-	-	840
mercury	0.2 U	0.2 U	n/a	0.2	0.2 U	2.00	2.00 b	2.00	11.0
nickel	14 B	13	n/a	76 B	26	100	100 a	100	730
potassium	19700	22000	n/a	5710	2140 U	-	-	-	-
silver	6 U	R	n/a	6 U	R	-	100	100	180
sodium	21100	24600	n/a	23100	19500	-	-	-	-
vanadium	4 U	4 U	n/a	43	4 U	-	-	-	260
zinc	33	51	n/a	143	55	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	5 U	n/a	4 B	5 U	n/a	5.00	2000 d	5.00	4.10
toluene	6	n/a	10 U	5 U	n/a	1000	1000 a	1000	750
trichloroethene	1 J	n/a	10 U	5 U	n/a	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW05I	01MW05I	01MW05I-F	01MW05S	01MW05S	ARARS & TBCs			
LOCATION:	01MW05I	01MW05I	01MW05I	01MW05S	01MW05S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Filter.Mon.Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/27/97	09/23/91	09/23/91	06/27/97	09/23/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	442 B	72 U	n/a	20000 J	-	-	-	37000
arsenic	n/a	2.4 E J	2 UJ	n/a	4.6 E J	50.0	-	50.0	0.0450
barium	n/a	159	155 B	n/a	524	2000	2000 a	2000	2600
beryllium	n/a	3 B	4 B	n/a	10 B	4.00	4000 e	4.00	0.0160
calcium	n/a	23000	23200	n/a	24100	-	-	-	-
chromium, total	n/a	20 B	18	n/a	12 B	100 *	100 a	100	180
cobalt	n/a	10 U	10 U	n/a	52	-	-	-	2200
copper	n/a	10 B	6 B	n/a	115	1300	-	1000	1500
iron	n/a	709	43 B	n/a	22900 E	-	-	-	11000
lead	n/a	39.8 E	4.5	n/a	10.5 E	15.0	-	5.00	15.0
magnesium	n/a	9450	10200	n/a	10600	-	-	-	-
manganese	n/a	65	6	n/a	4930 E	-	-	-	840
nickel	n/a	12 U	12 U	n/a	71 B	100	100 a	100	730
potassium	n/a	41600	38700	n/a	3420	-	-	-	-
silver	n/a	6 U	R	n/a	6 U	-	100	100	180
sodium	n/a	22400	21600	n/a	14800	-	-	-	-
vanadium	n/a	4 U	4 U	n/a	24	-	-	-	260
zinc	n/a	26	5	n/a	115	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	3 B	1 B	n/a	4 B	5 U	5.00	2000 d	5.00	4.10
toluene	10 U	4 J	n/a	10 U	5 U	1000	1000 a	1000	750
trichloroethene	10 U	1 J	n/a	10 U	5 U	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW05S-F	01MW06I	01MW06I	01MW06I-F	01MW06S	ARARS & TBCs			
LOCATION:	01MW05S	01MW06I	01MW06I	01MW06I	01MW06S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Filter.Mon.Well	Monitoring Well	Monitoring Well	Filter.Mon.Well	Monitoring Well				
SAMPLE DATE:	09/23/91	06/27/97	09/24/91	09/24/91	06/27/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	3430	n/a	1260	72 U	n/a	-	-	-	37000
barium	22 B	n/a	82	61	n/a	2000	2000 a	2000	2600
beryllium	9 B	n/a	4 B	4 E	n/a	4.00	4000 e	4.00	0.0160
cadmium	4 U	n/a	4 U	4 B	n/a	5.00	5.00 e	5.00	18.0
calcium	27300	n/a	30200	30700	n/a	-	-	-	-
chromium, total	7 U	n/a	11 B	10 B	n/a	100 *	100 a	100	180
cobalt	17	n/a	10 U	10 U	n/a	-	-	-	2200
copper	37	n/a	14 B	13 B	n/a	1300	-	1000	1500
iron	47 B	n/a	1310 J	46 B	n/a	-	-	-	11000
lead	1	n/a	5.8 E	1.2	n/a	15.0	-	5.00	15.0
magnesium	10700	n/a	7240	7390	n/a	-	-	-	-
manganese	981 E	n/a	79	6	n/a	-	-	-	840
nickel	26 B	n/a	12 U	19 B	n/a	100	100 a	100	730
potassium	2140 U	n/a	5980	2650	n/a	-	-	-	-
silver	R	n/a	R	6 U	n/a	-	100	100	180
sodium	14200	n/a	17300	15200	n/a	-	-	-	-
zinc	65	n/a	18 B	14 B	n/a	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	n/a	10 U	3 J	n/a	10 U	200	200 a	200	790
carbon tetrachloride	n/a	10 U	2 E J	n/a	10 U	5.00	70.0	5.00	0.160
methylene chloride	n/a	4 B	2 B	n/a	4 B	5.00	2000 d	5.00	4.10
tetrachloroethene	n/a	11 E	16 B	n/a	4 E J	5.00	1000 e	5.00	1.10
toluene	n/a	10 U	1 J	n/a	10 U	1000	1000 a	1000	750
trichloroethene	n/a	8 E J	10 E	n/a	2 E J	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW06S	01MW06S-DUP	01MW06S-DUP-F	01MW06S-F	01MW07I	ARARS & TBCs			
LOCATION:	01MW06S	01MW06S	01MW06S	01MW06S	01MW07I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Filter.Mon.Well	Filter.Mon.Well	Monitoring Well				
SAMPLE DATE:	09/24/91	09/24/91	09/24/91	09/24/91	06/27/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	4290	4410	72 U	72 U	n/a	-	-	-	37000
barium	149	176	65	64	n/a	2000	2000 a	2000	2600
beryllium	4 B	4 B	4 E	4 E	n/a	4.00	4000 e	4.00	0.0160
cadmium	4 U	4 U	5 B	4 U	n/a	5.00	5.00 e	5.00	18.0
calcium	12100	14200	12300	12400	n/a	-	-	-	-
chromium, total	12 B	15 B	9 B	8 B	n/a	100 *	100 a	100	180
cobalt	10 U	11	10 U	10 U	n/a	-	-	-	2200
copper	7 B	6 B	10 B	10 B	n/a	1300	-	1000	1500
iron	6320 J	6110 J	50 B	40 B	n/a	-	-	-	11000
lead	3.6	3.6	1 U	1 U	n/a	15.0	-	5.00	15.0
magnesium	5170	5850	3810	3780	n/a	-	-	-	-
manganese	337	348	31	32	n/a	-	-	-	840
nickel	16 B	18 B	12 U	14 B	n/a	100	100 a	100	730
potassium	3160	3020	2140 U	2140 U	n/a	-	-	-	-
silver	R	R	6 U	6 U	n/a	-	100	100	180
sodium	31000	33600	27900	28500	n/a	-	-	-	-
vanadium	8 B	10 B	5 B	4 U	n/a	-	-	-	260
zinc	35 B	55	26 B	24 B	n/a	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,2-dichloroethene (total)	5 U	5 U	n/a	n/a	5 J	70.0 a	70.0 a	70.0	55.0
methylene chloride	2 B	2 B	n/a	n/a	6 B	5.00	2000 d	5.00	4.10
tetrachloroethene	3 B	3 B	n/a	n/a	10 U	5.00	1000 e	5.00	1.10
trichloroethene	5 U	5 U	n/a	n/a	37 E	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW07I	01MW07I-F	01MW07S	01MW07S	01MW07S-F	ARARS & TBCs			
LOCATION:	01MW07I	01MW07I	01MW07S	01MW07S	01MW07S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Filter.Mon.Well	Monitoring Well	Monitoring Well	Filter.Mon.Well				
SAMPLE DATE:	09/24/91	09/24/91	06/27/97	09/24/91	09/24/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	297	72 U	n/a	166	72 U	-	-	-	37000
antimony	45 E	45 U	n/a	45 U	45 U	6.00	3.00 a	6.00	15.0
barium	236	213	n/a	58	38	2000	2000 a	2000	2600
beryllium	4 B	4 E	n/a	4 B	4 E	4.00	4000 e	4.00	0.0160
cadmium	4 U	5 B	n/a	4 B	6 B	5.00	5.00 e	5.00	18.0
calcium	26100	26000	n/a	26000	23600	-	-	-	-
chromium, total	8 B	7 UJ	n/a	7 U	8 B	100 *	100 a	100	180
copper	6 B	9 B	n/a	6 B	10 B	1300	-	1000	1500
iron	388 J	48 B	n/a	353 J	46 B	-	-	-	11000
lead	3.5	1 U	n/a	1.8	1 U	15.0	-	5.00	15.0
magnesium	6980	6850	n/a	9070	7940	-	-	-	-
manganese	62	43	n/a	218	167	-	-	-	840
nickel	13 B	16 B	n/a	22 B	17 B	100	100 a	100	730
potassium	2600	2460	n/a	2970	2260	-	-	-	-
silver	R	6 U	n/a	R	6 U	-	100	100	180
sodium	14900	14700	n/a	16600	15000	-	-	-	-
vanadium	5 B	4 U	n/a	4 U	4 B	-	-	-	260
zinc	9 B	9 B	n/a	32 B	47 B	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
carbon tetrachloride	7 E J	n/a	10 U	5 U	n/a	5.00	70.0	5.00	0.160
methylene chloride	2 B	n/a	10 UJ	5 U	n/a	5.00	2000 d	5.00	4.10
tetrachloroethene	5 U	n/a	5 E J	10 B	n/a	5.00	1000 e	5.00	1.10
toluene	2 J	n/a	10 U	5 U	n/a	1000	1000 a	1000	750
trichloroethene	120 E	n/a	1 J	5 U	n/a	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MW08I	01MW08S	01MWNW1	01MWNW1A	01MWNW1A	ARARS & TBCs			
LOCATION:	01MW08I	01MW08S	01MWNW1	01MWNW1	01MWNW1	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Production Well	Production Well	Production Well				
SAMPLE DATE:	07/07/97	06/30/97	07/08/97	10/07/91	10/08/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	n/a	n/a	n/a	97 B	-	-	-	37000
arsenic	n/a	n/a	n/a	n/a	4 E	50.0	-	50.0	0.0450
barium	n/a	n/a	n/a	n/a	233	2000	2000 a	2000	2600
beryllium	n/a	n/a	n/a	n/a	4 B	4.00	4000 e	4.00	0.0160
calcium	n/a	n/a	n/a	n/a	45400	-	-	-	-
copper	n/a	n/a	n/a	n/a	25 B	1300	-	1000	1500
Iron	n/a	n/a	n/a	n/a	156 B	-	-	-	11000
lead	n/a	n/a	n/a	n/a	3	15.0	-	5.00	15.0
magnesium	n/a	n/a	n/a	n/a	27300	-	-	-	-
manganese	n/a	n/a	n/a	n/a	2 B	-	-	-	840
sodium	n/a	n/a	n/a	n/a	12700	-	-	-	-
zinc	n/a	n/a	n/a	n/a	2 B	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,2-dichloroethene (total)	10 U	10 U	2 J	5 U	n/a	70.0 a	70.0 a	70.0	55.0
methylene chloride	6 B	6 B	10 UJ	5 U	n/a	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	10 U	36 E	53 E	n/a	5.00	1000 e	5.00	1.10
trichloroethene	10 U	10 U	6 E J	13 E	n/a	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MWNW1A-DU	01MWNW1A-DU	01MWNW1A-DU	01MWNW1A-F	01MWNW1B	ARARS & TBCs			
LOCATION:	01MWNW1	01MWNW1	01MWNW1	01MWNW1	01MWNW1	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Production Well	Production Well	Filter.Prod.Well	Filter.Prod.Well	Production Well				
SAMPLE DATE:	10/07/91	10/08/91	10/07/91	10/07/91	10/07/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	99 B	90	98	n/a	-	-	-	37000
arsenic	n/a	3.6 E	3.7 E	2.8 E	n/a	50.0	-	50.0	0.0450
barium	n/a	237	225	232	n/a	2000	2000 a	2000	2600
beryllium	n/a	4 B	4 E	3 E	n/a	4.00	4000 e	4.00	0.0160
calcium	n/a	44400	42800	42900	n/a	-	-	-	-
copper	n/a	25 B	15	16	n/a	1300	-	1000	1500
iron	n/a	177 B	46	56	n/a	-	-	-	11000
lead	n/a	1.8	1.1	1 U	n/a	15.0	-	5.00	15.0
magnesium	n/a	27500	25300	26600	n/a	-	-	-	-
manganese	n/a	2 B	2	2	n/a	-	-	-	840
sodium	n/a	12400	12000	12000	n/a	-	-	-	-
vanadium	n/a	4 B	4	4 U	n/a	-	-	-	260
zinc	n/a	2 U	2	2	n/a	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	5 U	n/a	n/a	n/a	1 B	5.00	2000 d	5.00	4.10
tetrachloroethene	52 E	n/a	n/a	n/a	37 E	5.00	1000 e	5.00	1.10
trichloroethene	12 E	n/a	n/a	n/a	10 E	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MWNW1B	01MWNW1B-F	01MWNW2	01MWNW2A	01MWNW2A	ARARS & TBCs			
LOCATION:	01MWNW1	01MWNW1	01MWNW2	01MWNW2	01MWNW2	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Production Well	Filter.Prod.Well	Production Well	Production Well	Production Well				
SAMPLE DATE:	10/08/91	10/08/91	07/08/97	09/27/91	09/30/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	135 B	105	n/a	n/a	99 B	-	-	-	37000
arsenic	4.2 E	2.4 E	n/a	n/a	3.2 B	50.0	-	50.0	0.0450
barium	200	114	n/a	n/a	241	2000	2000 a	2000	2600
beryllium	4 B	4 E	n/a	n/a	4 B	4.00	4000 e	4.00	0.0160
calcium	34800	21600	n/a	n/a	37400	-	-	-	-
copp r	19 B	12	n/a	n/a	31 B	1300	-	1000	1500
iron	62 B	40	n/a	n/a	247	-	-	-	11000
lead	1.2	1 U	n/a	n/a	2.8 K	15.0	-	5.00	15.0
magnesium	20400	12900	n/a	n/a	14700	-	-	-	-
manganes	1 B	1	n/a	n/a	1 B	-	-	-	840
nickel	12 U	12	n/a	n/a	12 U	100	100 a	100	730
selenium	4 U	4 U	n/a	n/a	R	50.0	-	50.0	180
sodium	9840	6530	n/a	n/a	10700	-	-	-	-
zinc	2	4	n/a	n/a	7 B	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	n/a	n/a	12 B	n/a	3 B	5.00	2000 d	5.00	4.10
tetrachloroethene	n/a	n/a	2 E J	n/a	4 E J	5.00	1000 e	5.00	1.10
trichloroethene	n/a	n/a	3 E J	n/a	6 E L	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MWNW2A-F	01MWNW2B	01MWNW2B	01MWNW2B-F	01MWWW1	ARARS & TBCs			
LOCATION:	01MWNW2	01MWNW2	01MWNW2	01MWNW2	01MWWW1	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Filter.Prod.Well	Production Well	Production Well	Filter.Prod.Well	Monitoring Well				
SAMPLE DATE:	10/02/91	09/27/91	09/30/91	10/02/91	07/09/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	133 B	n/a	101 B	113 B	n/a	-	-	-	37000
arsenic	2.2 E	n/a	2.4 B	2.9 E	n/a	50.0	-	50.0	0.0450
barium	280	n/a	287	299	n/a	2000	2000 a	2000	2600
beryllium	3 B	n/a	4 B	3 B	n/a	4.00	4000 e	4.00	0.0160
calcium	43000	n/a	41400	43900	n/a	-	-	-	-
copper	17 B	n/a	35 B	26 B	n/a	1300	-	1000	1500
iron	83 B	n/a	76 B	73 B	n/a	-	-	-	11000
lead	1 U	n/a	3.1	1 U	n/a	15.0	-	5.00	15.0
magnesium	16600	n/a	16900	17600	n/a	-	-	-	-
manganese	2 B	n/a	1 B	2 B	n/a	-	-	-	840
nickel	24 B	n/a	14	19 B	n/a	100	100 a	100	730
selenium	20 U	n/a	R	20 U	n/a	50.0	-	50.0	180
sodium	12100	n/a	12000	12000	n/a	-	-	-	-
zinc	8 B	n/a	8 B	11 B	n/a	-	2000 a	-	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	n/a	n/a	3 B	n/a	8 B	5.00	2000 d	5.00	4.10
tetrachloroethene	n/a	n/a	4 E J	n/a	10 U	5.00	1000 e	5.00	1.10
trichloroethene	n/a	n/a	5 E	n/a	8 E J	5.00	-	5.00	1.60

TABLE 4-18

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO ARARS AND TBCs - Site 01

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	01MWWW1-DUP	01MWWW1B	01MWWW2	01MWWW3	---	ARARS & TBCs			
LOCATION:	01MWWW1	01MWWW1B	01MWWW2	01MWWW3	---	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well					
SAMPLE DATE:	07/09/97	07/09/97	07/09/97	07/08/97					
VOLATILES	ug/L	ug/L	ug/L	ug/L		ug/L	ug/L	ug/L	ug/L
methyl ne chloride	7 B	3 B	8 B	5 B		5.00	2000 d	5.00	4.10
trichloroethen	8 E J	22 E	2 E J	10 U		5.00	-	5.00	1.60

Fo tnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).
UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.
UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.
No Value - Constituent was not analyzed for in this sample.
UR - Nondetected result is considered rejected based on exceedance of data validation quality control criteria.
J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.
L - Value is considered biased low because of exceedance of data validation quality control criteria.
K - Value is considered biased high because of exceedance of data validation quality control criteria.
R - Positive result is considered rejected based on exceedance of data validation quality control criteria.
E - Result exceeds one or more of the selected ARARs.

Footnotes to MCLs, MCLGs, or SMCLs:

- - No standard is available for this chemical in this classification.
a - Where applicable, value(s) represent the more stringent of criteria for total, cis-, and trans- isomers.
* - Criteria are for total chromium.
** - Copper action level 1300 ug/L for water treatment technology for public water supply systems.
*** - Lead action level 15 ug/L for water treatment technology for public water supply systems.

Footnotes to Health Advisories:

- - No standard is available for this chemical in this classification.
a - The listed health advisory criterion, lifetime adult, is equal to the most stringent of the EPA health advisories for this chemical.
b - The listed health advisory criterion, long-term adult, is equal to the most stringent of the EPA health advisories for this chemical.
c - The listed health advisory criterion, one-day child, is equal to the most stringent of the EPA health advisories for this chemical.
d - The listed health advisory criterion, ten-day child, is equal to the most stringent of the EPA health advisories for this chemical.
e - The listed health advisory criterion, long-term child, is equal to the most stringent of the EPA health advisories for this chemical.

F otnotes to PADEP Criteria:

MSC - Medium-Specific Concentration.

Shallow Wells – Unconfined Aquifer

Th shallow wells monitor the groundwater conditions of the unconfined or water-table aquifer. The principal VOCs detected in this aquifer are chlorinated solvents, particularly TCE and PCE. The highest VOC concentration detected in a shallow well during either phase of the investigation was 18 ug/l of TCE at 01MW03S in 1991. However, during Phase II sampling, TCE was not detected in this well. Only low levels of TCE (1 ug/l) and PCE (up to 5 ug/l) were detected in shallow wells. Well clusters 01MW04, 01MW05, and 01MW08 did not show detectable levels of VOCs in either well during Phase II sampling. Low levels (below reference criteria) of VOCs were detected in 01MW04I and 01MW05I during the 1991 sampling.

Intermediate Wells – Upper Portion of the Confined Aquifer

The intermediate wells monitor the upper portion of the confined aquifer. The highest levels of VOCs in intermediate wells were at locations 01MW03I (TCE, 16 ug/l), 01MW06I (PCE, 11 ug/l; TCE 8 J ug/l), and 01MW07I (TCE, 37 ug/l). TCE levels at 01MW03 have remained relatively unchanged since the 1991 sampling, and they have decreased from 120 ug/l at 01MW07I. In 1991, TCE was detected at 01MW06I at 10 ug/l; however, PCE was not detected at a confident level. The intermediate well at the Air Force Reserve facility (01MWWW1B) showed the highest levels of TCE (22 ug/l) detected in that portion of the facility. The shallow well at that location showed 8 J ug/l.

Supply Wells – Deeper Portion of Confined Aquifer

The production wells are open boreholes for hundreds of feet across multiple water-bearing units within the semi-confined to confined zone and possibly within the shallower, unconfined zone. Thus, grab samples collected from these wells represent a composite analysis of groundwater contributed by multiple water-bearing zones. The grab samples from Supply Well No. 1 (01MWNW1) contained concentrations of PCE at 36 ug/l and TCE at 6 J ug/l during Phase II, and PCE at 53 ug/l and TCE at 13 ug/l during Phase I. Supply well No. 2 (01MWNW2) contained TCE at 3 J ug/l and PCE at 2 J ug/l during Phase II, and TCE at 6 L ug/l and PCE at 4 J ug/l during Phase I. The composite groundwater samples indicate that Supply Well No. 1 is significantly more contaminated than Supply Well No. 2, that PCE is the dominant contaminant in well No. 1, and that PCE and TCE are present at approximately equally low concentrations within well No. 2. However, these results do not indicate whether the VOCs are entering the open boreholes at high concentrations via a few discrete fractures prior to dilution or if the VOCs are entering the boreholes at lower concentrations via many fractures throughout the entire vertical column.

As discussed, the USGS obtained discrete groundwater samples from isolated water-bearing zones within both supply wells through the use of straddle packers (USGS 2001 - Appendix O). The results of the VOC analyses from these samples are summarized in Table 4-19. The packer test results indicate that the groundwater contaminants are not homogeneously distributed throughout the boreholes.

Similar to the results of the grab (composite) groundwater samples, the USGS tests indicate that well No. 1 is the more highly contaminated supply well. The packer tests, however, also reveal that the deeper portions of well No. 1 are significantly more contaminated than the shallower portions, especially at and below a subsurface depth of 182 feet. Neither TCE nor cis-1,2-DCE were detected in four samples taken between depths of 52 to 152 feet, but each were detected consistently at generally low (less than 10 ug/L) concentrations in four samples taken between depths of 182 to 354 feet. PCE was detected at generally low concentrations (1.7 to 6.2 ug/L) in the four samples taken between 52 and 152 feet, but the concentrations sharply increased (16 to 39 ug/L) in the four samples taken between the depths of 182 to 354 feet.

The packer tests of well No. 2 indicate that no VOCs were detected in the shallow portion of the borehole. TCE was detected at low concentrations (1.1 to 1.6 ug/L) from two of the three samples taken between depths of 162 to 314 feet, and PCE was not detected until a subsurface depth of 205 feet (at 3.6 ug/L).

Therefore, the packer tests indicate that the deeper groundwater within the vicinity of the Privet Road Compound (below a depth of approximately 180 feet) is significantly more contaminated than the shallower groundwater. Through the correlation of the geophysical logs, the USGS also determined that the highest concentrations of TCE and PCE in each borehole are associated with the same lithologic unit (sandstone lithologic unit "H") that occurs at a subsurface depth greater than 200 feet below the Privet Road Compound. In addition, the USGS concluded that, although few water-bearing fractures in the two supply wells are common to lithologic units, the wells did indeed share a common (or interconnected) water-bearing fracture within lithologic unit "H." Based on the local bedrock strike and dip, this lithologic unit is interpreted to crop out approximately 2,000 feet southeast of well no. 1 and 1,700 feet southeast of well no. 2 (USGS, 2001).

Off-Site Groundwater Conditions

Off-site groundwater conditions were investigated to determine whether site-related groundwater contamination had migrated to off-site receptors or, conversely, whether the Privet Road Site in general, and the supply wells in particular, are being impacted by off-site groundwater contamination that is migrating on base either through the ambient hydraulic gradient or via capture by the pumping of the supply wells. The off-site conditions are summarized in Figure 4-23 and discussed below.

TABLE 4-19

SITE 1: PRIVET ROAD COMPOUND
USGS PACKER TEST ANALYTICAL RESULTS OF NAVY SUPPLY WELLS NO. 1 AND NO. 2

SUPPLY WELL NO. 1 (April 2000)				
SAMPLE DEPTH	TCE	PCE	c-1,2-DCE	1,1,1-TCA
52 - 59	ND	4.0 J	ND	1.5 J
79 - 85	ND	1.7 J	ND	2.6 J
106	ND	2.0 J	ND	2.3 J
124 - 152	ND	6.2 J	ND	ND
182	2.4 J	16	1.0 J	1.9 J
241	9.0 J	34	3.9 J	ND
256	8.3 J	39	4.7 J	ND
350 - 354	8.3 J	21	3.1 J	ND

SUPPLY WELL NO. 2 (March 2000)				
SAMPLE DEPTH	TCE	PCE	c-1,2-DCE	1,1,1-TCA
68 - 74	ND	ND	ND	ND
115	ND	ND	ND	ND
162	1.6 J	ND	ND	ND
205	1.1 J	3.6 J	ND	ND
314	ND	1.8 J	ND	ND

Notes:
Sample depth is in feet.
Analytical results are in ug/L.
TCE = Trichloroethene.
PCE = Tetrachloroethene.
c-1,2-DCE = cis-1,2-Dichloroethene.
1,1,1-TCA = 1,1,1-Trichloroethane.

1. Tinius Olsen Property / Retail Gasoline Station. The Tinius Olsen metal working (manufacturing) facility and the retail gasoline station are located approximately 4,000 feet and 5,000 feet southeast of the Privet Road Site, respectively. In 1997, the Navy installed four shallow monitoring wells around the Tinius Olsen property (which lies immediately adjacent to the Navy property) due to the detection of the gasoline component methyl tert butyl ether (MTBE) in the Tinius Olsen supply well (Brown & Root Environmental, 1997). Based on the determination of groundwater flow direction (generally toward the northwest) and the delineation of the plume, the report concluded that the contamination did not originate on Navy property and that the retail gasoline station (which had a documented gasoline release) was a possible source. Chlorinated solvents were not common in the wells (one well contained 12 ug/L of carbon tetratchloride, but no wells contained TCE or PCE), indicating that neither of these properties is a potential source of the contamination detected in the vicinity of the Privet Road site.

2. Horsham Township Municipal Authority (HTMA), Well No. 10. This supply well is located approximately 3,600 feet southeast of the Privet Road Site. Low concentrations of TCE and 1,1,1-TCA are detected fairly frequently, but inconsistently, in this supply well. In the most recent analysis available (October 25, 2001), TCE was detected at 0.2 ug/L and 1,1,1-TCA was detected at 0.2 ug/L. A review of historical (post-1996) data supplied by HTMA indicates that, although the data are incomplete, the concentrations reported for October 2001 are fairly typical for this well when organics are detected, although no detections are reported for many sampling events. According to the HTMA, this well is 271 feet deep and has casing set to a depth of 50 feet.

3. Former Kellet Aircraft Facility. This manufacturing facility is located approximately 2,000 feet southeast of the Privet Road Site and is situated very near (or directly above) the outcrop zone for lithologic unit "H," which is the most highly contaminated water-bearing zone beneath the Privet Road Site. This facility has been the subject of several investigations conducted by PADEP and EPA (a preliminary assessment in 1987 and a site investigation in 1989) due to a documented, unpermitted discharge of wastewater from an aluminum cleaning process onto the property.

The EPA site investigation (HNUS, 1989) detected VOCs in on-site surface water samples. PCE was detected at 43 ug/L and TCE was detected at 9 ug/L in samples taken from an on-site intermittent stream, and 1,1,1-TCA was detected at 11 ug/L and 10 ug/L (field duplicate) in a sample taken from an on-site drainage ditch. Drainage ditches and intermittent streams are not significant discharge points for groundwater and typically either collect surface water runoff or (infrequently) discharge from the shallowest portions of the saturated zone during times of an elevated water table. In either case, these detections most likely represent contamination that is originating at the former Kellet Aircraft Facility, rather than contaminated groundwater migrating from other locations.

4. Restaurant Well. This facility is located approximately 3,000 feet southeast of the Privet Road Site. Analytical data for this well were obtained from the PADEP files for the Kellet Aircraft facility. The well's construction details are not known (including its depth, yield, and casing depth), and it is not known if the well is used for potable supply. A groundwater sample obtained by PADEP in 1997 contained the following VOCs: PCE (16 ug/L), TCE (5 ug/L), cis-1,2-DCE (4.6 ug/L), 1,1-DCE (0.75J ug/L), and 1,1,1-TCA (0.31J ug/L).

Discussion and Significance of Off-Site Groundwater Conditions

The off-site groundwater conditions suggest that at least some of the contamination detected in the Navy supply wells may be attributable to an off-site source.

The surface water contamination at the Kellet Aircraft site indicates that TCE, PCE, and 1,1,1-TCA were apparently released at that facility (HNUS, 1989). These are the most abundant VOCs detected in the Navy supply wells. PCE is the dominant contaminant at both Kellet and within the supply wells. The Kellet facility sits on or very near the outcrop area of the most highly contaminated lithologic unit (Unit "H") beneath the Privet Road Site (USGS, 2001). The USGS also noted that the fractures associated with Lithologic Unit H formed one of the more pervasive fracture sets (in terms of interconnectedness or continuity) beneath the Privet Road Site and in the two supply well boreholes. Michalski (1997) points out that, within the Triassic Basin, updip extensions of the major bedding fractures into the weathered zone provide dominant pathways for downdip drainage across the weathered zone. Thus, a plausible conceptual model would include the introduction of the TCE, PCE, and 1,1,1-TCA into the aquifer (lithologic unit "H") at the Kellet facility, the downdip (and downgradient) migration of the contaminants primarily within the bedding plane fractures of Lithologic Unit H, and the subsequent capture of these contaminants by the Navy supply wells. This model also explains why the VOCs detected in the Navy supply wells and the Privet Road monitoring wells occur dominantly (or entirely) within the semi-confined to confined zone, as opposed to the shallower unconfined zone, which would be expected if these wells were located in the proximity of the contamination source.

The detections of VOCs in the restaurant well and the absence of or very limited detections of VOCs in the HTMA public Supply Well No. 10 indirectly support the hypothesis of an off-site VOC source in the vicinity of the wells. The HTMA well is known to be cased to a depth of 50 feet, which would effectively case off the shallow groundwater of the unconfined zone and place the open portion of the borehole within the semiconfined to confined zone (based on the conceptual model for the Privet Road Site). Although the construction details for the restaurant well are not known, it is assumed that the construction details for a well serving a single establishment would be similar to a residential well, and it is possible that the casing depth would be much shallower for this well (competent rock is typically encountered at a

subsurface depth of approximately 20 feet in this area), which would allow groundwater from the shallow unconfined zone to enter the well. Although circumstantial, the absence of VOCs in a well known to be cased off from the shallow groundwater and the presence of VOCs in a well that is probably not cased off from the shallow groundwater would appear to be indicative of a shallow source of groundwater contamination in the vicinity of the wells.

The source of the VOC contamination in the restaurant well is not known. The presence of PCE and TCE occurring in approximately the same concentrations and ratios as detected at the Kellet facility (and the Navy supply wells) would suggest that the VOCs in the restaurant well and those detected at the Kellet facility share a common source. However, it is also recognized that the restaurant well is located approximately 1,000 feet upgradient and updip from the Kellet facility, and it is not certain if the capture zone of the restaurant well (which presumably serves only that single establishment) has such an areal extent.

In summary, a review of the off-site groundwater and surface water data reveals the presence of VOC contamination adjacent to NASJRB Willow Grove. The primary off-site VOCs (PCE, TCE, and 1,1,1-TCA) are detected at concentrations and ratios generally similar to those detected in the Navy supply wells. The source of the VOC contamination is not known but may originate in the vicinity of the former Kellet Aircraft facility. The area geology (bedrock dip) and hydraulic gradients permit the migration of the VOC contaminants from the off-site locations toward the capture zone of the Navy supply wells, but conversely, it is not possible for any groundwater contamination that might originate at the Privet Road Compound to migrate toward and impact the areas where the off-site contamination has been detected. Therefore, by presenting a nearby and technically viable source for the VOC contamination in the Navy supply wells, these data are believed to support the conclusion that the source of the VOCs in the Navy wells is not the Privet Road Compound.

4.5.6 Conclusions

Soils

Based on the findings of previous investigations, it was recognized that, due to leakage from PCB-containing transformers stored in the vicinity of the present bowling alley at the Privet Road Site, there existed an area of soil contaminated with PCBs at the surface and shallow subsurface. PCBs were detected at a high frequency in on-site surface soil samples. Limited migration of PCBs was occurring, as evidenced by only one detection in surface water sediment receiving drainage from the site. The Navy performed a soil removal action for the (PCB) contaminated soils near the bowling alley located on the Privet Road Compound Area in June 1999. Appendix D contains the PCB soil removal summary report.

Groundwater

The analytical results for the unconfined and confined aquifers from the Privet Road monitoring wells and the Air Force Washrack monitoring wells were compared to the analytical results from the Navy supply wells and evaluated relative to the new interpretation of the groundwater flow directions under pumping and non-pumping scenarios. The analytical results suggest

- The Privet Road Compound (Site 1) is not the source of the groundwater contamination or is, at most, a relatively minor source.

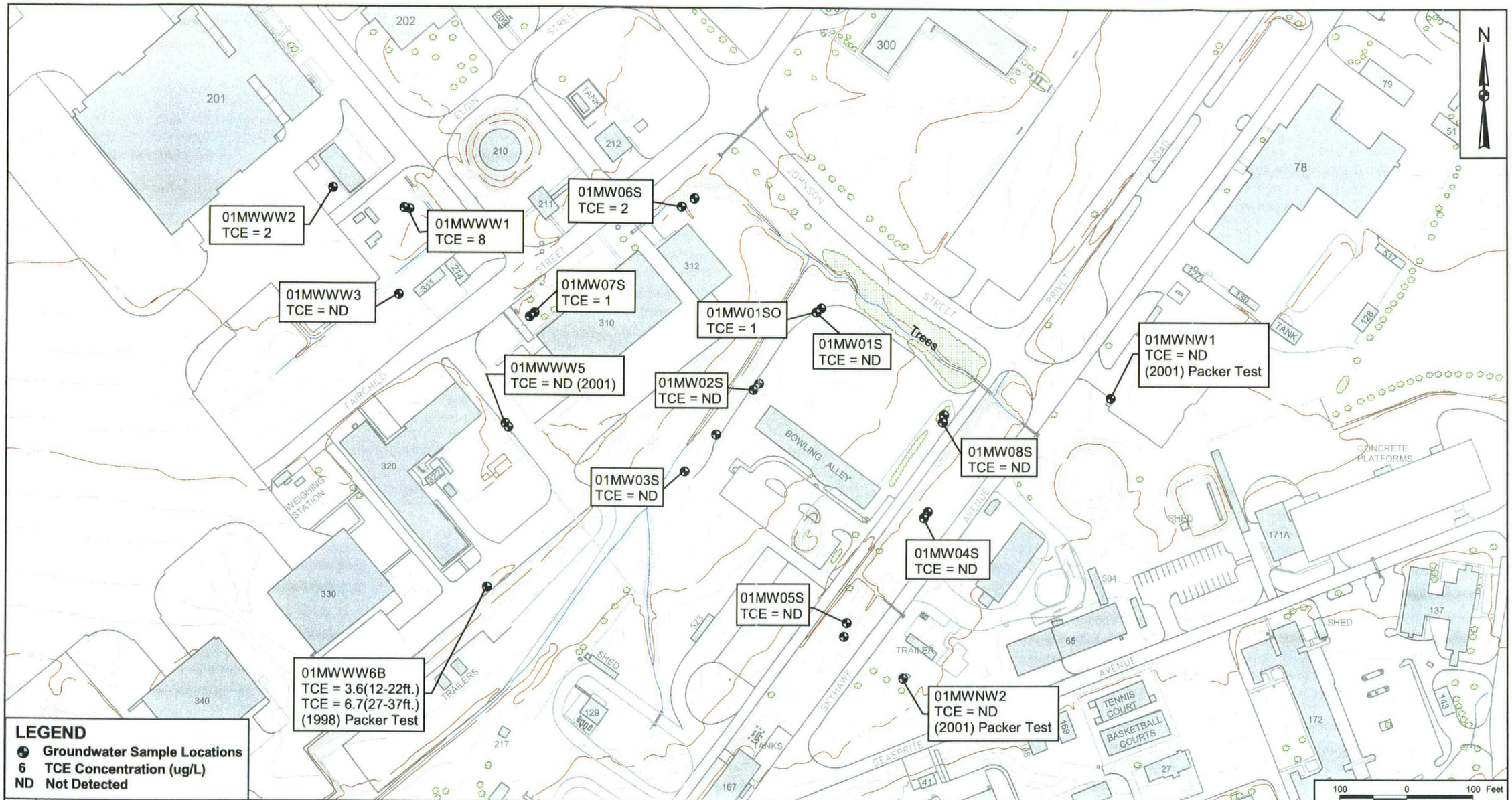
- At least three (possibly four) individual plumes may coalesce beneath the Privet Road Compound.
  - Several on-site source areas create a separate TCE plume and mixed (PCE and TCE) plume.
  - An off-site source(s) creates a mixed TCE and PCE plume contributing to the deeper (greater than160 feet) groundwater contamination detected in the Navy supply wells.

The distribution of TCE within the unconfined and confined aquifers at Site 1 is illustrated in Figures 4-24 and 4-25. The distribution of PCE within the unconfined and confined aquifers at Site 1 is illustrated in Figures 4-26 and 4-27. The majority of the posted data were collected during the Phase II investigation (1997), but these data are supplemented with post-Phase II data (2001) supplied by the Air Force for monitoring wells installed as part of their Wash Rack investigation. The depth-specific (packer test) analytical data for the Navy supply wells was supplied by the USGS (2001).

PCE

The distribution of the PCE in the vicinity of the Privet Road Compound and within the supply well boreholes indicates that the PCE may originate at two different sources. As will be discussed below, the data suggest that a shallow, less concentrated source may exist in the vicinity of Supply Well No. 1 and that the deeper, more highly contaminated groundwater may be migrating to the supply wells from an off-site source. Whether there are multiple sources and regardless of their location(s), however, the data also indicate that the Privet Road Compound is not the source of the PCE.

PCE was not detected within either the unconfined or the confined aquifer upgradient of the Privet Road Compound. PCE was detected rarely within both the unconfined aquifer (at 6 ug/l) and the confined aquifer (at 5 ug/l) at one monitoring well cluster (01MW01) located immediately downgradient of the northwestern corner of the compound, but PCE was not detected in the other (more southern) downgradient monitoring



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

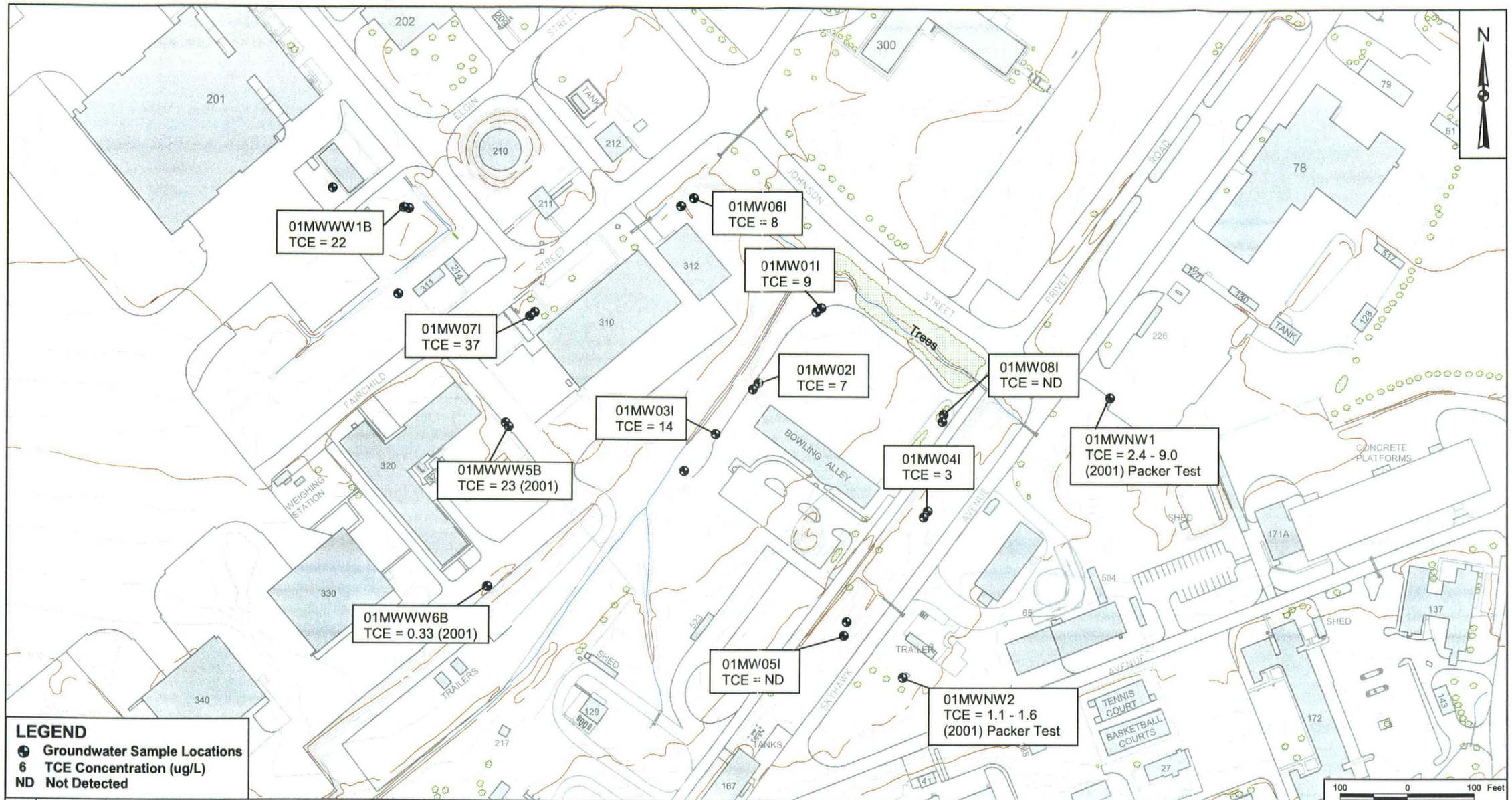
DRAWN BY CM / LDL DATE 2/22/02
CHECKED BY KCK DATE 2/22/02
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

DISTRIBUTION OF TCE IN THE UNCONFINED AQUIFER
NASJRB SITE 1 - PRIVET ROAD
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NO. 5466
OWNER NO. 2207
APPROVED BY RET DATE
APPROVED BY DATE
DRAWING NO. **FIGURE 4-24** REV.

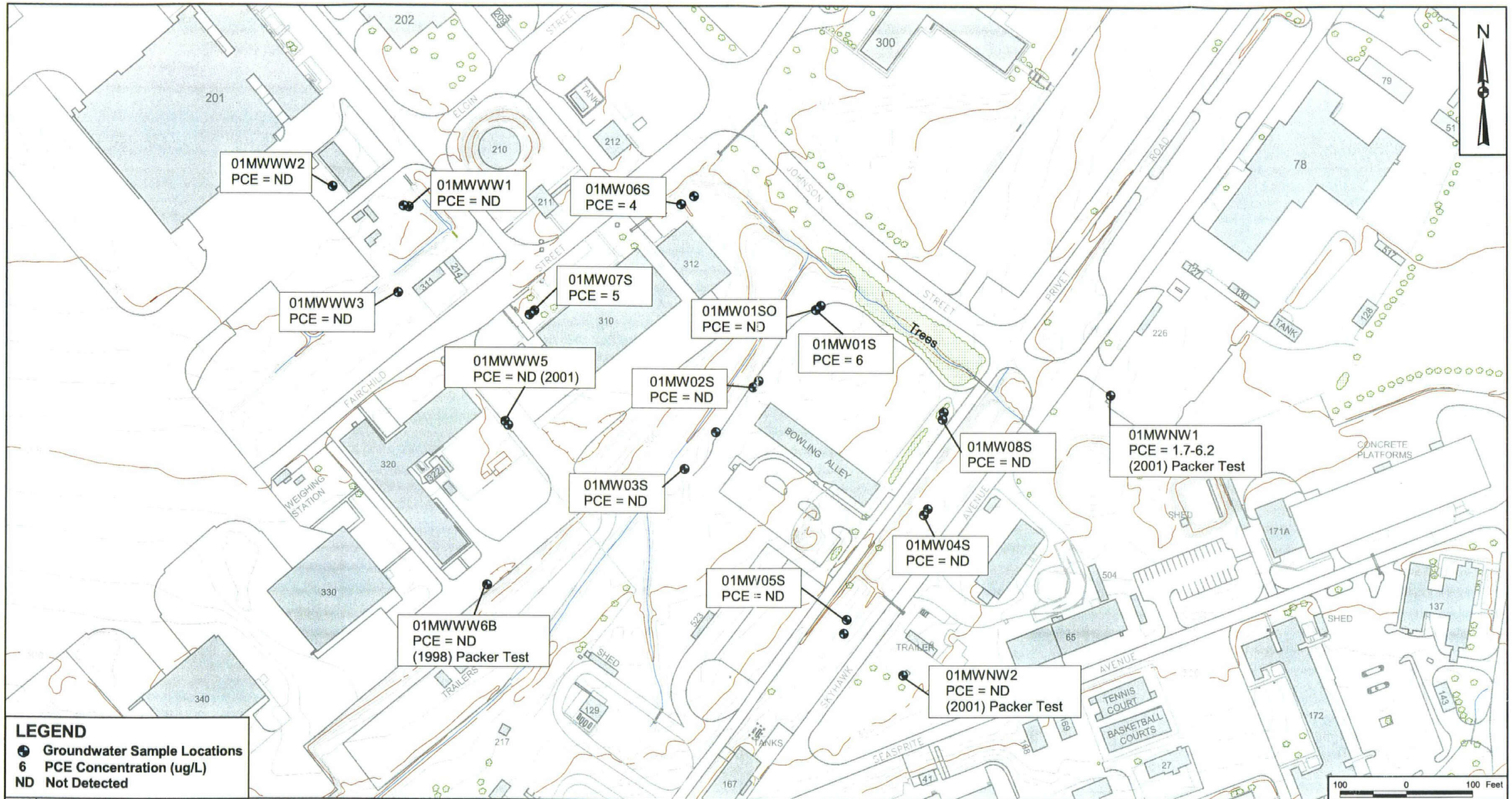
FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1.apr - LAYOUT: FIGURE 4-24
DATE: 2/12/02 BY: CM



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/28/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/28/02	DISTRIBUTION OF TCE IN THE CONFINED AQUIFER NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4- 25 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1 apr - LAYOUT: FIGURE 4-25 DATE: 2/12/02 BY: CM



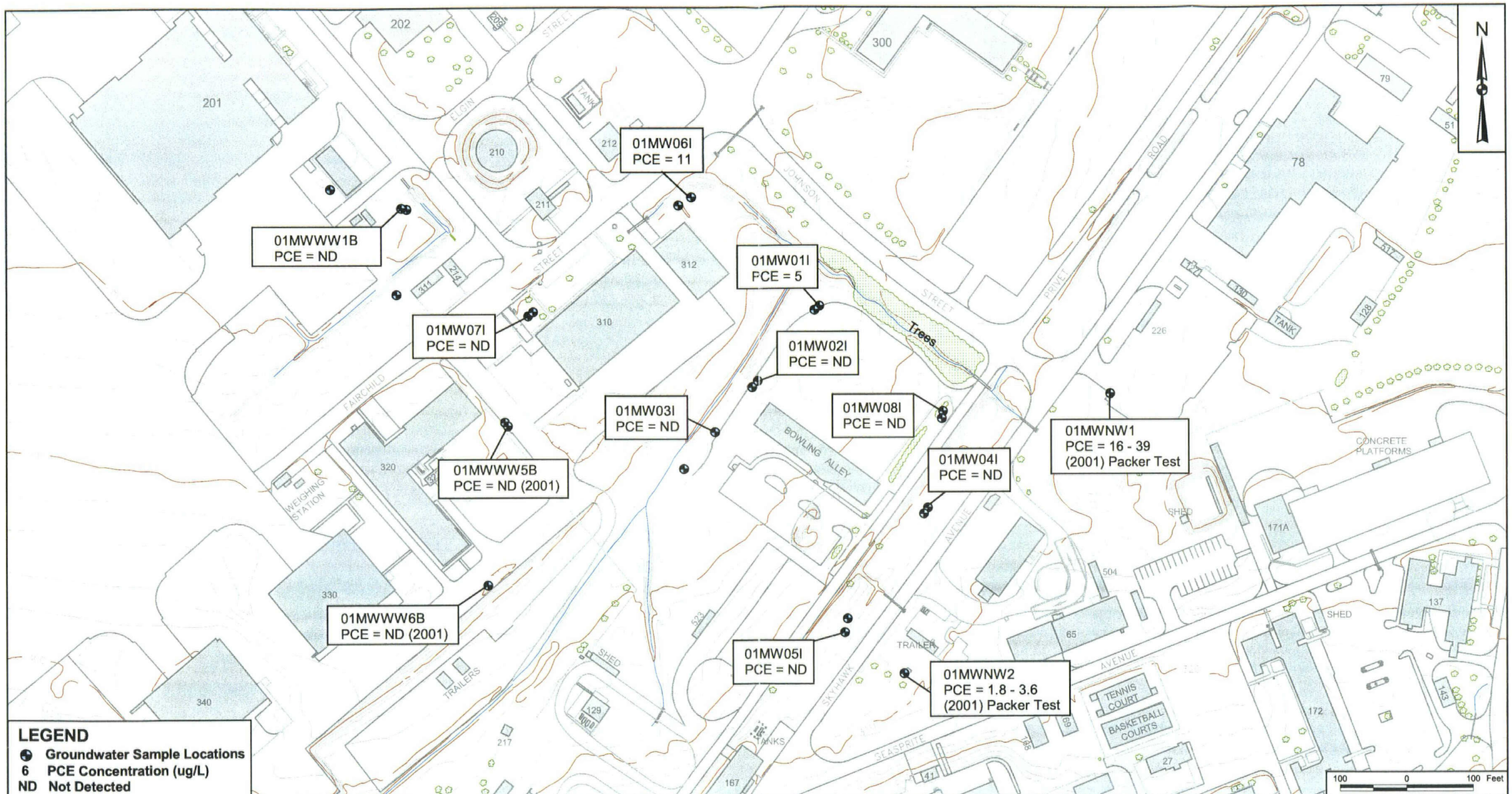
LEGEND

- Groundwater Sample Locations
- 6 PCE Concentration (ug/L)
- ND Not Detected

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL	DATE 2/28/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466 / OWNER NO. 2207
CHECKED BY KCK	DATE 2/28/02	DISTRIBUTION OF PCE IN THE UNCONFINED AQUIFER NASJRB SITE 1 - PRIVET ROAD NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY / DATE
COST/SCHED-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 4-26 / REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1.apr - LAYOUT: FIGURE 4-26
DATE: 2/12/02 BY: CM



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY CM / LDL DATE 2/28/02
CHECKED BY KCK DATE 2/28/02
COST/SCHED-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

DISTRIBUTION OF PCE IN THE CONFINED AQUIFER
NASJRB SITE 1 - PRIVET ROAD
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NO. 5466
OWNER NO. 2207
APPROVED BY RET DATE
APPROVED BY DATE
DRAWING NO. **FIGURE 4-27** REV.

FILE: H:/GIS/GIS-Projects/Pittsburgh-Willow_Grove/
SITE-1.apr - LAYOUT: FIGURE 4-27
DATE: 2/12/02 BY: CM

well clusters (01MW02 and 01MW03) that are also located immediately adjacent to the compound, and PCE was not detected from either aquifer in the vicinity of the Air Force Washrack. Therefore, the areal distribution of PCE appears to indicate either a potential minor source of PCE in the northwestern corner of the Privet Road Compound or a source migrating through the northwestern corner of the compound from an unknown and farther upgradient source. The fact that no PCE was detected from any of the soil borings drilled in the compound proper during the Phase I RI would support the interpretation that the Privet Road Compound is not the source of the PCE. In addition, under pumping conditions, a monitoring well cluster with no detections of PCE in either aquifer (01MW08) lies directly between the supply well and the potential source area in the northwestern corner of the compound near 01MW01, which would also support the conclusion that PCE is not migrating from the compound to the supply well.

The PCE concentration detected in the grab sample from Navy Well No. 1 (36 ug/l) is much higher than the levels detected in any monitoring well, suggesting that Well No. 1 is either closer to the source or is capturing the contaminated groundwater from a groundwater plume located elsewhere than beneath the Privet Road Compound. The vertical profile performed by the USGS indicates that PCE occurs at relatively low concentrations (1.7 to 6.2 ug/L) between subsurface depths of 53 feet (just below casing) and 152 feet and that significantly higher concentrations (16 to 39 ug/L) occur between depths of 182 feet and 354 feet. Based on the conceptual site model and current interpretation, a casing depth of 52 feet in this area would probably not be deep enough to case or seal off the entire shallow (or unconfined) aquifer (although the lack of well control in the immediate vicinity of Supply Well No. 1 makes this conclusion somewhat tentative). If the PCE that is detected in the shallower portion of the borehole at relatively lower concentrations is reflecting the local water quality of the unconfined aquifer or the transition zone, a PCE source may exist upgradient of the Privet Road Compound and in the vicinity of Supply Well No. 1.

It is also noteworthy that, in 1984, approximately 13 ug/l of PCE was detected in a deep (200-foot) open borehole monitoring well that was located northeast of the supply wells, near the Public Works Building (Earth Data, Inc., 1984) (this well could not be located during the present investigation and is assumed to be destroyed). This well was cased to a depth of 40 feet and had multiple water-bearing zones within the open interval, so the depth(s) of the PCE contamination is not known. Regardless of the vertical profile of contamination, however, the Privet Road Compound could not have been the source of the PCE in this former monitoring well because it is not possible (under the current site interpretation) for groundwater from the compound to flow to the vicinity of the Public Works Building under either pumping or non-pumping conditions. It is possible, however, for groundwater from the vicinity of this former monitoring well to be captured by and flow to the supply wells, which again may indicate that a source of the PCE contamination in the former monitoring well and in the supply wells is situated in the vicinity of the former monitoring well (i.e., near Building 78). The surface topography in this portion of the base also suggests that, although the regional groundwater flow direction is toward the northwest, it would not be unreasonable

to expect groundwater under non-pumping conditions to flow locally from the Public Works Building toward the Privet Road Compound (hydraulic head data do not exist for this area). All of these data and observations suggest that the Privet Road Compound is not the source of the PCE detected in the shallower portion (above 182 feet) of Navy Supply Well No. 1 and that this PCE may be migrating from an undetermined source located northeast of the supply well.

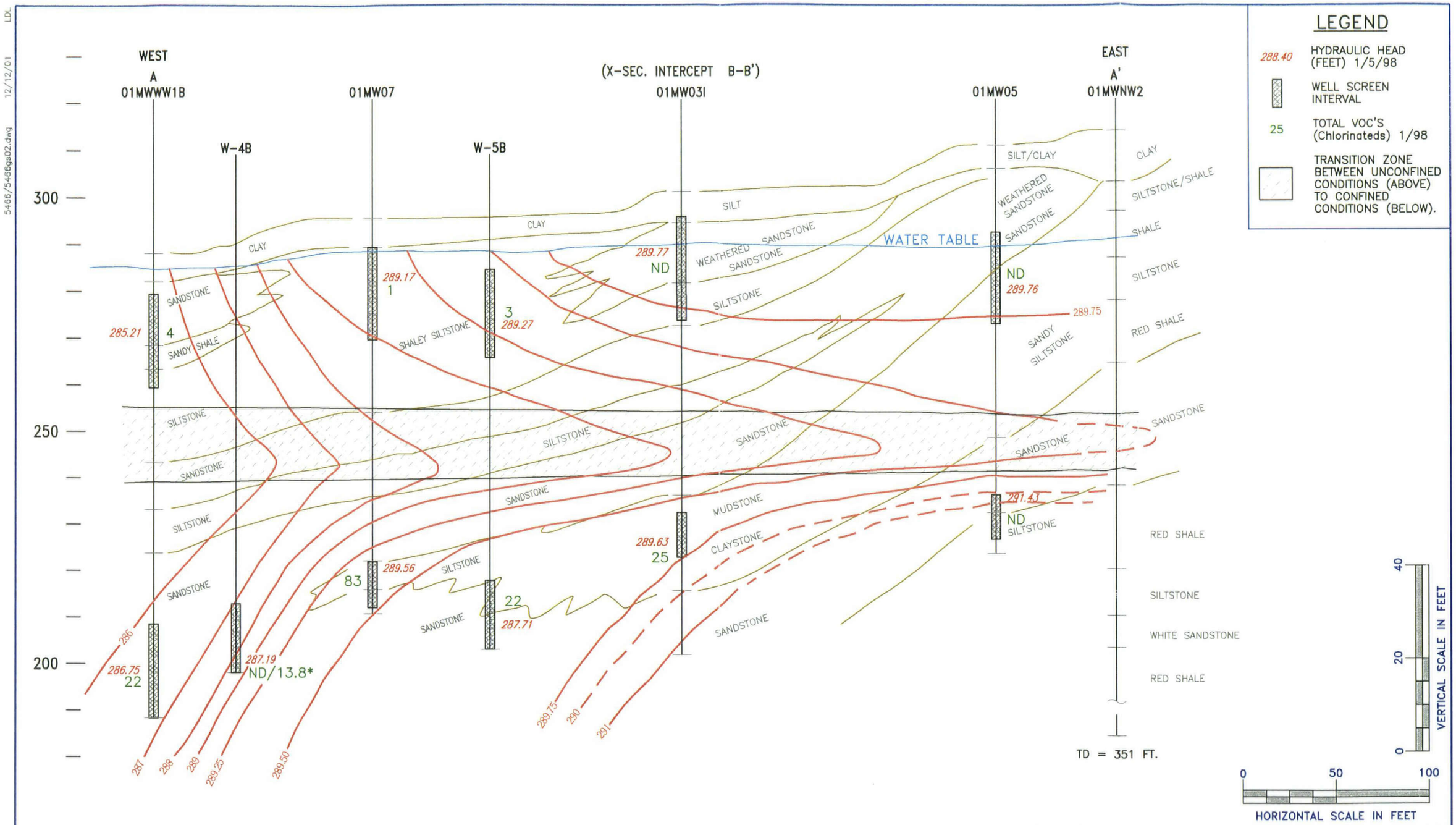
No monitoring wells monitor the deeper portions of the semi-confined to confined aquifer to subsurface depths as great as the supply wells. The vertical profiles obtained in the supply wells by the USGS (Table 4-19), however, indicate that the deeper portions of the boreholes are significantly more contaminated with chlorinated solvents (TCE, PCE, cis-1,2-DCE) than the shallower portions of the borehole, suggesting that the wells are not located proximal to the source of the more significant contamination. As discussed, it is believed that this deeper, more highly contaminated groundwater detected in the deeper portions of the supply well boreholes originates at an off-site source (possibly in the vicinity of the Kellet Aircraft facility) and is migrating downdip and downgradient along major bedding plane fractures associated with the lithologic units that crop out in that off-site area. Regardless of its ultimate source (to be discussed below), it appears clear that the Privet Road Compound is not the source of the contamination detected in the deeper portion of the supply wells.

TCE

The nature and three-dimensional extent of TCE in the vicinity of the Privet Road Compound is extremely complex and it is very difficult to attribute any particular TCE detection to any particular source. The hydrogeological and chemical data are somewhat inconsistent and conflicting but are interpreted to be indicative of at least three (and possibly four) separate TCE plumes that coalesce (at least laterally, if not vertically) in the vicinity of the Privet Road Compound. The vertical distribution of TCE along the site hydrogeologic cross-section is illustrated in Figure 4-28.

TCE was not detected within the unconfined aquifer upgradient of the Privet Road Compound but was detected within the unconfined aquifer at two monitoring well clusters [01MW01 (1 ug/L), and 01MW06 (4 ug/L)] located immediately downgradient of the northwestern corner of the compound. The absence of TCE in the upgradient monitoring wells and its detection in at least some of the downgradient monitoring wells suggest that the Privet Road Compound could be a source of TCE, which would confirm the report in the site investigation (EA Engineering, 1990) that approximately 120 gallons of TCE were disposed at the compound between 1967 and 1975.

Other hydrogeological data, however, suggest that the Privet Road Compound is not a continuing source of the TCE detected at 01MW01 and 01MW06. TCE was not detected from either the surface soils or the



* PACKER TEST RESULT (12/97)

DRAWN BY LDL DATE 4/30/02	Tetra Tech NUS, Inc.	CROSS--SECTION A–A'	CONTRACT NO. 5466
CHECKED BY DATE		SITE 1 – PRIVET ROAD COMPOUND	OWNER NO. 2007
REVISED BY DATE		NON-PUMPING CONDITIONS: SUPPLY WELLS ON NASJRB WILLOW GROVE	APPROVED BY DATE
SCALE AS NOTED		WILLOW GROVE, PENNSYLVANIA	DRAWING NO. FIGURE 4–28 REV.

LDL 12/12/01 5466/5466gs02.dwg

5466gs02.dwg

subsurface soil borings drilled in the compound during the Phase I RI, suggesting that the compound is not a source of TCE. In addition, TCE immediately downgradient of the compound is detected very rarely and at relatively low concentrations, and the highest concentration within the unconfined aquifer occurs in a well (Air Force 01MWWW1) located much farther downgradient. This distribution pattern is not indicative of a dissolved plume emanating from the compound. That is, if the dissolved plume was emanating from a residual source beneath the compound, the highest TCE concentrations would be expected in the wells immediately downgradient from the compound. Alternatively, a TCE source could be present within the compound, with the occurrence pattern resulting from restricted lateral migration of the plume due to a hydraulic gradient that is oriented principally downward (Figure 4-28), but this hypothesis is not supported by the areal distribution of TCE within the shallower portions of the confined aquifer (as will be discussed). Overall, the data are inconclusive but suggest that the compound is not a source of TCE.

The downgradient presence of TCE in the unconfined aquifer in the northwestern corner of the site can be the result of a release other than one from the Privet Road Compound. The areal distribution of TCE in the unconfined aquifer is similar to the distribution of PCE. TCE is not detected upgradient of the compound and is detected immediately downgradient of the compound only in the most northwestern monitoring wells (01MW01 and 01MW06). It is also noteworthy that the former monitoring well located in the vicinity of the Public Works Building (which is hydraulically upgradient from the Privet Road Compound under both pumping and non-pumping conditions) contained TCE (2.3 ug/L) at levels roughly comparable to the levels detected in the supply wells. The similarity in the areal distribution of TCE with PCE suggests that the TCE detections in the unconfined aquifer in the northwestern corner of the Privet Road Compound may originate near the source of the PCE or somewhere in the vicinity of Supply Well No. 1. This potential mixed PCE and TCE plume could migrate through the northwestern corner of the Privet Road Compound, following the subtle surface drainage pattern. Unlike PCE, however, TCE is not present within the shallower portions of Navy Supply Well No. 1, where detections would be expected if the TCE and PCE shared a common source area. Unfortunately, the vertical distribution of VOCs within the former monitoring well is not known, and the drilling log identified multiple water-bearing zones within the borehole (Earth Data, 1985). If the TCE did indeed enter the borehole at relatively shallow depths, it would confirm that a local source of TCE exists in the vicinity of the borehole, but it is also possible that the TCE only entered the borehole within the deeper, confined aquifer, indicating that the former monitoring well was impacted by a more distant source. Overall, although the data are inconclusive and somewhat conflicting, a relatively minor source of TCE appears to exist in the vicinity of the former monitoring well near the Public Works Building.

Packer tests conducted by the Air Force in 1998 for monitoring well borehole 01MWWW6B (Figures 4-24 and 4-26) impact the interpretation of the unconfined aquifer in the vicinity of the Privet Road Compound. This well is located sidegradient, rather than downgradient, from the compound. Although no shallow well was installed within the unconfined aquifer at this location, the results of the packer tests conducted within

the borehole indicate that the shallow groundwater at this location contained TCE in concentrations of 3.6 ug/L (12 to 22 feet) and 6.7 ug/L (27 to 37 feet) and that PCE was not detected from any depth within the borehole. These results strongly suggest the presence of a TCE source (with no intermixed PCE) somewhere near and upgradient from the well and conclusively indicate (by both the groundwater flow directions and the presence of several intervening clean wells) that neither the Privet Road Compound nor the hypothesized source in the vicinity of Supply Well No. 1 is the source of this TCE.

Within the shallower portions of the confined aquifer (to a subsurface depth of approximately 125 feet), the TCE concentrations are significantly higher in the monitoring wells located farthest downgradient from the site and outside the supply wells' capture zones. The levels of TCE actually increase with increasing distance from the Privet Road Compound until, at the Washrack area, the TCE levels are approximately six times higher than the levels detected in the supply wells. As discussed, although the consistent occurrence of TCE in the confined aquifer may result from the downward migration of the groundwater induced by the periodic downward vertical hydraulic gradient created by the pumping of the supply wells, a more consistent detection pattern and higher TCE concentrations in the unconfined aquifer and a more uniform distribution of TCE within the confined aquifer would be expected under this hypothesis. The chemical dissimilarity between the wells monitoring the unconfined and confined aquifer also suggests that the TCE detected within each aquifer comes from a different source because the higher concentrations of TCE detected in the confined aquifer do not contain any PCE, and the lower concentrations of TCE detected in the unconfined aquifer also contain PCE.

The quantitative distribution of TCE within the upper portion of the confined aquifer indicates either that there is a source of TCE located west of the Privet Road Compound or that the TCE is migrating to that area from a direction other than from the compound, since neither the monitoring wells located adjacent to the compound nor the Navy supply wells contain comparable concentrations of TCE (in fact, many of the wells are non-detect for TCE). The Air Force Washrack is in the vicinity of the most highly contaminated wells but cannot be the source because the consistently highest detections of TCE within the upper part of the confined aquifer occur at monitoring well cluster 01MW07, which is located about 200 feet southeast of the Washrack and is hydraulically upgradient of the Washrack under both pumping and non-pumping conditions. Although the data are incomplete and inconclusive, it is believed that the source of this TCE plume may be in the general vicinity (or upgradient) of the Navy Fuel Farm. As discussed, the packer tests conducted by the Air Force within monitoring well 01MWWW6B indicate that TCE is detected within the shallow, unconfined aquifer at this location, which is generally downgradient and downdip of the Fuel Farm and upgradient and updip of the highest concentrations of TCE detected within the upper portions of the confined aquifer.

The chemical signature of the plume within the deeper portion of the confined aquifer, as determined by the USGS packer tests in the Navy supply wells, is significantly different than the chemical signature of the shallower portion of the confined aquifer that is discussed above. The packer test results indicate that a significant chemical change (suggesting a change in the groundwater flow regime or the presence of another, different groundwater plume) occurs at a depth of 182 feet in well No. 1 and 162 feet in well No. 2 (Table 19). Based on the USGS subsurface correlations, a common lithologic unit is associated with these significant chemical changes in each well. As previously discussed, the most highly contaminated intervals within each well (which occur just below these depths of significant change) also share a common lithologic unit and bedding plane fracture, and the chemical signature of these zones (containing predominantly PCE and to a lesser extent, TCE) is different from the chemistry of the upper portion of the confined aquifer but similar to the shallow groundwater and surface water contamination reported from off-site locations. These observations support the conclusion that the mixed (PCE and TCE) groundwater plume encountered within the deeper portion of the confined aquifer beneath the Privet Road Compound originates at an off-site location that is geologically updip and hydraulically upgradient of the Privet Road Compound. The chemical differences between supply well nos. 1 and 2, even though they share many common lithologic units and some water-bearing fractures, suggest that this off-site plume is not migrating directly toward the Privet Road Compound but instead is being captured from an off-site location by the pumping of the supply wells. This interpretation is supported by the conclusion that the solvent concentrations within the supply wells generally increase with increasing pumping rates (Earth Data, 1985), and this hypothesis would explain why Supply Well No. 1 is more highly contaminated than well no. 2, since well no. 1 has been determined to be a much more productive and efficient well than well no. 2 (Earth Data, 1985; USGS, 2001).

In summary, the interpretation of the nature and extent of groundwater contamination at the Privet Road Compound is difficult. Groundwater plumes emanating from multiple on-site and off-site sources are either drawn to the site by the pumping of the two deep and high-yielding supply wells or migrate through the site under natural flow conditions. The difficulty and uncertainty in delineating the individual extents and sources of the multiple plumes are compounded by the complex hydrogeology, which is characterized by the presence of multiple (unconfined and semi-confined to confined) aquifers that respond differently to the daily pumping of the two supply wells. The potential source areas that have been delineated include the following:

- A possible minor source of TCE at the Privet Road Compound
- A source of TCE southwest of the compound, in the vicinity or upgradient of the Navy Fuel Farm
- A source of PCE and TCE in the vicinity of Supply Well No. 1 or the Public Works Building
- An off-site source of PCE and TCE, possibly in the vicinity of the former Kellet Aircraft Facility

As discussed, the data suggest that the Privet Road Compound is not a major source but is at least a minor historical source of the TCE detected in the area groundwater. The data conclusively indicate, however, that the compound is being impacted by the migration of groundwater plumes originating outside the compound. Due to the complex hydrogeology and existence of multiple plumes, it is very doubtful that additional investigation would yield the identification or delineation of a compound-sourced plume, if one exists. In addition, even if the compound is, in fact, a minor contributor of VOCs, it would not be feasible (either technically or logistically) to treat the groundwater impacted by just this site.

4.6 CONTAMINANT FATE AND TRANSPORT

As described in the previous section describing the nature and extent of contamination, a number of organic and inorganic contaminants were detected in surface and subsurface soils, groundwater, surface water, and associated sediments at Site 1 of the NASJRB Willow Grove facility. General classes of substances detected include VOCs, pesticides, PCBs, PAHs, and metals.

4.6.1 Transport and Transformation of Detected Contaminants

The VOCs TCE and PCE were detected in the groundwater obtained from monitoring wells surrounding the site. Due to their high vapor pressures and aqueous solubilities and low potential for adsorption to soils, VOCs released to the soil will be readily lost by volatilization and transported to groundwater by dissolution in infiltrating precipitation. Once in the groundwater, compounds of this class will be transported by groundwater movement through advection and dispersion. Under anaerobic conditions, PCE will biodegrade to yield TCE as a degradation product. TCE may itself be slowly biodegraded to yield vinyl chloride.

Since TCE and PCE were detected infrequently and at low concentrations in Site 1 soils, the Privet Road Compound does not appear to be a contributing source of groundwater VOC contamination at this time. Due to the complex hydrogeology and the effect of intermittent pumping of the two supply wells on the direction of groundwater flow, it may not be possible to trace the source of the groundwater VOC contamination or predict its further transport.

Acetone was detected infrequently in surface soil and surface water samples at very low levels. Acetone has a high vapor pressure, is miscible in water, and does not adsorb to soils. If released to surface soil, acetone would be expected to volatilize and leach to groundwater. Acetone was detected in several subsurface soil samples but was not detected in groundwater. In surface waters, acetone will rapidly be lost through volatilization.

PCBs (since removed) were detected in surface and shallow subsurface soils in the area of the compound. Since PCBs are strongly adsorbed to soils, leaching and transport to groundwater are not a migration pathway for these compounds. Drainage swales are located on the northeastern and southeastern sides of the site. Surface runoff and erosion of contaminated surface soil are potential transport mechanisms for PCBs. However, PCBs were detected at a fairly low level in only one sediment sample, indicating that overland flow and surface erosion are not significant processes at this site. In addition, the removal action of PCB-contaminated soils performed in 1999 precludes further transport of PCBs from the site.

The chlorinated pesticides dieldrin and heptachlor were detected in soils at levels above background. Dieldrin released to the soil will persist for a long time. It will not leach to groundwater, biodegrade, or undergo hydrolysis. In surface waters, dieldrin will adsorb strongly to sediments, bioconcentrate in fish, and degrade slowly through photolytic processes. As with PCBs, the principal transport mechanism for dieldrin is erosion of contaminated soil particles and migration to surface water, which does not appear to be a significant process at the site. Dieldrin concentrations in the soils are expected to remain constant for an extended time.

Due to its large Henry's Law constant, when released to soil surfaces, heptachlor will volatilize from the surface, especially in moist soils. Once heptachlor is incorporated into soil, volatilization will be slower. Hydrolysis in moist soils is a significant degradation mechanism for heptachlor. Heptachlor will biodegrade in soils to 1-hydroxychlordene, heptachlor epoxide, and an unidentified metabolite. Biodegradation, especially under anaerobic conditions, may be significant. Heptachlor will bind strongly to soil, making leaching to groundwater unlikely. In water, heptachlor will hydrolyze quickly to 1-hydroxychlordene or be lost by volatilization. In the subsurface soils of the Privet Road Compound, volatilization is not an important fate process for heptachlor. The pesticide is expected to be removed primarily by biodegradation.

Dibenzodioxins and dibenzofurans were detected in soils at low levels. Chlorinated dioxins and furans exhibit similar fate and transport properties to PCBs. Their low water solubilities, high adsorption coefficients, and resistance to chemical and biological degradation result in their retention on soils. Leaching to groundwater is unlikely and, as indicated by the low levels of these compounds in downstream sediments, erosion of contaminated soils does not occur to a significant extent. These contaminants are expected to persist in the soils at their present concentrations.

Several PAHs were detected in soils and sediments at Site 1 at concentrations comparable to those detected in background soils. PAHs are widespread contaminants in soils since they are released

primarily during th combustion of fossil fuels. PAHs released to the atmosphere may enter soils and surface water through wet and dry deposition. Microbial metabolism is the major process responsible for degradation of PAHs in soils. Photolysis, hydrolysis, and chemical oxidation are not considered to be significant mechanisms for the degradation of PAHs in soils. PAHs in surface waters can volatilize, photodegrade, oxidize, biodegrade, bind to particulates, or accumulate in aquatic organisms. Hydrolysis is not an important mechanism for PAH degradation.

Due to their large octanol-water partition coefficients, PAHs in the environment will partition primarily to soils and sediments. Leaching to groundwater is not an important transport pathway for PAHs. Therefore, as is the case with PCBs, the only significant potential for transport of PAH-contaminated soils is via overland transport of eroded soil particle during runoff. The absence of significant contamination in sediments indicates that this pathway is not important at the Privet Road Compound. Microbial degradation is expected to provide the primary transformation process for soil PAH contamination at the site.

A number of metals were detected in site samples at levels above background or exceeding reference criteria. Cadmium, mercury, and silver were detected in Site 1 surface soils but were not detected in background samples. Arsenic and iron were detected in Site 1 surface soils at concentrations that exceeded reference criteria. Arsenic concentrations were in excess of reference criteria in all site and background samples. Arsenic, mercury, and manganese were detected at elevated levels in subsurface soils; lead, zinc, and antimony were detected in surface water samples. Barium, along with arsenic, cadmium, lead, and manganese, were present in sediment. Beryllium, manganese, arsenic, and lead were detected in groundwater samples. With the exception of beryllium, the metals in groundwater were associated with suspended solids, as indicated by comparison of filtered and unfiltered sample concentrations. Truly dissolved metals have a greater potential for transport through the aquifer than those adsorbed to suspended solids. Adsorption to soils and sediments is the controlling process for the environmental transport of most metals.

There are many inorganic and organic forms of arsenic of environmental significance. These species contain the metal in any of four valence states (-3, 0, +3, and +5), depending on environmental factors such as redox potential and pH. The transport and partitioning of the metal in water depend on the chemical form of arsenic and its interaction with other materials. Soluble forms of arsenic are generally rather mobile in aquatic systems and groundwater. The environmental transport of arsenic is controlled largely by adsorption/desorption processes in soils and sediments, and soluble forms may be removed from solution by adsorption onto clays, iron oxides, aluminum hydroxides, and organic material. The predominant form of arsenic in surface waters is arsenate, but this form may be reduced by aquatic microorganisms to arsenite and methylated arsenicals. The transformations of arsenic in soil are similar

to those in water, with As(V) predominating in aerobic soils and As(III) in slightly reduced soils. In very reducing conditions, arsenic exists as arsine, methylated arsine, and elemental arsenic. Some aquatic organisms readily bioaccumulate arsenic. Leaching of soluble arsenic from soil is a possible source of the metal in groundwater. However, because of the widespread presence of arsenic in background soils, an off-site source cannot be ruled out.

Beryllium is generally immobile in soil and sediment. Because of its geochemical similarity to aluminum, beryllium is found adsorbed to clay minerals of soils or sediments. In the aqueous solution, beryllium exhibits only the +2 oxidation state and is not affected by redox conditions. In most soils, it is tightly adsorbed because it displaces divalent cations that share its adsorption sites. Some beryllium may also be present as insoluble beryllium complexes. Although most common beryllium compounds are soluble in water, hydrolysis of soluble beryllium salts to less soluble beryllium hydroxide occurs in water at the pH range of most natural systems. Beryllium is not likely to be found in the soluble state in most soils and should not leach to groundwater to any significant extent. There is no evidence of any environmental process such as biomethylation that would result in the volatilization of beryllium from water or soil. Beryllium does not bioaccumulate.

Cadmium is relatively mobile in the aqueous environment compared to most heavy metals. Cadmium in natural waters exists primarily as the hydrated ion Cd (+2) $6H_20$. Cadmium concentrations in water decrease with increasing pH and dissolved organic matter concentration. Since cadmium exists only in the +2 oxidation state, the redox conditions of the water do not exert a significant influence on the form of the metal. However, under reducing conditions, cadmium may form the sulfide that is relatively insoluble and tends to precipitate. Precipitation and sorption to mineral surfaces and organic materials are the most important removal processes for cadmium compounds in aquatic systems. Photolysis and biological methylation are unimportant fate processes for cadmium compounds. In soils, cadmium may leach into water, especially under acidic conditions.

Lead occurs in one of three oxidation states (0, +2, and +4) in the environment. Lead is very persistent in soil, and very little is transported to surface water or groundwater. Lead is strongly sorbed to organic matter in soil and, although it is not susceptible to leaching, the metal may be transported to surface water as the result of erosion of contaminated soil particles. The amount of dissolved lead in surface waters depends on the pH of the water and its salinity. Sulfate ions, if present, limit the concentration of lead in solution through the formation of lead sulfate. In most surface and groundwaters, the concentration of dissolved lead is low because the metal will form relatively insoluble compounds with common anions in water such as hydroxide, carbonate, sulfate, and phosphate. Lead was detected in unfiltered groundwater samples but not in filtered samples, indicating that the metal was associated with suspended solids.

4.6.2 C nclusions

VOCs were detected in groundwater samples collected from monitoring wells surrounding the Privet Road Compound. The absence of VOC contamination in surface or subsurface soils indicates that the site itself is not the source of the groundwater contamination at the present time. The complex hydrogeology and effect of intermittent pumping of the supply wells on groundwater flow make it difficult to identify the current source of VOC contamination.

PCBs, PAHs, and pesticides were detected in on-site soils but are not expected to migrate significantly from the contaminated source. In addition, all PCB-contaminated soils at concentrations in excess of regulatory guidelines were removed in June 1999.

Metals were detected in site soils and in groundwater from monitoring wells surrounding the site. Metals are typically strongly adsorbed to soil materials in the environment, but many may be converted into soluble forms. Leaching of metals from the site to groundwater is a potential transport mechanism.

4.7 BASELINE HUMAN HEALTH RISK ASSESSMENT

This section presents the baseline human health risk assessment for Site 1 at NASJRB Willow Grove. It describes a qualitative and quantitative assessment of actual or potential estimated risks for Site 1. It also includes the data evaluation, toxicity assessment, exposure assessment, risk characterization, and uncertainties in the risk assessment for Site 1. The methodologies and techniques used in the assessment are outlined in Section 3.1. Details on the PCB contamination (before soil removal) and risk assessment considerations were addressed in Section 4.5.6. Conclusions about the baseline human health risk assessment, including a discussion of how the estimated human health risks were altered by the PCB-contaminated soil removal in 1999, are presented in Section 4.7.6.

4.7.1 Data Evaluation

A list of the chemicals of potential concern (COPCs) was developed for each environmental medium, as necessary. The COPCs were selected in accordance with protocol established in Section 3.1. Only those chemicals found to be of potential concern were considered for evaluation in the quantitative risk assessment. A discussion of those chemicals identified as COPCs for each medium is provided in this section.

Surface Soils (bef re Soil Removal)

Several 2,3,7,8-substituted-dioxins/furans, OCDD, OCDF, PAHs, PCBs, dieldrin, phthalates, acetone, chloroform, and metals were detected in Site 1 surface soil samples. The occurrence and distribution, COPC selection results, background comparisons, and representative concentrations for chemicals detected in Site 1 surface soils are presented in Table 4-20. Results of individual background comparison tests are presented in Table 4-6.

The following chemicals were selected as COPCs in surface soils:

Inorganics	Organics
Aluminum	13-2,3,7,8-substituted-Dioxin/Furan Isomers
Arsenic	OCDD
Cadmium	OCDF
Iron	Dieldrin
	PCBs (total) (since removed)
	Benz(a)anthracene
	Benzo(a)pyrene
	Benzo(b)fluoranthene
	Benzo(k)fluoranthene
	Chrysene
	Dibenz(a,h)anthracene
	Indeno(1,2,3-cd)pyrene

Aluminum, arsenic, and iron were selected as COPCs, because they were detected in all surface soil samples, with both the maximum and the representative concentrations exceeding residential RBC and background values. Additionally, cadmium was selected as a COPC. Cadmium was detected at a frequency of five out of 13 surface soil samples, with the maximum concentration exceeding residential RBC and background values. Dioxins/furan congeners were detected in approximately 60 percent of the surface soils collected at Site 1. The concentrations of 1,2,3,4,7,8-HxCDF, 2,3,4,7,8-PeCDF, and OCDD exceeded residential RBC values. Therefore, all 2,3,7,8 - congeners were identified as COPCs. PCBs were detected at a frequency of 54 out of 64 samples, with all concentrations exceeding residential RBC and background values. Carcinogenic PAHs were generally detected in 50 percent of the surface soil samples collected at Site 1 with maximum concentrations of benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene

Table 4-20
Sel ction of Chemicals of Potential Concern in Surface Soils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Residential Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
1,2,3,4,6,7,8-HPCDD	6/6	0.0647 -	0.136	NA	0.13	0.41	Y
1,2,3,4,6,7,8-HPCDF	6/6	0.0048 -	0.321	NA	0.236	0.41	Y
1,2,3,4,7,8,9-HPCDF	5/6	0.0063 -	0.19	NA	0.19	0.41	Y
1,2,3,4,7,8-HXCDD	4/6	0.0015 -	0.0021	NA	0.0019	0.041	Y
1,2,3,4,7,8-HXCDF	6/6	0.0026 -	0.374	NA	0.374	0.041	Y
1,2,3,6,7,8-HXCDD	5/6	0.0017 -	0.0051	NA	0.00505	0.041	Y
1,2,3,6,7,8-HXCDF	5/6	0.0017 -	0.0248	NA	0.0179	0.041	Y
1,2,3,7,8,9-HXCDD	6/6	0.0027 -	0.0129	NA	0.0109	0.041	Y
1,2,3,7,8,9-HXCDF	3/6	0.00055 -	0.009	NA	0.009	0.041	Y
1,2,3,7,8-PECDF	4/6	0.003 -	0.0049	NA	0.00431	0.082	Y
2,3,4,6,7,8-HXCDF	6/6	0.0011 -	0.0136	NA	0.011	0.041	Y
2,3,4,7,8-PECDF	5/6	0.0023 -	0.0142	NA	0.0116	0.0082	Y
2,3,7,8-tetrachlorodibenzofuran	5/6	0.0015 -	0.0076	NA	0.00677	0.041	Y
octachlorodibenzo-p-dioxin	6/6	4.58 -	15.59	NA	12.2	4.1	Y
octachlorodibenzofuran	6/6	0.009 -	0.815	NA	0.636	4.1	Y
aluminum	13/13	9470 -	22000	Y	18200	7800	Y
arsenic	13/13	2 -	16.2	Y	9.52	0.43	Y
barium	13/13	59.4 -	129	Y	99.4	550	N
cadmium	5/13	1.6 -	5.8	Y	2.55	3.9	Y
calcium	13/13	991 -	13700	Y	7450	-	N
chromium	13/13	21.5 -	37.2	Y	31.3	39	N
cobalt	13/13	6.6 -	12.2	Y	10.1	470	N
copper	13/13	12.8 -	44	Y	32.5	310	N
iron	13/13	18600 -	33300	Y	27300	2300	Y
lead	13/13	9.2 -	149	Y	117	400	N
magnesium	13/13	2300 -	10600	Y	5450	-	N
manganese	13/13	166 -	867	N	634	180	N

Table 4-20
Selection of Chemical f Potential Concern in Surface Soils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Residential Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
mercury	5/13	0.14	0.36	N	0.191	2.3	N
nickel	13/13	12.3	19.6	Y	16.3	160	N
potassium	13/13	638	2140	Y	1420	-	N
silver	1/13	3	3	N	1.13	39	N
sodium	13/13	508	978	Y	830	-	N
thallium	6/10	0.25	0.45	N	0.3	0.51	N
vanadium	13/13	27.2	47.8	Y	41.8	55	N
zinc	13/13	39.1	200	Y	126	2300	N
dieldrin	1/13	77	77	N	77	40	Y
pcbs (tot. all)	54/64	550	230000	NA	52700	320	Y
1,2,4-trichlorobenzene	1/6	120	120	N	120	78000	N
2-methylnaphthalene	1/6	130	130	N	130	-	N
acenaphthene	1/6	66	66	N	66	470000	N
anthracene	1/6	250	250	N	225	2300000	N
benz(a)anthracene	3/6	35	1300	N	1300	880	Y
benzo(a)pyrene	3/6	40	1200	N	1200	88	Y
benzo(b)fluoranthene	2/6	440	1500	N	1500	880	Y
benzo(g,h,i)perylene	2/6	140	960	N	808	-	N
benzo(k)fluoranthene	2/6	260	770	N	589	8800	Y
butylbenzylphthalate	2/6	220	270	N	239	1600000	N
chrysene	3/6	52	1400	N	1400	88000	Y
di-n-butylphthalate	2/6	91	110	N	110	780000	N
dibenz(a,h)anthracene	2/6	43	290	N	252	88	Y
fluoranthene	3/6	62	1800	N	1800	310000	N
fluorene	1/6	65	65	N	65	310000	N
indeno(1,2,3-cd)pyrene	2/6	160	1100	N	944	880	Y
naphthalene	1/6	92	92	N	92	310000	N

Table 4-20
Selection of Chemicals of Potential Concern in Surface Soils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Residential Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
phenanthrene	2/6	370 -	1100	N	1000	-	N
pyrene	3/6	59 -	2500	N	2500	230000	N
acetone	3/12	4 -	7	NA	6.22	780000	N
chloroform	1/13	1 -	1	NA	1	100000	N

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).
Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.
The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.
Residential RBCs originate from EPA Region 3 RBCs for residential exposure, incidental soil ingestion, with non-cancer risk adjusted to 0.1 hazard inde
An RBC for lead based on cancer risk or hazard index is not available. The 400 mg/kg OSWER residential soil guideline is used as an RBC for soil ingestion.

exceeding residential RBC values. Because maximum concentrations of specific carcinogenic PAHs exceeded RBC values, all carcinogenic PAHs were considered COPCs. Dieldrin was detected at a frequency of one out of 13 samples, with the maximum concentration (77 ug/kg) exceeding residential RBC values.

Subsurface Soil

PCBs, heptachlor, acetone, carbon disulfide, and metals were detected in Site 1 subsurface soil samples. The occurrence and distribution, COPC selection results, background comparisons, and representative concentrations for chemicals detected in Site 1 subsurface soils are presented in Table 4-21. Results of individual background comparison tests are presented in Table 4-8. The following chemicals were selected as COPCs in subsurface soils:

Inorganics	Organics
Aluminum	PCBs (total)
Arsenic	
Iron	

Aluminum, arsenic, and iron were selected as COPCs because they were detected in all surface soil and subsurface soil samples and because the maximum concentrations exceeded industrial RBC values. PCBs were detected at a frequency of 19 out of 84 samples, with the maximum concentrations exceeding industrial RBC values.

Sediment

PAHs, Aroclor 1260, dieldrin, and metals were detected in Site 1 sediment samples. The occurrence and distribution, COPC selection results, background comparisons, and representative concentrations for chemicals detected in Site 1 sediments are presented in Table 4-22. Results of individual background comparison tests are presented in Table 4-14. The following chemicals were selected as COPCs in sediments:

Inorganics	Organics
Arsenic	None Selected

Table 4-21
Selection of Chemicals of Potential Concern in Subsurface Soils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site			Are Site Results Above Background ?	Representative Concentration For Site Data	Industrial Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum		Maximum				
aluminum	59/59	5910	-	24500	Y	16000	100000	Y
arsenic	45/59	0.9	-	16	Y	5.29	3.8	Y
barium	59/59	45.6	-	422	Y	109	14000	N
cadmium	26/59	0.79	-	4.5	N	1.12	100	N
calcium	58/59	154	-	13100	Y	1400	-	N
chromium	59/59	10.6	-	33.7	Y	25.5	1000	N
cobalt	59/59	5.1	-	30.2	Y	12.1	12000	N
copper	58/59	4.1	-	39.2	Y	18.5	8200	N
cyanide	1/59	3.2	-	3.2	N	1.17	4100	N
iron	59/59	12900	-	35400	Y	25400	61000	Y
lead	59/59	1.9	-	164	Y	11.1	400	N
magnesium	59/59	261	-	7830	Y	2350	-	N
manganese	59/59	70.3	-	2310	Y	779	4700	N
mercury	2/59	0.11	-	0.24	N	0.0574	61	N
nickel	57/59	5.9	-	38.2	Y	14.8	4100	N
potassium	59/59	184	-	2840	Y	1170	-	N
selenium	0/34		-		NA		1000	N
sodium	59/59	387	-	1250	Y	773	-	N
thallium	21/53	0.18	-	0.41	N	0.191	16	N
vanadium	59/59	19.5	-	48.8	Y	35.3	1400	N
zinc	59/59	10.7	-	237	N	37.8	61000	N
heptachlor	1/59	9.7	-	9.7	NA	5.84	300	N
pcbs (tot. all)	19/84	11	-	5800	NA	302	2860	Y
acetone	12/42	4	-	21	NA	7.76	20000000	N
carbon disulfide	1/60	1	-	1	NA	1	20000000	N

Table 4-21
Selection of Chemicals f P tential Concern in Subsurface Soils, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Industrial Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).
Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.
The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.
Industrial RBCs originate from EPA Region 3 RBCs for industrial exposure, incidental soil ingestion, with non-cancer risk adjusted to 0.1 hazard index.
An RBC for lead based on cancer risk or hazard index is not available. The 400 mg/kg OSWER residential soil guideline is used as an RBC for soil ingestion.

Table 4-22
Selection of Chemicals of Potential Concern in Sediments, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
aluminum	6/6	8060 -	18700	Y	18700	78000	N
antimony	1/3	7.4 -	7.4	N	7.4	31	N
arsenic	6/6	3.6 -	8.5	Y	7.97	4.3	Y
barium	6/6	39.7 -	167	Y	159	5500	N
beryllium	3/3	0.78 -	1.4	Y	1.4	1.5	N
cadmium	5/6	0.87 -	4.7	N	4.7	39	N
calcium	6/6	1510 -	9220	Y	8450		N
chromium	6/6	14.7 -	31.8	Y	29.2	390	N
cobalt	6/6	5.2 -	17.1	Y	14.9	4700	N
copper	6/6	8.8 -	36.1	Y	28.6	3100	N
iron	6/6	12800 -	33500	N	28300	23000	N
lead	6/6	23.4 -	88.6	Y	75.1	4000	N
magnesium	6/6	1910 -	5400	Y	4840		N
manganese	6/6	243 -	1280	Y	1160	1800	N
nickel	6/6	7.6 -	22.3	N	21.3	1600	N
potassium	6/6	692 -	1550	N	1380		N
selenium	1/6	0.32 -	0.32	N	0.32	390	N
sodium	1/6	188 -	188	N	188		N
vanadium	6/6	21 -	41.7	Y	40.7	550	N
zinc	6/6	67.2 -	124	Y	109	23000	N
Aroclor-1260	1/6	980 -	980	N	835	3200	N
dieldrin	1/6	210 -	210	N	210	400	N
benz(a)anthracene	4/6	140 -	400	N	381	8800	N
benzo(a)pyrene	4/6	180 -	320	N	307	880	N
benzo(b)fluoranthene	4/6	250 -	590	N	576	8800	N
benzo(g,h,i)perylene	2/6	89 -	150	N	150		N
benzo(k)fluoranthene	4/6	170 -	250	N	237	88000	N

Table 4-22
Selection of Chemicals of Pot ntial Concern in Sediments, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
bis(2-ethylhexyl)phthalate	3/6	330 -	1500	N	1500	460000	N
butylbenzylphthalate	4/6	91 -	340	N	340	16000000	N
chrysene	4/6	200 -	460	N	441	880000	N
fluoranthene	6/6	65 -	760	N	655	3100000	N
indeno(1,2,3-cd)pyrene	2/6	140 -	200	N	200	8800	N
phenanthrene	4/6	130 -	400	N	400		N
pyrene	6/6	49 -	890	N	728	2300000	N

Notes:

Units are mg/kg for inorganics, ug/kg for organics.
Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).
Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.
The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.
Sediment RBCs are adapted using residential soil RBC X 10, due to less frequent exposure with recreational receptor activities.
An RBC for lead based on cancer risk or hazard index is not available. The 400 mg/kg OSWER residential soil guideline is used as an RBC for soil ingestion.

Arsenic was the only metal selected as a COPC. It was detected at a frequency of six out of six sediment samples, with the maximum concentration and representative concentration exceeding RBC values.

Surface Water

4-Methyl-2-pentanone, acetone, and metals were detected in Site 1 surface water samples. The occurrence and distribution, COPC selection results, background comparisons, and representative concentrations for chemicals detected in Site 1 surface water are presented in Table 4-23. Results of individual background comparison tests are presented in Table 4-11. No chemicals were selected as COPCs in Site 1 surface water.

Groundwater

PCE, TCE, and metals were detected in Site 1 groundwater samples. The occurrence and distribution, COPC selection results, background comparisons, MCL comparisons, and representative concentrations for chemicals detected in Site 1 groundwater are presented in Table 4-24. Results of individual background comparison tests are presented in Table 4-17.

The following chemicals were selected as COPCs in groundwater:

Inorganics	Organics
Arsenic	TCE
Barium	PCE
Beryllium	
Lead	
Manganese	

Arsenic was detected at a frequency of two out of 14 samples (4 ug/l to 4.2 ug/l), with both detected concentrations exceeding the tap water RBC value. Barium was detected at a frequency of 13 out of 13 samples, with the maximum and representative concentration (287 ug/l) exceeding the tap water RBC value. Beryllium was detected at a frequency of six out of six samples (3 ug/l to 4 ug/l), with all concentrations exceeding the tap water RBC value. Lead was detected at a frequency of 11 out of 16 samples, with the maximum concentration (18 ug/l) exceeding the MCL and the tap water RBC value. Manganese was detected at a frequency of 12 out of 12 samples, with the maximum and representative concentration (981 ug/l) exceeding the tap water RBC value. PCE was detected at a frequency of seven out of 23 samples (2 ug/l to 36 ug/l), with all concentrations exceeding the tap water RBC value. TCE was

Table 4-23
Selection of Chemicals of Potential Concern in Surface Water, Site 1
NASJRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site		Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Risk-Based Concentration	Chemical Selected as a COPC ?
		Minimum	Maximum				
aluminum	2/2	1260	1440	NA	1440	37000	N
antimony	1/5	47	47	N	41.3	15	N
barium	3/5	5	37	N	37	2600	N
calcium	5/5	7420	42000	N	42000		N
chromium	2/5	7	10	N	8.3	180	N
iron	5/5	571	1660	Y	1490	11000	N
lead	5/5	1.5	5.2	Y	4.69	150	N
magnesium	5/5	1950	9040	N	9040		N
manganese	3/3	21	41	N	41	840	N
potassium	4/5	2380	5160	Y	4920		N
sodium	1/5	16700	16700	N	16700		N
zinc	2/2	45	194	Y	194	11000	N
4-methyl-2-pentanone	2/5	92	220	N	220	2900	N
acetone	2/5	170	1300	N	1300	3700	N

Notes:

Units are ug/L.

Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).

Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.

The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.

Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.

RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.

Surface water RBCs are adapted using tap water RBC X 10, due to smaller and less frequent ingestion exposures with recreational activities.

Potable spring samples are compared to tap water RBCs for illustration purposes only. No exposure scenario is defined.

An RBC for lead based on cancer risk or hazard index is not available. The 15 ug/L EPA MCL is used as an applicable RBC for tap water ingestion.

Table 4-24
Selection of Chemicals of Potential Concern in Gr undwater, Site 1
NASJRB Willow Gr ve, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site Minimum	Maximum	Are Site Results Above Background ?	Representative Concentration For Site Data	Applicable Drinking Water MCL	Chemical Exceeds MCL?	Tap Water Risk-Based Concentration	Chemical Selected as a COPC ?
aluminum	4/11	85	3430	N	1760	-	-	3700	N
arsenic	2/14	4	4.2	N	1.88	50	N	0.045	N
barium	13/13	17	287	N	287	2000	N	260	N
beryllium	6/6	3	4	N	4	4	N	0.016	N
calcium	16/16	12400	45400	N	35800	-	-	-	N
chromium	1/10	18	18	N	6.95	100	N	18	N
cobalt	2/16	10	17	N	7.07	-	-	220	N
copper	1/1	37	37	N	37	1300	N	150	N
iron	2/2	247	576	N	576	-	-	1100	N
lead	11/16	1	18	N	6.08	15	N	15	N
magnesium	16/16	3780	27300	Y	15800	-	-	-	N
manganese	12/12	6	981	N	981	-	-	84	N
nickel	2/6	14	26	N	24.8	100	N	73	N
potassium	9/16	2180	38700	N	11200	-	-	-	N
sodium	16/16	9840	28500	Y	18500	-	-	-	N
zinc	5/5	2	65	N	59.2	-	-	1100	N
tetrachloroethene	7/23	2	36	N	7.49	5	Y	1.1	Y
trichloroethene	14/23	1	37	N	11	5	Y	1.6	Y

Notes:

Units are ug/L.
Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).
Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.
The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer hazard index of 0.1.
Tap water RBCs originate from EPA Region 3 RBCs for residential exposure, tap water ingestion, with non-cancer risk adjusted to 0.1 hazard index.
An RBC for lead based on cancer risk or hazard index is not available. The 15 ug/L EPA MCL is used as an applicable RBC for tap water ingestion.

detected at a frequency of 14 out of 23 samples, with the maximum concentration (37 ug/l) and representative concentration (11 ug/l) exceeding the tap water RBC value.

4.7.2 Toxicity Assessment

The toxicological profiles for selected COPCs at Site 1 are presented in Appendix J of the Phase II RI report. All relevant quantitative and qualitative toxicity assessment information and methods are presented in Section 3.1.

4.7.3 Exposure Assessment

The COPCs that were selected for each environmental medium sampled at Site 1 are presented in Section 4.5. The potential receptors include current occupational workers, current adolescent and adult trespassers, future excavation workers, future recreational children, and future residents. Consequently, the potential receptors and exposure pathways presented in Section 3.1 were evaluated quantitatively. Exposure parameters, exposure routes, intakes, and other relevant exposure assessment information are presented in Section 3.1. Example calculations for estimated intakes are presented in Appendix J of the Phase II RI report.

4.7.4 Risk Characterization

This section presents the results of the quantitative risk assessment evaluated under a reasonable maximum exposure (RME) and a central tendency exposure (CTE). CTE will only be included if the total carcinogenic risk for an exposure pathway exceeds 1E-04 or if a hazard index (noncarcinogenic risk) for an exposure pathway exceeds 1.0. This section discusses the human health risk as follows:

- Carcinogenic risks (before soil removal)
- Carcinogenic risks (after soil removal)
- Noncarcinogenic risks (before soil removal)
- A discussion of the impact of subsurface soil exposure risks to future residential receptors

Noncarcinogenic risks after the PCB-contaminated soil removal were also modeled, but there was little difference in the total risk under each exposure scenario from the pre-soil removal scenario results. Therefore, no separate discussion of non-carcinogenic risk after soil removal is included.

Carcinogenic Risks

Table 4-25 lists the estimated cumulative RME carcinogenic risks at Site 1 for current occupational workers, current trespassers, future recreational children, future excavation workers, and future residents before the PCB-contaminated soil removal. Table 4-25a lists the corresponding estimated RME carcinogenic risks after the PCB-contaminated soil removal for comparison.

Table 4-26 lists the estimated cumulative CTE carcinogenic risks at Site 1 for current occupational workers, current trespassers, future recreational children, future excavation workers, and future residents. Table 4-26a lists the corresponding estimated CTE carcinogenic risks after the PCB-contaminated soil removal for comparison. EPA's target cancer risk range of 1E-04 to 1E-06 is often used to determine the need for environmental remediation. Chemical-specific risks for COPCs are presented in Appendix J of the Phase II RI report.

RME Risks (before Soil Removal)

Estimated Cancer Risks Equal to or Exceeding EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the future residents is 8E-04, which exceeds the upper end of the EPA target cancer risk range of 1E-04 to 1E-06. The estimated carcinogenic risk for the current occupational worker is 1E-04, which is at the upper end of the EPA target cancer risk range of 1E-04 to 1E-06. Incidental ingestion and dermal contact with surface soil and ingestion of groundwater contribute the most to the cumulative carcinogenic risks for the future resident. Incidental ingestion and dermal contact with surface soil contribute the most to the cumulative carcinogenic risks for the current occupational worker. The principal COPCs contributing to this cancer risk are arsenic, PCBs (total), and benzo(a)pyrene in surface soil and beryllium and arsenic in groundwater. The estimated contribution to the carcinogenic risk for the future residents from groundwater exposure is 4E-04.

Cancer Risks within EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the current trespassers is 2E-05; the estimated carcinogenic risk for the future recreational child is 4E-06; the estimated carcinogenic risk for the future excavation worker is 2E-06. All risks are within the EPA's target risk range. Incidental ingestion and dermal contact with surface soil contribute the most to the cumulative carcinogenic risks for the current trespasser, future recreational child, and future excavation worker. The principal COPC contributing to this cancer risk is PCBs (total) (surface soil - before soil removal in 1999).

Table 4-25
Summary f Exp sure Pathway Risks by Site - Estimated RME Cancer Risks for Site 01
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Cancer Risk Current Occupational Worker				Estimated Cancer Risk Current Trespasser				Estimated Cancer Risk Future Recreational Child			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	T tal
Site 01												
Surface Soil, TOTAL RISK:	2.53E-05	9.43E-05	7.89E-09	1.20E-04	8.37E-06	1.34E-05	6.53E-10	2.17E-05	2.24E-06	1.57E-06	8.71E-11	3.80E-06
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	6.91E-07	8.45E-07	NA	1.54E-06	1.85E-07	8.21E-08	NA	2.67E-07
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NC	NC	NA	NC	NC	NC	NA	NC
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**2.53E-05**	**9.43E-05**	**7.89E-09**	**1.20E-04**	**9.06E-06**	**1.42E-05**	**6.53E-10**	**2.33E-05**	**2.42E-06**	**1.65E-06**	**8.71E-11**	**4.07E-06**

Area of Interest / Exposure Medium	Estimated Cancer Risk Future Excavation Worker				Estimated Cancer Risk Future Resident			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01								
Surface Soil, TOTAL RISK:	1.17E-06	4.52E-07	1.14E-10	1.62E-06	2.27E-04	2.07E-04	6.89E-08	4.34E-04
Subsurface Soil, TOTAL RISK:	6.88E-08	1.79E-08	3.6E-11	8.66E-08	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	3.07E-04	6.14E-05	1.17E-06	3.69E-04
GROUP TOTAL:	**1.24E-06**	**4.70E-07**	**1.5E-10**	**1.71E-06**	**5.34E-04**	**2.68E-04**	**1.24E-06**	**8.03E-04**

Notes:

NA -- Not Applicable
NT -- No toxicity factor
NC -- No COPCs selected
RME -- Reasonable Maximum Exposure

Table 4-25a
Summary of Exposure Pathway Risks by Site - Estimated RME Cancer Risks for Sit 01 (Revised for Soil Rem val)
NASJRB Willow Gr ve

Area of Interest / Exposure Medium	Estimated Cancer Risk Current Occupational Worker				Estimated Cancer Risk Current Trespasser				Estimated Cancer Risk Future Recreational Child			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalati n	Total
Site 01												
Surface Soil, TOTAL RISK:	7.87E-06	2.01E-05	7.16E-09	2.79E-05	2.60E-06	2.87E-06	5.92E-10	5.48E-06	6.95E-07	3.33E-07	7.90E-11	1.03E-06
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	6.91E-07	8.45E-07	NA	1.54E-06	1.85E-07	8.21E-08	NA	2.67E-07
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NC	NC	NA	NC	NC	NC	NA	NC
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**7.87E-06**	**2.01E-05**	**7.16E-09**	**2.79E-05**	**3.29E-06**	**3.72E-06**	**5.92E-10**	**7.01E-06**	**8.79E-07**	**4.15E-07**	**7.90E-11**	**1.29E-06**

Area f Interest / Exposure Medium	Estimated Cancer Risk Future Excavation Worker				Estimated Cancer Risk Future Resident			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01								
Surface Soil, TOTAL RISK:	3.62E-07	9.63E-08	1.03E-10	4.59E-07	7.05E-05	4.41E-05	4.41E-08	1.15E-05
Subsurface Soil, TOTAL RISK:	4.73E-08	1.19E-08	2.59E-11	5.92E-08	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	3.07E-04	6.14E-05	1.17E-06	3.69E-04
GROUP TOTAL:	**4.10E-07**	**1.08E-07**	**1.29E-10**	**5.18E-07**	**3.78E-04**	**1.06E-04**	**1.21E-06**	**3.81E-04**

Notes:

NA -- Not Applicable
NT -- No toxicity factor
NC -- No COPCs selected
RME -- Reasonable Maximum Exposure

Table 4-26
Summary f Exp sure Pathway Risks by Site - Estimated CTE Cancer Risks for Sit 01
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Cancer Risk Current Occupational Worker				Estimated Cancer Risk Current Trespasser				Estimated Cancer Risk Future Recreational Child			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01												
Surface Soil, TOTAL RISK:	9.12E-06	3.39E-05	2.84E-09	4.30E-05	5.53E-07	1.53E-06	8.62E-11	2.08E-06	3.73E-07	5.17E-07	2.90E-11	8.90E-07
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	4.56E-08	1.07E-07	NA	1.53E-07	3.08E-08	2.71E-08	NA	5.78E-08
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NC	NC	NA	NC	NC	NC	NA	NC
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**9.12E-06**	**3.39E-05**	**2.84E-09**	**4.30E-05**	**5.99E-07**	**1.64E-06**	**8.62E-11**	**2.24E-06**	**4.04E-07**	**5.44E-07**	**2.90E-11**	**9.48E-07**

Area of Interest / Exposure Medium	Estimated Cancer Risk Future Excavation Worker				Estimated Cancer Risk Future Resident			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01								
Surface Soil, TOTAL RISK:	5.83E-07	2.26E-07	5.68E-11	8.10E-07	3.64E-05	6.36E-05	2.17E-08	1.00E-04
Subsurface Soil, TOTAL RISK:	3.44E-08	8.93E-09	1.8E-11	4.33E-08	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	6.59E-05	3.38E-05	3.40E-07	1.00E-04
GROUP TOTAL:	**6.18E-07**	**2.35E-07**	**7.48E-11**	**8.53E-07**	**1.02E-04**	**9.74E-05**	**3.62E-07**	**2.00E-04**

Notes:

NA -- Not Applicable
NT -- No toxicity factor
NC -- No COPCs selected
CTE -- Central Tendency Exposure

Table 4-26a
Summary of Exp sure Pathway Risks by Sit - Estimated CTE Cancer Risks for Sit 01 (Revised f r Soil Removal)
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Cancer Risk Current Occupational Worker				Estimated Cancer Risk Current Trespasser				Estimated Cancer Risk Future Recreational Child			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01												
Surface Soil, TOTAL RISK:	2.83E-06	7.22E-06	2.58E-09	1.01E-05	1.72E-07	3.31E-07	7.82E-11	5.03E-07	1.16E-07	1.10E-07	2.63E-11	2.26E-07
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	4.56E-08	1.07E-07	NA	1.53E-07	3.08E-08	2.71E-08	NA	5.78E-08
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NC	NC	NA	NC	NC	NC	NA	NC
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**2.83E-06**	**7.22E-06**	**2.58E-09**	**1.01E-05**	**2.17E-07**	**4.38E-07**	**7.82E-11**	**6.56E-07**	**1.47E-07**	**1.37E-07**	**2.63E-11**	**2.84E-07**

Area of Interest / Exposure Medium	Estimated Cancer Risk Future Excavation Worker				Estimated Cancer Risk Future Resident			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01								
Surface Soil, TOTAL RISK:	1.81E-07	4.81E-08	5.16E-11	2.29E-07	1.13E-05	1.35E-05	1.96E-08	2.49E-05
Subsurface Soil, TOTAL RISK:	2.36E-08	5.95E-09	1.29E-11	2.96E-08	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	6.59E-05	3.38E-05	3.40E-07	1.00E-04
GROUP TOTAL:	**2.05E-07**	**5.41E-08**	**6.45E-11**	**2.59E-07**	**7.72E-05**	**4.73E-05**	**3.60E-07**	**1.25E-04**

Notes:

NA -- Not Applicable
NT -- No toxicity factor
NC -- No COPCs selected
CTE -- Central Tendency Exposure

RME Risks (aft r Soil R moval)

Cancer Risks within EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the future resident (4E-04) continues to exceed the upper end of the EPA target cancer risk range (1E-04 to 1E-06), mainly due to the exposure-to-groundwater scenario.

Cancer Risks within EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the current occupational worker is 3E-05. The estimated carcinogenic risk for the current trespasser is 7E-06, and the estimated carcinogenic risk for the future recreational child is 1E-06. These estimated risks fall within EPA's target risk range. Incidental ingestion and dermal contact with surface soil contribute the most to the cumulative carcinogenic risks for the current occupational worker, the current trespasser, and the future recreational child.

CTE Risks (before Soil Removal)

Estimated Cancer Risks Equal to or Exceeding EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the future resident is 2E-04, which exceeds the upper end of the EPA target cancer risk range of 1E-04 to 1E-06. Incidental ingestion and dermal contact with surface soil and ingestion of groundwater contribute the most to the cumulative carcinogenic risk for the future resident. The principal COPCs contributing to this cancer risk are arsenic, PCBs (total - before soil removal in 1999), and benzo(a)pyrene in surface soil and beryllium and arsenic in groundwater. The estimated contribution to the carcinogenic risk for the future residents from groundwater exposure is 1E-04.

Cancer Risks within EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the current occupational worker is 4E-05, and the estimated carcinogenic risk for the current trespassers is 2E-06. All risks are within EPA's target risk range. Incidental ingestion and dermal contact with surface soil contribute the most to the cumulative carcinogenic risks for the current occupational worker, current trespasser, and the future recreational child. The principal COPC contributing to this cancer risk is PCBs (total) (surface soil - before soil removal in 1999).

CTE Risks (after Soil Rem val)

Estimated Cancer Risks Equal to or Exceeding EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the future resident is 1E-04, which exceeds the upper end of the EPA target cancer risk range of 1E-04 to 1E-06. Ingestion of groundwater contributes the most to the cumulative carcinogenic risk for the future resident.

Cancer Risks within EPA's Target Risk Range of 1E-04 to 1E-06

The estimated carcinogenic risk for the current occupational worker is 1E-05. These risks are within EPA's target risk range. Incidental ingestion and dermal contact with surface soil contribute the most to the cumulative carcinogenic risks for the current occupational worker.

N ncarcinogenic Risks - RME

Table 4-27 lists the estimated cumulative RME noncarcinogenic risks at Site 1 for current occupational workers, current trespassers, future recreational children, future excavation workers, and future residents. Table 4-28 lists the estimated cumulative CTE noncarcinogenic risks at Site 1 for current occupational workers, current trespassers, future recreational children, future excavation workers, and future residents. EPA's cumulative HI of 1.0 is often used to determine the need for environmental remediation. EPA's HI of 1.0 is a benchmark below which adverse noncarcinogenic health effects are not anticipated under conditions established in the exposure assessment. Chemical-specific risks for COPCs are presented in Appendix J of the Phase II RI report.

RME Risks

Noncarcinogenic Hazard Indices Above 1.0

The cumulative HI for the future residential child (6.0) exceeds 1.0. Incidental ingestion of surface soil and ingestion of groundwater are the main contributors to the HI exceeding 1.0. The principal COPCs contributing to the noncarcinogenic risk are iron in surface soil (iron HQ is equal to 1.3) and manganese in groundwater (manganese HQ is equal to 2.7). The target organs for iron are the liver, pancreas, and the gastrointestinal (GI) tract. Iron was detected in all surface soil samples and was detected at concentrations elevated above background concentrations. The target organ for manganese is the central nervous system. Manganese was detected at a frequency of 12 out of 12 samples, with several

Table 4-27
Summary of Exposure Pathway Risks by Sit - Estimat d RME Hazard Indices for Site 01
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Hazard Index Current Occupational Worker				Estimated Hazard Index Current Adult Trespasser				Estimated Hazard Index Current Adolescent Trespasser			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01												
Surface Soil, TOTAL RISK:	7.10E-02	1.19E-01	NT	1.90E-01	1.36E-02	1.14E-02	NT	2.51E-02	2.98E-02	2.95E-02	NT	5.93E-02
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	2.50E-03	3.98E-03	NA	6.47E-03	5.46E-03	7.60E-03	NA	1.31E-02
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NC	NC	NA	NC	NC	NC	NA	NC
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**7.10E-02**	**1.19E-01**	**NT**	**1.90E-01**	**1.61E-02**	**1.54E-02**	**NT**	**3.15E-02**	**3.53E-02**	**3.71E-02**	**NT**	**7.23E-02**

Area of Interest / Exposure Medium	Estimated Hazard Index Future Recreational Child				Estimated Hazard Index Future Excavation Worker				Estimated Hazard Index Future Residential Adult			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01												
Surface Soil, TOTAL RISK:	2.61E-02	NT	2.08E-06	2.61E-02	8.17E-02	1.43E-02	NT	9.60E-02	1.99E-01	1.67E-01	NT	3.65E-01
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	6.67E-02	8.37E-03	NT	7.50E-02	NA	NA	NA	NA
Sediment, TOTAL RISK:	4.78E-03	2.13E-03	NA	6.91E-03	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NC	NC	NA	NC	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NT	NT	1.55E+00	2.76E-02	NT	1.58E+00
GROUP TOTAL:	**3.09E-02**	**2.13E-03**	**2.08E-06**	**3.30E-02**	**1.48E-01**	**2.27E-02**	**NT**	**1.71E-01**	**1.75E+00**	**1.95E-01**	**NT**	**1.95E+00**

Area of Interest / Exposure Medium	Estimated Hazard Index Future Residential Child			
	Ingestion	Dermal Contact	Inhalation	Total
Site 01				
Surface Soil, TOTAL RISK:	1.85E+00	4.25E-01	NT	2.28E+00
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA
Groundwater, TOTAL RISK:	3.62E+00	5.80E-02	NA	3.68E+00
GROUP TOTAL:	**5.47E+00**	**4.83E-01**	**NT**	**5.96E+00**

Notes:

NA -- Not considered applicable
NT -- No toxicity factor
NC -- No COPC's selected
RME -- Reasonable Maximum Exposure

Table 4-28
Summary f Exp sure Pathway Risks by Site - Estimated CTE Hazard Indices f r Site 01
NASJRB Willow Grove

Area of Interest / Exposure Medium	Estimated Hazard Index Current Occupational Worker				Estimated Hazard Index Current Adult Trespasser				Estimated Hazard Index Current Adolescent Trespasser			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01												
Surface Soil, TOTAL RISK:	7.10E-02	1.19E-01	NT	1.90E-01	3.41E-03	5.72E-03	NT	9.12E-03	7.45E-03	1.51E-02	NT	2.26E-02
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA	6.24E-04	1.99E-03	NA	2.61E-03	1.36E-03	3.90E-03	NA	5.27E-03
Surface Water, TOTAL RISK:	NA	NA	NA	NA	NC	NC	NA	NC	NC	NC	NA	NC
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GROUP TOTAL:	**7.10E-02**	**1.19E-01**	**NT**	**1.90E-01**	**4.03E-03**	**7.71E-03**	**NT**	**1.17E-02**	**8.81E-03**	**1.90E-02**	**NT**	**2.79E-02**

Area of Interest / Exposure Medium	Estimated Hazard Index Future Recreational Child				Estimated Hazard Index Future Excavation Worker				Estimated Hazard Index Future Residential Adult			
	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total	Ingestion	Dermal Contact	Inhalation	Total
Site 01												
Surface Soil, TOTAL RISK:	1.31E-02	NT	2.08E-06	1.31E-02	4.09E-02	7.15E-03	NT	4.80E-02	9.93E-02	1.67E-01	NT	2.66E-01
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA	3.33E-02	4.19E-03	NT	3.75E-02	NA	NA	NA	NA
Sediment, TOTAL RISK:	2.39E-03	2.11E-03	NA	4.50E-03	NA	NA	NA	NA	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NC	NC	NA	NC	NA	NA	NA	NA	NA	NA	NA	NA
Groundwater, TOTAL RISK:	NA	NA	NA	NA	NA	NA	NT	NT	1.09E+00	2.76E-02	NT	1.11E+00
GROUP TOTAL:	**1.54E-02**	**2.11E-03**	**2.08E-06**	**1.76E-02**	**7.42E-02**	**1.13E-02**	**NT**	**8.55E-02**	**1.18E+00**	**1.95E-01**	**NT**	**1.38E+00**

Area of Interest / Exposure Medium	Estimated Hazard Index Future Residential Child			
	Ingestion	Dermal Contact	Inhalation	Total
Site 01				
Surface Soil, TOTAL RISK:	9.27E-01	4.21E-01	NT	1.35E+00
Subsurface Soil, TOTAL RISK:	NA	NA	NA	NA
Sediment, TOTAL RISK:	NA	NA	NA	NA
Surface Water, TOTAL RISK:	NA	NA	NA	NA
Groundwater, TOTAL RISK:	2.54E+00	1.74E-01	NA	2.71E+00
GROUP TOTAL:	**3.47E+00**	**5.95E-01**	**NT**	**4.06E+00**

Notes:

NA -- Not considered applicable
NT -- No toxicity factor
NC -- No COPC's selected
CTE -- Central Tendency Exposure

concentrations exceeding the tap water RBC value. No other combination of HQs that affect the same target organ for the future residential child would result in an HI of greater than 1.0.

The cumulative HI for the future residential adult (2.0) exceeds 1.0. Ingestion of groundwater is the main contributor to the HI exceeding 1.0. The principal COPC contributing to the noncarcinogenic risk is manganese in groundwater (manganese HQ is equal to 1.2). The target organ for manganese is the central nervous system. Manganese was detected at a frequency of 12 out of 12 samples, with several concentrations exceeding the tap water RBC value. No other combination of HQs that affect the same target organ for the future residential adult would result in an HI of greater than 1.0.

Noncarcinogenic Hazard Indices less than 1.0

The HIs for current occupational workers, current trespassers, future recreational children, and future excavation workers at Site 1 are less than 1.0.

CTE Risks

Noncarcinogenic Hazard Indices above 1.0

The cumulative HI for the future residential child (4.1) exceeds 1.0. Incidental ingestion of surface soil and ingestion of groundwater are the main contributors to the HI exceeding 1.0. The principal COPCs contributing to the noncarcinogenic risk are iron in surface soil (iron HQ is equal to 0.7) and manganese in groundwater (manganese HQ is equal to 2.0). The target organ for manganese is the central nervous system. Manganese was detected at a frequency of 12 out of 12 samples, with several concentrations exceeding the tap water RBC value. No other combination of HQs that affect the same target organ for the future residential child would result in an HI of greater than 1.0.

The cumulative HI for the future residential adult (1.4) exceeds 1.0. Ingestion of groundwater is the main contributor to the HI exceeding 1.0. The principal COPC contributing to the noncarcinogenic risk is manganese in groundwater (manganese HQ is equal to 0.9). However, no combination of HQs that affect the same target organ for the future residential adult would result in an HI of greater than 1.0.

Noncarcinogenic Hazard Indices less than 1.0

The HIs for current occupational workers, current trespassers, future recreational children, and future excavation workers at Site 1 are less than 1.0.

A Discussion of the Impact f Subsurfac Soil Exposure Risks to Future R id ntial Receptors

Subsurface soil exposure to future residential receptors can be evaluated using the COPCs that are drivers for the risks in surface soil, arsenic (carcinogenic risks), PCBs (carcinogenic risks), and iron (noncarcinogenic risks). Arsenic, PCBs, and iron are also the main drivers to the carcinogenic and noncarcinogenic risks to the excavation worker in subsurface soils. Arsenic has a representative concentration of 5.29 mg/kg in subsurface soil. Iron has a representative concentration of 25,400 mg/kg in subsurface soil. PCBs (total) has a representative concentration of 302 ug/kg in subsurface soil. Subsurface soil would be assumed to be surface soil for the future residential receptors. Assuming a standard residential RME exposure scenario for exposure to subsurface soils, the estimated carcinogenic risk to the future residential receptor would be within EPA's target cancer risk range of 1E-04 to 1E-06. The risks from arsenic would be estimated at approximately 1E-05, and the risks from PCBs (since removed) would be approximately 1E-06. The noncarcinogenic risks to the future residential child would exceed HIs of 1.0.

4.7.5 Uncertainties

Beyond the uncertainties associated with the human health risk assessment process discussed in Section 3.1, the following uncertainties should be considered in any evaluation of Site 1 risk assessment results:

- The uncertainty associated with the dermal exposure is high because of the derivation of the dermal slope factor and reference dose. The dermal toxicity factors are based on default oral absorption factors. This can result in an overestimation of the toxicity factors. It eventually causes dermal exposure to be a primary contributor to the cumulative cancer risk and HI (via surface soils) for the future residential receptors and current occupational workers. The uncertainty associated with the dermal exposure route may overestimate the risk at Site 1.

- Arsenic is a major contributor to the cumulative carcinogenic risks in surface soil and, to a lesser extent, groundwater. The carcinogenicity of arsenic via ingestion is not confirmed by the available data. However, EPA has proposed an oral unit risk factor that was used from oral and dermal exposures to arsenic. Since arsenic is a major contributor to the risk, risks may be overstated.

- Iron is the main contributor to the noncarcinogenic risks for the future residential child (surface soil exposure). There is uncertainty associated with the oral RfD for iron. Risks at Site 1 from iron exposure may be overestimated.

- Three chemicals, 2-methylnaphthalene (surface soils), benzo(g,h,i)perylene (surface soil and sediment), and phenanthrene (surface soil and sediment), did not have listed toxicity values for use in the quantitative risk assessment; therefore, no risks were estimated for exposure to the COPCs. These chemicals generally had low or similar frequencies of detection as chemicals within the same class (i.e., PAHs). This uncertainty could possibly underestimate the carcinogenic and noncarcinogenic risk at Site 1, but, without additional toxicity information, this remains unknown.

4.7.6 Conclusions

The total cumulative carcinogenic risk for the current occupational worker was calculated to be equal to EPA's target cancer risk range at Site 1 for the RME scenario and within EPA's target cancer risk range for the CTE scenario before the PCB-contaminated soil was removed in 1999. The total cumulative carcinogenic risk for the future residential receptor exceeded EPA's target cancer risk range for the RME and CTE. PCBs at Site 1 were the main contributors to cancer risk for the potential receptors.

Recalculating carcinogenic risk estimating scenarios after the PCB-contaminated soil was removed in 1999 reduced the estimated potential impact from the site. Only the estimated risk (4E-04) to a hypothetical future resident exceeded the EPA's maximum target cancer risk range, due mainly to exposure to groundwater.

After accounting for the PCB-contaminated soil removal in 1999, the revised estimated carcinogenic risk for the current occupational worker is 3E-05. The revised estimated carcinogenic risk for the current trespasser is 7E-06, and the revised estimated carcinogenic risk for the future recreational child is 1E-06. These estimated risks fall within EPA's target risk range.

Groundwater at Site 1 is currently used for human consumption (after VOC stripping tower treatment). The RME and CTE risks for groundwater consumption (untreated groundwater) for a future residential receptor are 4E-04 and 9E-05, respectively, both of which exceed or equal the EPA target cancer risk range of 1E-04 to 1E-06. Beryllium and arsenic are the main contributors to the RME and CTE groundwater carcinogenic risk at Site 1 for the future residential receptor. Iron is the main contributor in surface soils, and manganese is the main contributor in groundwater to the RME and CTE noncarcinogenic risk (HIs greater than 1.0) at Site 1 for the future residential child receptor. All other noncarcinogenic HIs for the other potential receptors at Site 1 are less than 1.0. The history of Site 1 use as a waste transfer and handling station and for storage of PCB transformers is consistent with the COPCs found in soil media at the site.

4.8 ECOLOGICAL RISK ASSESSMENT

This section presents the results of the ecological risk assessment performed at Site 1, the Privet Road Compound, and consists of a discussion of the problem formulation, effects characterization, exposure assessment, risk characterization, and risk management.

4.8.1 Problem Formulation

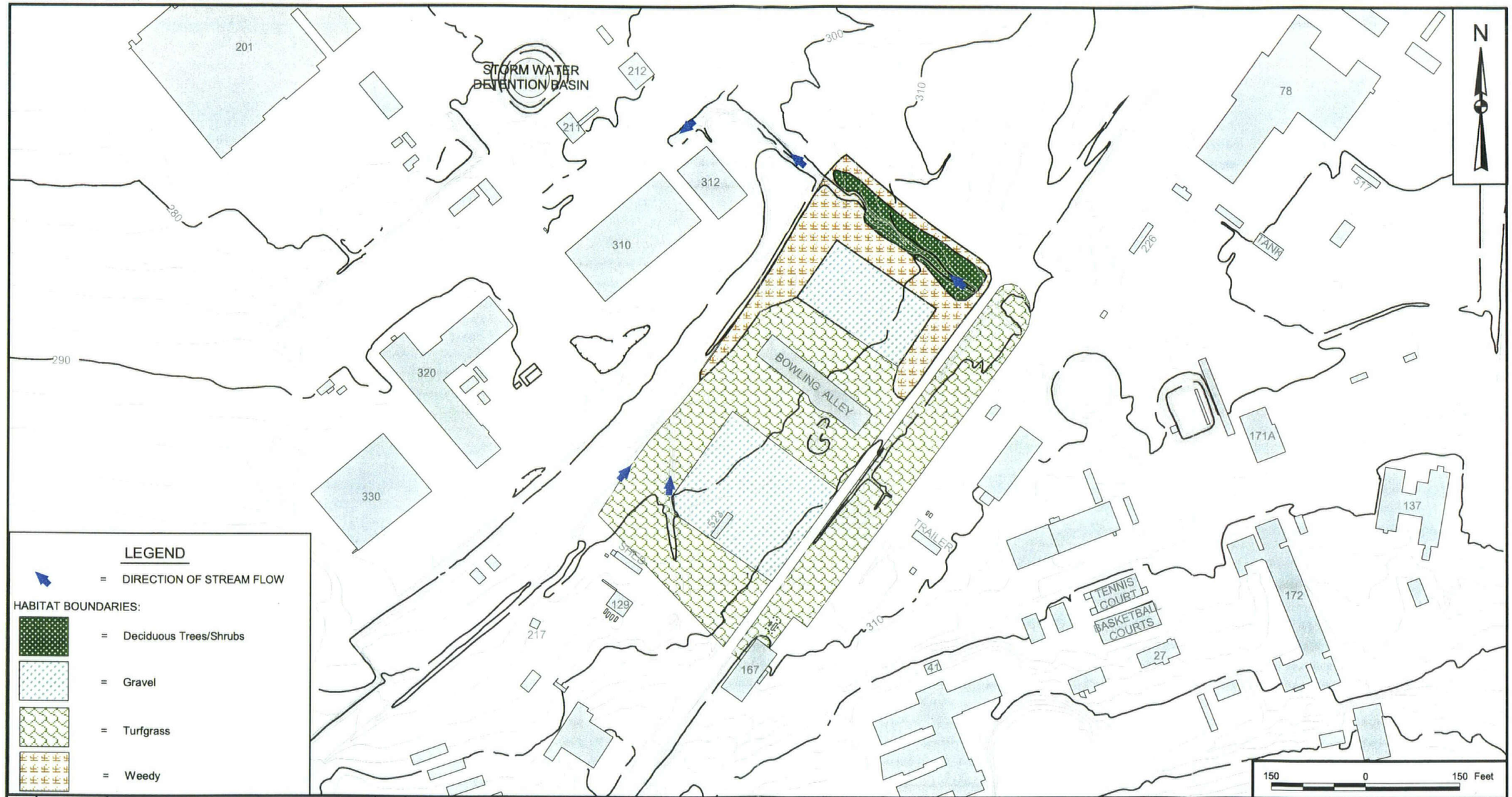
This section includes a discussion of available habitats, ecological receptors, contaminant sources, release mechanisms, migration pathways, exposure routes, selection of preliminary contaminants of potential concern (PCOCs), assessment and measurement endpoints, and the conceptual site model.

4.8.1.1 Habitat Types and Ecological Receptors

The site lies within a heavily developed section of NASJRB Willow Grove (Figures 1-2 and 4-29). The base bowling alley and associated parking lot are located in the southern portion of the site. A work/storage yard is located in the northern portion of the site. The work/storage yard is covered in gravel. Vegetation on most of the site consists of frequently mowed turf grass. A few locust trees are located in the lawn near the bowling alley. An occasionally mowed weedy area is located in the northern portion of the site outside the work/storage yard. Paved roads border the eastern and western boundaries of the site. The northern end of the site is bordered by a 30-foot-wide strip of trees and brush, beyond which lies Johnson Street. This 30-foot-wide area is dominated by tulip poplar, sumac, maple, sassafras, honey suckle, and poison ivy (Figure 4-29). A 12-inch-wide drainage ditch parallels Johnson Street within the strip of trees.

Since the site is in a developed area where habitat consists only of mowed turf grass and small weedy areas, the site provides poor wildlife habitat. Terrestrial receptors at Site 1 consist of those that have become accustomed to urban areas. These include mammals such as raccoons, mice, and exotic rodents such as the Norway rat, black rat, and house mouse. Various birds forage in the lawns and weedy areas on the site. A few species of reptiles and amphibians (e.g., lizards, frogs) undoubtedly utilize the weedy areas, at least occasionally. The drainage ditches and swales are normally dry and there are no wetlands at the site. Thus, there is no aquatic habitat at or near the site, except following rain events. In addition, the stormwater detention basin into which site stormwater flows is underground. Thus, the detention basin is not utilized by aquatic receptors.

GIS\NASJRB Willow Grove.apr 4/30/02 LDL SITE 1 - HABITAT MAP



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY LDL	DATE 4/30/02
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

HABITAT MAP
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NUMBER 5466	OWNER NUMBER 2207
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 4-29	REV

4.8.1.2 Contaminant S urces, Release Mechanisms, and Migration Pathways

The contaminant source at the Privet Road Compound consists of the area where wastes were formerly handled and disposed. As discussed earlier, the site was used from 1967 until 1975 (after closure of the Ninth Street Landfill) for the disposal of general refuse, paint wastes, chemical wastes, scrap metal, and sewage sludge. Additional contaminant sources consist of wastes generated by vehicles and lawn maintenance.

The contaminant migration pathways from this area include wind erosion, overland runoff, and infiltration of contaminants. Contaminated fugitive dust can be generated during ground-disturbing activities, such as construction or excavation. The contaminants could then be dispersed in the surrounding environment and transported to downwind locations where they could repartition to surface soil, surface water, or sediment through gravitational settling, precipitation, and deposition. However, the paved areas, turf grass, and weeds serve to minimize the airborne contaminant transport pathway. Precipitation runoff can carry contaminants via drainage swales and ditches to the stormwater detention basin west of the site. Infiltrating precipitation can cause contamination of subsurface soil and groundwater. After reaching the water table, contaminants can be carried with the flow of groundwater to downgradient locations. Contaminants can be deposited subsequently in sediment or surface water and can potentially accumulate in the tissues of aquatic organisms. Groundwater beneath the site flows northward or northwestward toward Park Creek, which is approximately 5,000 feet from the site. There is no evidence that groundwater surfaces to Park Creek. Surface water samples obtained downgradient from Site 1 do not show site-related-type compounds (e.g., TCE).

4.8.1.3 Exposure Routes

Terrestrial animals at Site 1 can be exposed to soil contaminants through the ingestion of contaminated food items. In addition, animals can incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items that are covered with soil (such as roots and tubers). Terrestrial vegetation can be exposed to contaminants through direct aerial deposition and root translocation. Aerial deposition, however, is minimal due to the presence of turf grass and gravel on the site (over the landfilled wastes). Terrestrial receptors can also come into contact with contaminants in surface water by using it for drinking, although this exposure route generally represents a negligible portion of total exposure for most receptors. Aquatic and semi-aquatic organisms can be exposed to contaminants through direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Exposure to contaminants in the soil via dermal contact can occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons minimize the transfer of contaminants across dermal tissue.

Volatile constituents could be present in some site soils and soil-bound contaminant airborne suspension could occur at Site 1. However, previous sampling activities at the site indicate that volatile contamination is minimal at the site. In addition, inhalation does not represent a significant exposure pathway because this investigation assumes that air contaminant concentrations are quite low, even for burrowing wildlife. Furthermore, inhalation ecotoxicity data for chronic exposure are lacking. Hence, the air pathway was not considered for ecological receptors.

4.8.1.4 Selection of Preliminary Contaminants of Concern (PCOCs)

Calcium, magnesium, potassium, and sodium were excluded as preliminary contaminants of concern (PCOCs) in all media because they are essential nutrients that are toxic only at extremely high concentrations. Otherwise, analytes selected for evaluation consisted of all analytes detected during current and previous sampling of surface water, sediment, and surface soil at Site 1 (Section 4.8.4).

4.8.1.5 Assessment and Measurement Endpoints

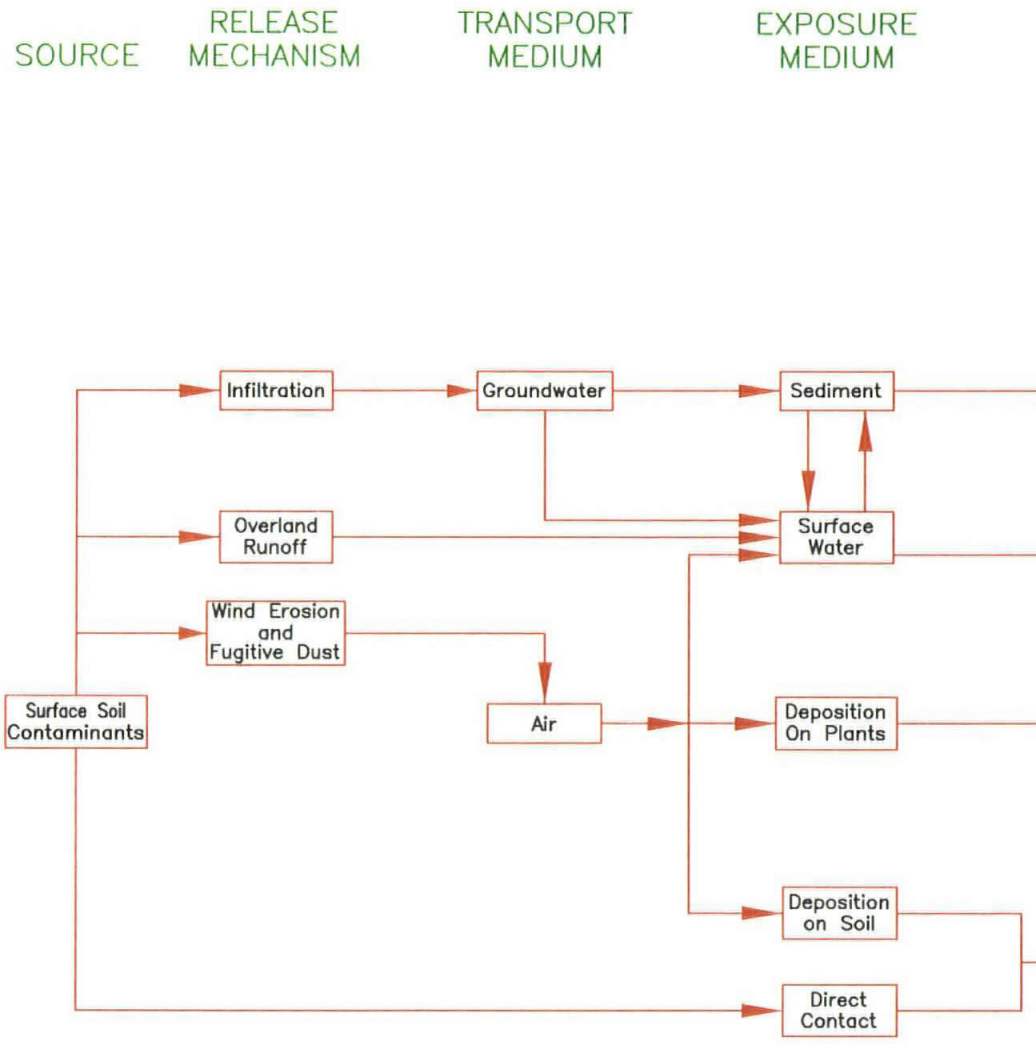
A description of assessment and measurement endpoints for this investigation is presented in Section 3.1.

4.8.1.6 Conceptual Site Model

Figure 4-30 shows the conceptual model for Site 1. Wind erosion and fugitive dust are presented as release mechanisms but are thought to be minimal due to the general absence of bare dirt and the presence of vegetation on the site.

4.8.2 Ecological Effects Characterization

Ecologically based screening levels (e.g., concentrations of contaminants in various media protective of ecological receptors) were compared to exposure point concentrations of detected analytes in surface water, sediment, and surface soil to determine if the analytes qualify as ecological PCOCs at Site 1. The selection of screening levels is discussed in Section 3.2. Subsequent to this initial screening, other ecological screening levels were used to assess risks from site contaminants in the risk management phase.



EXPOSURE MECHANISM	Terrestrial Wildlife	Aquatic	Terrestrial Plant	Terrestrial Invertebrate
Direct Contact	c	c	n	n
Ingestion of Sediment	c	c	n	n
Ingestion of Prey	c	c	n	n
Direct Contact	c	c	n	n
Ingestion	c	c	n	n
Direct Contact	n	n	c	n
Ingestion of Plants	c	n	n	n
Ingestion of Prey	c	n	n	n
Dermal Contact – Soil	c	n	n	c
Ingestion of Soil	c	n	n	c
Uptake by Plants	n	n	c	n
Ingestion of Plants	c	n	n	n
Ingestion of Prey	c	n	n	n

LEGEND

c = COMPLETE EXPOSURE PATHWAY

n = EXPOSURE ROUTE NOT APPLICABLE TO RECEPTOR

DRAWN BY LDL	DATE 4/30/02	Tetra Tech NUS, Inc.	CONTRACT NO. 5466
CHECKED BY	DATE	CONCEPTUAL SITE MODEL	OWNER NO. 2207
REVISED BY	DATE	SITE 1 – PRIVET ROAD COMPOUND AREA NASJRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	APPROVED BY DATE
SCALE NONE			DRAWING NO. FIGURE 4–30 REV.

5466gf04.dwg

4.8.3 Exposure Assessment

This section presents the ecological exposure assessment for Site 1 and includes a discussion of exposure point contaminant concentrations.

4.8.3.1 Exposure Point Contaminant Concentrations

The maximum detected contaminant concentrations in surface water, sediment, and soil were used as exposure point concentrations for screening against ecological screening levels. Mean contaminant concentrations and 95 percent upper confidence level (UCL) of the mean contaminant concentrations were used as more representative exposure point concentrations for comparison to alternate guidelines in the risk management section.

4.8.4 Risk Characterization

This section presents the results and a discussion of the ecological risks at Site 1.

4.8.4.1 Results - Ecological Screening Assessment

The maximum detected concentrations of aluminum, antimony, barium, chromium, iron, lead, and zinc in surface water exceeded screening levels and therefore they were retained as inorganic PCOCs (Table 4-29). The organic 4-methyl-2-pentanone was retained as a PCOC since no surface water screening level was available. Arsenic, cadmium, copper, lead, and nickel were retained as inorganic sediment PCOCs since their maximum concentrations exceeded screening levels (Table 4-30). Aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium were retained as sediment PCOCs since no screening levels were available. Several organics in sediments were retained as PCOCs since their maximum concentrations exceeded screening levels, including the PCB mixture Aroclor 1260, benz(a)anthracene, bis(2-ethylhexyl) phthalate, butylbenzyl phthalate, chrysene, fluoranthene, phenanthrene, pyrene, and total PAHs. Dieldrin and benzo(k)fluoranthene were retained as sediment PCOCs since no screening levels were available.

Aluminum, arsenic, cadmium, chromium, copper, lead, manganese, mercury, thallium, vanadium, and zinc were retained as inorganic PCOCs in soils since their maximum concentrations exceeded screening levels (Table 4-31). Immunoassay PCBs, total PCBs, the PCB mixture Aroclor 1260, total PAHs, and pyrene were retained as organic PCOCs in soils since their maximum concentrations exceeded screening levels. In addition, 1,2,4-trichlorobenzene, 2-methylnaphthalene, and the VOCs acetone and chloroform were retained as organic PCOCs since no screening levels were available.

TABLE 4-29
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN IN SURFACE WATER
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE

Contaminant	Frequency of Detection	Range of Detected Concentrations (µg/L)		Location of Maximum	Screening Level (µg/L)	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
Inorganics							
Aluminum	2/2	1,260	1,440	01SWS2	25[1]	57.6	Yes
Antimony	1/5	47	47	01SWS6	30[1]	1.57	Yes
Barium	3/5	5	37	01SWS5	3.9[2]	9.5	Yes
Chromium	2/5	7	10	01SWS5	10[3]	1.0	Yes
Iron	5/5	571	1,660	01SWS2	1,000[3]	1.7	Yes
Lead	5/5	2	5	01SWS2	2.5[3]	2.0	Yes
Manganese	3/3	21	41	01SWS2	80[2]	0.5	No
Zinc	2/2	45	194	01SWS6	100[3]	1.9	Yes
VOCs							
Acetone	2/5	170	1,300	01SWS5	9,000,000	0.00	No
SVOCs							
4-methyl-2-pentanone	2/5	92	220	PRSWS5	NA	NA	Yes

1. Region III BTAG screening level (EPA, 1995)
2. Tier II value (EPA, 1996)
3. AWQC or FCV (EPA, 1996)

TABLE 4-30
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN IN SEDIMENT
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE

Contaminant	Frequency of Detection	Range of Detections		Location of Maximum	Screening Level	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
Inorganics (mg/kg)							
Aluminum	6/6	8,060	18,700	01SD05	NA	NA	Yes
Antimony	1/3	7.4	7.4	01SD12	150[1]	0.05	No
Arsenic	6/6	4.0	8.5	01SD12	8.2[2]	1.04	Yes
Barium	6/6	40.0	167.0	01SD02	NA	NA	Yes
Beryllium	3/3	0.78	1.0	01SD02	NA	NA	Yes
Cadmium	5/6	1.0	5.0	01SD02	1.2[2]	4.17	Yes
Chromium	6/6	15.0	32.0	01SD05	81[2]	0.4	No
Cobalt	6/6	5.0	17.0	01SD02	NA	NA	Yes
Copper	6/6	9.0	36.0	01SD02	34[2]	1.05	Yes
Iron	6/6	12,800	33,500	01SD02	NA	NA	Yes
Lead	6/6	23.0	89.0	01SD01	47[2]	1.9	Yes
Manganese	6/6	243	1,280	01SD02	NA	NA	Yes
Nickel	6/6	8.0	22.0	01SD02	21[2]	1.05	Yes
Selenium	1/6	0.32	0.32	01SD12	1.0[4]	0.3	No
Vanadium	6/6	21.0	42	01SD05	NA	NA	Yes
Zinc	6/6	67.2	124	01SD05	150[2]	0.83	No
Pesticides/PCBs (µg/kg)							
Aroclor-1260	1/6	980	980	01SD12	50[3]	19.6	Yes
Dieldrin	1/6	210	210	012D01	NA	NA	Yes

TABLE 4-30
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN IN SEDIMENT
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
PAGE 2 OF 2

Contaminant	Frequency of Detection	Range of Detections		Location of Maximum	Screening Level	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
SVOCs (µg/kg)							
Benz(a)anthracene	4/6	140	400	01SD08	261[2]	1.53	Yes
Benzo(a)pyrene	4/6	180	320	01SD08	430[2]	0.74	No
Benzo(b)fluoranthene	4/6	250	590	01SD08	3,200[1]	0.18	No
Benzo(g,h,i)perylene	2/6	89	150	01SD12	670[1]	0.22	No
Benzo(k)fluoranthene	4/6	170	250	01SD08	NA	NA	Yes
Bis(2-ethylhexyl)phthalate	3/6	330	1,500	01SD09	1,300[1]	1.15	Yes
Butylbenzylphthalate	4/6	91	340	01SD08	63[1]	5.4	Yes
Chrysene	4/6	200	460	01SD08	384[2]	1.20	Yes
Fluoranthene	6/6	65	760	01SD08	600[2]	1.27	Yes
Indeno(1,2,3-cd)pyrene	2/6	140	200	01SD12	600[1]	0.33	No
Phenanthrene	4/6	130	400	01SD12	240[2]	1.67	Yes
Pyrene	6/6	49	890	01SD08	660[2]	1.35	Yes
Total PAHs	6/6	114	4,020	01SD08	4,000[2]	1.01	Yes

1 Region III BTAG Screening Level (EPA, 1995)
2. ERL (Long etal 1995)
3. Long and Morgan (1990)
4. Wisconsin DNR (1985)

TABLE 4-31
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN FOR SURFACE SOIL
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE

Contaminant	Frequency of Detection	Range of Detections		Location of Maximum	Screening Level	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
Inorganics (mg/kg)							
Aluminum	13/13	9470.00	22000.00	01SB17-0002	1[1]	22000	Y s
Arsenic	13/13	2.00	16.00	01SB11-0002	10[2]	1.6	Y s
Barium	13/13	59.00	129.00	01SB03-0002	412.5[3]	0.3	No
Cadmium	5/13	2.00	6.00	01SB11-0002	3[2]	2.0	Y s
Chromium	13/13	22.00	37.00	01SB16-0002	10[4]	3.7	Yes
Cobalt	13/13	7.00	12.20	01SB16-0002	130[3]	0.1	No
Copper	13/13	13.00	44.00	01SB12-0002	100[2]	0.4	No
Iron	13/13	18600.00	33300.00	01SB17-0002	12[1]	2750	Yes
Lead	13/13	9.00	149.00	01SB11-0002	50[4]	3.0	Yes
Manganese	13/13	166.00	867.00	01SB03-0002	330.00[1]	2.63	Yes
Mercury	5/13	0.14	0.36	01SB07-0002	0.1[4]	3.6	Yes
Nickel	13/13	12.00	20.00	01SB16-0002	30[2]	0.7	No
Silver	1/13	3.00	3.00	01SB07-0002	9.8E-06[1]	3.1E-05	No
Thallium	6/10	0.25	0.45	01SB17-0002	0.001[1]	450	Yes
Vanadium	13/13	27.00	48.00	01SB17-0002	20[4]	2.4	Yes
Zinc	13/13	39.00	200.00	01SB11-0002	50[4]	4.0	Y s
P sticid s/PCBs (ug/kg)							
PCBs (immunoassay)	46/51	550	25000	01SS23	510[3]	49	Yes
PCBs (total)	54/64	550	230000	01SB03-0002	510[3]	451	Yes
Aroclor-1260	11/16	51	230000	01SB03-0002	51[3]	4510	Yes
Dieldrin	1/13	77.00	77.00	01SB10-0002	100[1]	0.77	No

TABLE 4-31
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN FOR SURFACE SOIL
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
PAGE 2 OF 3

Contaminant	Frequency of Detection	Range of Detections		Location of Maximum	Screening Level	Hazard Quotient	S lected as PCOC?
		Minimum	Maximum				
SVOCs (ug/kg)							
1,2,4-trichlorobenzene	1/6	120.00	120.00	01SS25	NA	NA	Yes
2-methylnaphthalene	1/6	130.00	130.00	01SS25	NA	NA	Yes
Acenaphthene	1/6	66.00	66.00	01SS25	100[1]	0.66	No
Anthracen	1/6	250.00	250.00	01SS25	2050[3]	0.1	No
Benzo(a)anthracene	3/6	35.00	1300.00	01SS25	2050[3]	0.6	No
Benzo(a)pyrene	3/6	40.00	1200.00	01SS25	2050[3]	0.6	No
Benzo(b)fluoranthene	2/6	440.00	1500.00	01SS25	2050[3]	0.7	No
Benzo(g,h,i)perylene	2/6	140.00	960.00	01SS25	2050[3]	0.5	No
Benzo(k)fluoranthene	2/6	260.00	770.00	01SS25	2050[3]	0.4	No
Butylbenzylphthalate	2/6	220.00	270.00	01SS26	3005[3]	0.1	No
Chrysen	3/6	52.00	1400.00	01SS25	2050[3]	0.7	No
Di-n-butylphthalate	2/6	91.00	110.00	01SS25	3005[3]	0.04	No
Dibenz(a,h)anthracene	2/6	43.00	290.00	01SS25	2050[3]	0.1	No
Fluoranthene	3/6	53.00	1800.00	01SS25	2050[3]	0.9	No
Fluorene	1/6	65.00	65.00	01SS25	2050[3]	0.03	No
Indeno(1,2,3-cd)pyrene	2/6	160.00	1100.00	01SS25	2050[3]	0.5	No
Naphthalene	1/6	92.00	92.00	01SS25	2050[3]	0.04	No
Phenanthrene	2/6	370.00	1100.00	01SS25	2050[3]	0.5	No
Pyrene	3/6	59.00	2500.00	01SS25	2050[3]	1.2	Yes
Total PAHs	3/6	217.5	14,500	01SS25	4,000[5]	3.6	Yes

TABLE 4-31
SELECTION OF PRELIMINARY CONTAMINANTS OF CONCERN FOR SURFACE SOIL
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
PAGE 3 OF 3

Contaminant	Frequency of Detection	Range of Detections		Location of Maximum	Screening Level	Hazard Quotient	Selected as PCOC?
		Minimum	Maximum				
VOCs (ug/kg)							
Acetone	3/12	4.00	7.00	PRB-7-0002	NA	NA	Yes
Chloroform	1/13	1.00	1.00	PRB-8-0002	NA	NA	Yes
Dioxins/Furans (ug/kg)							
TCDD Toxicity Equivalents	6/6	0.00955	0.0648	01SB19-0002	10	0.01	No

1. Region III BTAG screening level (EPA, 1995)
2. Will and Suter (1995b)
3. Netherlands (1994)
4. ORNL (1996)
5. ERL for sediment (Longetal, 1995)

4.8.4.2 Risk Manag m nt

This section discusses PCOCs in surface water, sediment, and surface soil from a risk management perspective and describes the selection of final COCs.

4.8.4.2.1 Surface Water

The inorganics aluminum, antimony, barium, chromium, iron, lead, and zinc were retained as surface water PCOCs. Aluminum is one of the most common elements in the earth's crust (Goyer, 1986) and is rarely toxic under normal pH conditions. Antimony was detected in one of five samples and the one detection only slightly exceeded the screening level. The maximum concentration of barium was that much less than the BTAG screening level and was also less than background concentrations (Table 4-32). Likewise, the maximum concentration of chromium in surface water was less than the BTAG screening level. Iron is a common element and essential nutrient that is rarely toxic under normal pH conditions, and the average concentration of this metal in surface water only slightly exceeded the screening level for iron, which is the AWQC. The average concentration of lead only slightly exceeded the BTAG screening level for that inorganic.

The HQ value for zinc in surface water was relatively low (HQ = 1.76). One organic, 4-methyl-2-pentanone, was a surface water PCOC but was detected in two of five samples at 92 and 220 ppb. Aquatic toxicity data for this organic are scarce, but it was not detected in sediments or soils from Site 1. For these reasons, no surface water COCs (contaminants that may require remediation) were selected for Site 1.

4.8.4.2.2 Sediment

Arsenic, cadmium, copper, lead, and nickel all had maximum sediment concentrations in excess of screening levels. However, the HQs of these metals only slightly exceeded 1.0, and their maximum concentrations were below their ER-M values (Table 4-32). Furthermore, the maximum site-specific concentrations of arsenic, copper, and nickel were comparable to the maximum concentrations in background samples. Aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium were retained as PCOCs since no screening levels were available. Aluminum is one of the most common elements in the earth's crust (Goyer, 1986). The average concentrations of barium, beryllium, cobalt, iron, manganese, and vanadium in sediments were comparable to the average concentrations in background.

TABLE 4-32
ECOLOGICAL RISK MANAGEMENT
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE

Contaminant	Frequency of Detection	Range of Detections		95% UCL	Mean Concentration	Initial Screening Level[1]	BTAG Screening Level	Alternate Screening Level[2]	Mean/Max. Background	Retained as Final COC?
		Minimum	Maximum							
Surface Water (µg/L)										
Aluminum	2/2	1,260	1,440	-	1,350	25	25	87	ND	No
Antimony	1/5	47	47	41.3	27.4	30	30	NA	ND	No
Barium	3/5	5	37	663	10	3.9	10,000	NA	101/112	No
Chromium	2/5	7	10	8.3	5.5	10	11	NA	ND	No
Iron	5/5	571	1,660	1,490	1,070	1,000	320	NA	85.3/519	No
Lead	5/5	2	5	4.69	3.4	2.5	3.2	NA	ND	No
Zinc	2/2	45	194	-	120	100	110	NA	6.8/9.1	No
4-Methyl-2-pentanone	2/5	92	220	367,000	297	NA	NA	NA	ND	No
Sediment[3]										
Aluminum	6/6	8,060	18,700	19,000	13,500	NA	NA	NA	6,300/8,950	No
Arsenic	6/6	4.0	8.5	7.97	6.58	8.2	0.057	70	4.51/7.2	No
Barium	6/6	40.0	167.0	159	91.9	NA	NA	NA	95.9/142	No
Beryllium	3/3	0.78	1.0	1.62	1.09	NA	NA	NA	0.865/1.2	No
Cadmium	5/6	1.0	5.0	5.53	2.09	1.2	1.2	9.6	ND	No
Cobalt	6/6	5.0	17.0	14.9	9.55	NA	NA	NA	7.08/12.4	No
Copper	6/6	9.0	36.0	28.6	21.1	34	34	270	13.3/27.8	No

TABLE 4-32

ECOLOGICAL RISK MANAGEMENT
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
PAGE 2 OF 4

Contaminant	Frequency of Detection	Range of Detections		95% UCL	Mean Concentration	Initial screening Level[1]	BTAG Screening Level	Alternate Screening Level	Mean/Max. Background	Retained as Final COC?
		Minimum	Maximum							
Sediment[3] (continued)										
Iron	6/6	12,800	33,500	28,300	22,600	NA	NA	NA	16,200/35,400	No
Lead	6/6	23.0	89.0	75.1	42.4	47	46.7	218	15.2/26.8	No
Manganese	6/6	243	1,280	1,160	580	NA	NA	1,110	505/759	No
Nickel	6/6	8.0	22.0	21.3	14.2	21	20.9	51.6	12.2/22.7	No
Vanadium	6/6	21.0	42	40.7	34.4	NA	NA	NA	22.3/52.6	No
Aroclor-1260	1/6	980	980	835	338	50	22.7	180	ND	No
Dieldrin	1/6	210	210	2,000	49.7	NA	NA	8	2.26/3.1	No
Benzo(a)anthracene	4/6	140	400	381	259	261	261	1,600	275/580	No
Benzo(k)fluoranthene	4/6	170	250	237	214	NA	NA	NA	240/300	No
Bis(2-ethylhexyl)phthalate	3/6	330	1,500	1,570	505	1,300	1,300	2,647	ND	No
Butylbenzylphthalate	4/6	91	340	349	181	63	63	11,000	ND	No
Chrysene	4/6	200	460	441	299	384	384	2,800	240/640	No
Fluoranthene	6/6	65	760	655	414	600	600	5,100	226/510	No
Phenanthrene	4/6	130	400	402	248	240	240	1,500	235/260	No

TABLE 4-32
ECOLOGICAL RISK MANAGEMENT
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE
PAGE 3 OF 4

Contaminant	Frequency of Detection	Range of Detections		95% UCL	Mean Concentration	Initial Screening Level[1]	BTAG Screening Level	Alternate Screening Level[2]	Mean/Max. Background	Retained as Final COC?
		Minimum	Maximum							
S dIment[3] (continued)										
Pyrene	6/6	49	890	728	438	660	665	2,600	319/1,300	No
Total PAHs	6/6	114	4,020	3,560	2,140	4,000	NA	44,792	834/4,790	No
Surface Soil[3]										
Aluminum	13/13	9,470.00	22,000.00	18,200	16,600	1	1	600	11,400/15,000	No
Arsenic	13/13	2.0	16.0	9.52	7.1	10	328	NA	6.6/10.6	No
Cadmium	5/13	2.00	6.00	2.55	1.3	3	2.5	20	ND	No
Chromium	13/13	22.00	37.00	31.3	29	10	0.0075	0.4	15.4/20.8	No
Iron	13/13	18,600.00	33,300.00	27,300	24,900	12	12	200	14,900/17,600	No
Lead	13/13	9.0	149.0	117	51	50	0.01	NA	31/64.7	No
Manganese	13/13	166.00	867.00	634	444	330	330.00	100	641/1,190	No
Mercury	5/13	0.14	0.36	0.191	0.114	0.1	0.06	NA	ND	No
Thallium	6/10	0.25	0.45	0.30	0.228	0.001	0.001	NA	0.226/0.34	No
Vanadium	13/13	27.00	48.00	41.8	38.3	20	0.5	NA	20.9-28.2	No
Zinc	13/13	39.00	200.00	126	90.0	50	10	200	90.5/597	No
PCBs (immunoassay)	46/51	550	25,000	31,000	10,700	510	100	NA	ND	No
PCBs (total)	54/64	550	230,000	52,700	14,400	510	100	NA	ND	No

TABLE 4-32
ECOLOGICAL RISK MANAGEMENT
SITE 1 - PRIVET ROAD COMPOUND
NASJRB WILLOW GROVE

Contaminant	Frequency of Detection	Range of Detections		95% UCL	Mean Concentration	Initial Screening Level[1]	BTAG Screening Level	Alternate Screening Level[2]	Mean/Max. Background	Retained as Final COC?
		Minimum	Maximum							
Surface Soil[3]										
Aroclor-1260	11/16	51	230,000.00	2,210,000	26,300	51	51	NA	ND	Yes
1,2,4-trichlorobenzene	1/6	120.00	120.00	224	184	NA	NA	1,050	ND	No
2-methylnaphthalene	1/6	130.00	130.00	218	186	NA	NA	NA	ND	No
Pyrene	3/6	59.00	2,500.00	12,100	627	2050	100.00	NA	723/2,100	No
Total PAHs	3/6	217.5	14,500	1,880,000	3,140	4,000	NA	NA	4,450/14,100	No
Acetone	3/12	4.00	7.00	6.22	5.78	NA	NA	NA	ND	No
Chloroform	1/13	1.00	1.00	3.37	2.81	NA	NA	NA	ND	No

1 See Tables 4-34, 4-35, 4-36 and 4-37 for sources
2 For surface water, AWQCs and Tier II values from USEPA (1996); for sediment, effects Range Medium from NOAA (ER-Ms), Severe Effects Levels from MOE (SELs), Probables Effects Levels from FDEP (PELs), OSWER sediment quality benchmarks (SQBs), and Washington State Department of Ecology (WSDE) values from Efroymson et al. (1996); for soil Oak Ridge National Laboratory (ORNL) screening levels and Dutch "B" target soil standards.
3 mg/kg for inorganics, µg/kg for organics.
NA = not available or not applicable.
ND = not detected.

Aroclor 1260 and dieldrin were PCOCs in sediments, but they were detected in only one of six samples. All the PAH compounds that were PCOCs had HQ values that were relatively low (all 1.67 or less). All the PAH PCOCs in Site 1 sediments had maximum concentrations less than or comparable to the maximum concentrations in background. Although PAHs are not naturally occurring, PAH compounds are commonly present in media in and near developed areas. Two phthalate compounds, bis(2-ethylhexyl) phthalate and butylbenzyl phthalate, had maximum concentrations in excess of screening levels. Nonetheless, the HQ values were rather low, and the maximum concentrations of bis(2-ethylhexyl) phthalate and butylbenzyl phthalate are less than the alternate guidelines presented on Table 4-31 of 2647 ug/kg [probable effects level (PEL)] and 11,000 ug/kg [OSWER sediment quality benchmark (SQB), respectively]. Hence, no sediment COCs were selected for Site 1.

4.8.4.2.3 Surface Soil

The inorganics aluminum, arsenic, cadmium, chromium, iron, lead, manganese, mercury, thallium, vanadium, and zinc were retained as PCOCs in soils at Site 1. Aluminum is one of the most common elements in the earth's crust. The maximum concentrations of cadmium and zinc were less than (zinc was equal to) the alternative guidelines presented on Table 4-32 [these guidelines are Oak Ridge National Laboratory (ORNL) benchmarks] and the maximum concentration of arsenic was less than the BTAG screening level. Iron is a common element and essential nutrient. The average concentration of iron in soils was approximately 1.7 times the average concentration in background, and concentrations of vanadium and thallium were similar to background levels. The average concentration of manganese was less than the average concentration in background, and the average concentration mercury was almost identical to the alternate guideline presented on Table 4-32 (an ORNL benchmark). The average lead concentration (51mg/kg) was only slightly greater than the screening level (50 mg/kg).

The maximum and average concentrations of chromium in Site 1 soils exceed all available screening levels. However, this is most likely due to the conservatism of the screening levels. ORNL state that their screening levels have proven to be conservative in practice and, in some cases, the screening levels may be lower than background concentrations (Will and Suter, 1995a). It is believed that this is because the screening levels are based on toxicity tests that dose test substrates with soluble salts of metals that are more available than most naturally occurring metals and even metals at many, if not most, waste sites (Will and Suter, 1995a). Most metals in natural soils and contaminants of waste sites are in poorly available forms (Will and Suter, 1995a). Shacklette and Boerngen (1984) present a range of background concentrations of 15 to 20 mg/kg for chromium in eastern United States soil (primarily data from Maryland soils). The average background concentration of chromium at a North Carolina military installation was 8.85 mg/kg (B&R Environmental, 1995). Towill et al. (1978) present a range of world-wide background soil chromium concentrations from trace amounts to 250 mg/kg. For the most part, the average

concentration of chromium in Site 1 soils is comparable to these ranges. The Site 1 average concentration (29.0 mg/kg) is slightly less than twice the average base-wide background concentration (15.4 mg/kg).

The organics 1,2,4-trichlorobenzene and 2-methylnaphthalene were PCOCs in soils but they were detected in one of six samples at 120 and 130 ug/kg. These two contaminants were not detected in surface water or sediment samples collected near the compound, indicating that they are not migrating off site. The one detection of 2-methylnaphthalane was well below the screening level for other PAHs. Pyrene was detected in three of six soil samples, but only one value exceeded the screening level, and its HQ value (HQ = 1.2) was indicative of low potential risk. Values for total PAHs were similar to those found in background soil samples. Two volatiles, acetone and chloroform, were retained as pre-remediation PCOCs since no BTAG screening levels were available. Acetone and chloroform, however, were detected in three of 12 and one of 13 samples, respectively. All detected concentrations of these two contaminants were 7 ug/kg or less, and acetone is a common laboratory contaminant.

Before PCB-contaminated soil removal, the maximum and average concentrations of immunoassay PCBs, total PCBs, and the PCB mixture Aroclor 1260 all significantly exceeded available screening levels, and PCBs had high frequencies of detection. Aroclor 1260 also contains higher concentrations of highly chlorinated and coplanar PCB congeners, which are generally more toxic than lower chlorinated congeners (Eisler, 1986). Additionally, PCBs bioaccumulate in the tissues of higher-level organisms (e.g., birds, mammals) and biomagnify in the aquatic and terrestrial foodchains. However, it does not appear that PCBs migrated to aquatic habitats off site. Aroclor 1260 was detected in only one sediment sample (01SD12), which was collected adjacent to the edge of the site. PCBs were not detected in downgradient sediment samples. PCBs are highly lipophilic and have a strong tendency to bind to soil organic carbon; therefore, it is unlikely that they will migrate in the future. The site is relatively flat and water flow in the adjacent drainage ditches is low and ephemeral, precluding significant runoff of contaminants. As a result, the elevated concentrations of PCBs on the site would pose potential risk only to terrestrial receptors. Since the site is paved, gravelled, or covered by turf grass and weeds and it is located in a highly developed section of the base, use of the site by terrestrial receptors is probably minimal and limited to receptors adapted to urban areas, such as raccoons, small mammals, and some bird species. Since the affinity of PCBs for organic carbon is high, PCBs have a tendency to bind to organic soils particles and therefore are generally in poorly bioavailable form (Eisler, 1986). For the reasons discussed above, PCBs were selected as COCs for soils at Site 1, but, due to the lack of significant habitat on the site and the PCB-contaminated soil removal, potential risks are heavily mitigated.

4.8.4.3 Ecol gical Risk Summary

Several inorganic and organic contaminants were present in Site 1 surface water, sediment, and surface soil samples at concentrations in exceedance of ecological screening levels and were, therefore, retained as PCOCs. Several other contaminants in all media assessed in this ERA were retained as PCOCs since no screening levels were available. However, almost all these contaminants were eliminated as COCs in the risk management phase of the assessment for one or more reasons, including low frequency of detection, maximum concentrations comparable to or below background (primarily inorganics), or alternative guidelines and spatial analysis of detections.

PCBs (now removed) were determined to be present at high enough concentrations in soils, with high frequencies of detection, to pose potential risks to terrestrial receptors. Therefore, they were selected as COCs in soils. However, it does not appear that PCBs were migrating from Site 1 since they were not detected in downgradient sediment samples collected in the drainageways that collect runoff from the site. The PCBs on the site were probably in poorly bioavailable form in site soils as a result of their strong affinity for organic carbon in soils. The site is located in a commercial-type area of the base; terrestrial habitat on the site is minimal and of poor quality, especially in the area where PCB concentrations were the highest. Hence, significant use of the site by ecological receptors is unlikely. Due to this combination of mitigating factors and the fact that PCB-contaminated soils have been removed, potential risks to terrestrial receptors from soil PCBs appear to be very low.

4.8.5 Step 3a: Discussion

Step 3 of the eight-step ecological risk assessment process is baseline ecological risk assessment problem formulation (EPA, 1997). This step consists of several sub-steps designed to develop the goals, breadth, and focus of the baseline ecological risk assessment. The initial sub-step within Step 3 is refinement of contaminants of potential concern, and is referred to as "Step 3a - Refinement of Conservative Exposure Assumptions" in the Navy's ERA guidance (DON, 1999).

An exposure assumption inherent in the Hazard Quotients shown in Tables 4-29 through 4-31 is that the Privet Road Compound provides habitat that supports ecological receptors, and exposure to site-related contaminants is possible at the site. However, as discussed in Sections 4.1 and 4.8.1.1, the site lies within a heavily developed section of NASJRB Willow Grove. Most of the 2-acre area where wastes were formerly handled is covered by gravel, a bowling alley, or a parking lot. The remainder of the site consists of largely of mowed turf grass, with a small area of occasionally mowed weeds. Although a few ecological receptors utilize the lawn and weedy portions of the site, the developed condition of the site and poor habitat largely preclude the significant use of the site by ecological receptors.

A complete exposure pathway has three components: a source of contaminants that can be released to the environment, a route of contaminant transport through an environmental medium, and an exposure or contact point for an ecological receptor. The absence of terrestrial habitat (other than small areas of turfgrass and weedy areas) and the developed condition of the site and surrounding vicinity largely preclude the use of the site by terrestrial receptors. Aquatic habitat is absent. Thus, these conditions prevent any substantial exposure to soil contaminants. For these reasons, a complete exposure pathway essentially does not exist at the site. Therefore, the potential for ecological impacts from site-related contaminants is negligible. The current conditions at the site are expected to exist throughout the foreseeable future.

4.9 EVALUATION SUMMARY

Consistent with EPA guidelines, the reasonable anticipated future land use exposure scenario is Occupational Worker. Under the current occupational worker exposure scenario, the human health risk assessment performed for Site 1 indicates cancer risk at the upper end of the EPA's acceptable risk range, largely for potential exposure to PCBs in site soils. Noncancer risks were below guidelines for the current occupational worker exposure scenario. The human health risk assessment and the ecological screening assessment found that the site does not pose a threat to current or reasonably anticipated future human and ecological receptors. However, several other historical issues or guidelines in law must be considered, as discussed by medium below.

S ils

No further action for site soils is recommended.

- The Navy performed a soil removal action for PCB-contaminated soils near the bowling alley located on the Privet Road Compound Area in June 1999. Appendix D contains the PCB soil removal summary report prepared for the Navy by Foster Wheeler Corporation. Potential risks to human and ecological receptors from PCB-contaminated soils at site were virtually eliminated by the Navy's removal action.

Sediment and Surface Water

No further action for sediment or surface water is recommended.

- Compounds found in soils at Site 1 do not appear to be migrating from Site 1, since they were not detected in downgradient sediment or surface water samples collected in the drainageways that collect runoff from the site. Removal of PCB-containing soils in 1999 eliminated any possibility of future migration.

Gr undwater

No further action for groundwater is recommended based on the findings at Site 1.

- Concentrations of chlorinated VOCs were found in excess of the federal water quality standard for drinking water MCLs. The Navy operates two groundwater pumping wells near Site 1 that supply air station potable water needs. The potable water supply system includes an air stripper to remove VOCs from the extracted groundwater. In effect, the Navy is performing de facto remediation of the groundwater in the area.

- The Privet Road Compound is a probable historical contributing source to the VOCs in local groundwater. However, based on the finding of chlorinated VOCs in monitoring wells upgradient of Site 1, it does not appear to be the sole or major source. It is likely that additional historical sources of VOCs to groundwater exist upgradient of the Privet Road Compound, possibly in the vicinity of Building 78 (the current Public Works Building), off station, or in the vicinity of the Navy Fuel Farm.

- The Privet Road Compound is not a major continuing source of chlorinated VOC contamination in the area and no concentrated source of VOCs has been found. The Navy may consider a plan to identify the other suspected on-station source or sources of chlorinated VOCs in groundwater in the area.

- Additional groundwater investigations to further quantify the contribution from historical off-station source areas may be warranted, but would be the responsibility of others under the direction of the appropriate regulatory agency.

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Jones, D.S., G. W. Suter II, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4. Oak Ridge national Laboratory, Health Sciences Division, Oak Ridge, TN.

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APPENDIX A

ANALYTICAL RESULTS

For analytical results prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX B

SOIL BORING AND MONITORING WELL INSTALLATION LOGS

For soil boring and monitoring well installation logs prior to 1997
see Phase II Remedial Investigation Report
Appendices (TtNUS, April 1998)

APPENDIX C

SAMPLE COLLECTION LOGS

For sample collection logs prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX D

PCB Soil Removal Summary Report

CONTRACTOR DRAWINGS & INFORMATION SUBMITTAL
NORTHNAVFACENGCOM 4335/3 (Rev. 6/80)

Prepare in quintuplicate (original and 4 copies)
CONTROL NO. 1B

CONTRACT NO.	DELIVERY ORDER #	ACTIVITY LOCATION
N62472-94-D-0398	42	Willow Grove NAS, PA

PROJECT TITLE:
Removal of PCB Contaminated Soil – Privet Road Site

FROM:	DATE
Foster Wheeler Environmental Corp. - Program QCM: Mark Miller	November 15, 1999
TO:	DATE
J Briggs (10 copies)	November 15, 1999

1. THE CONTRACTOR SUBMITTALS LISTED BELOW ARE FORWARDED FOR YOUR REVIEW AND RECOMMENDATIONS.
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1b	SD-18, Records; Final Contractor's Closeout Report – R0	M Miller			

U.S. NAVY NORTHERN DIVISION
REMEDIAL ACTION CONTRACT (RAC)
CONTRACT NO. N62472-94-D-0398
DELIVERY ORDER NO. 0042

FINAL
CONTRACTOR'S CLOSE-OUT REPORT
FOR
REMOVAL OF PCB-CONTAMINATED SOIL
PRIVET ROAD SITE
WILLOW GROVE NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

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WILLOW GROVE NAVAL AIR STATION - PRIVET ROAD
CLOSE-OUT REPORT
PCB-CONTAMINATED SOIL REMOVAL

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ATTACHMENTS

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Attachment C	Waste Manifests
Attachment D	Surveyed Sample Locations and Map

1.0 INTRODUCTION

Foster Wheeler Environmental Corporation (Foster Wheeler) has prepared this Contractor's Close-out Report for Delivery Order No. 0022 & 0042 under the U.S. Navy Northern Division (the Navy) Remedial Action Contract (RAC) N62472-94-D-0398. This report summarizes the field activities and analytical results for the removal of PCB-contaminated soil from Site 1 and six (6) nearby hotspot areas at the Privet Road Site, Willow Grove Naval Air Station (NAS), Willow Grove, Pennsylvania. Most of the sampling and excavation activities were conducted from June 9, 1999 through July 17, 1999, with final hydroseeding/restoration being completed on October 7, 1999.

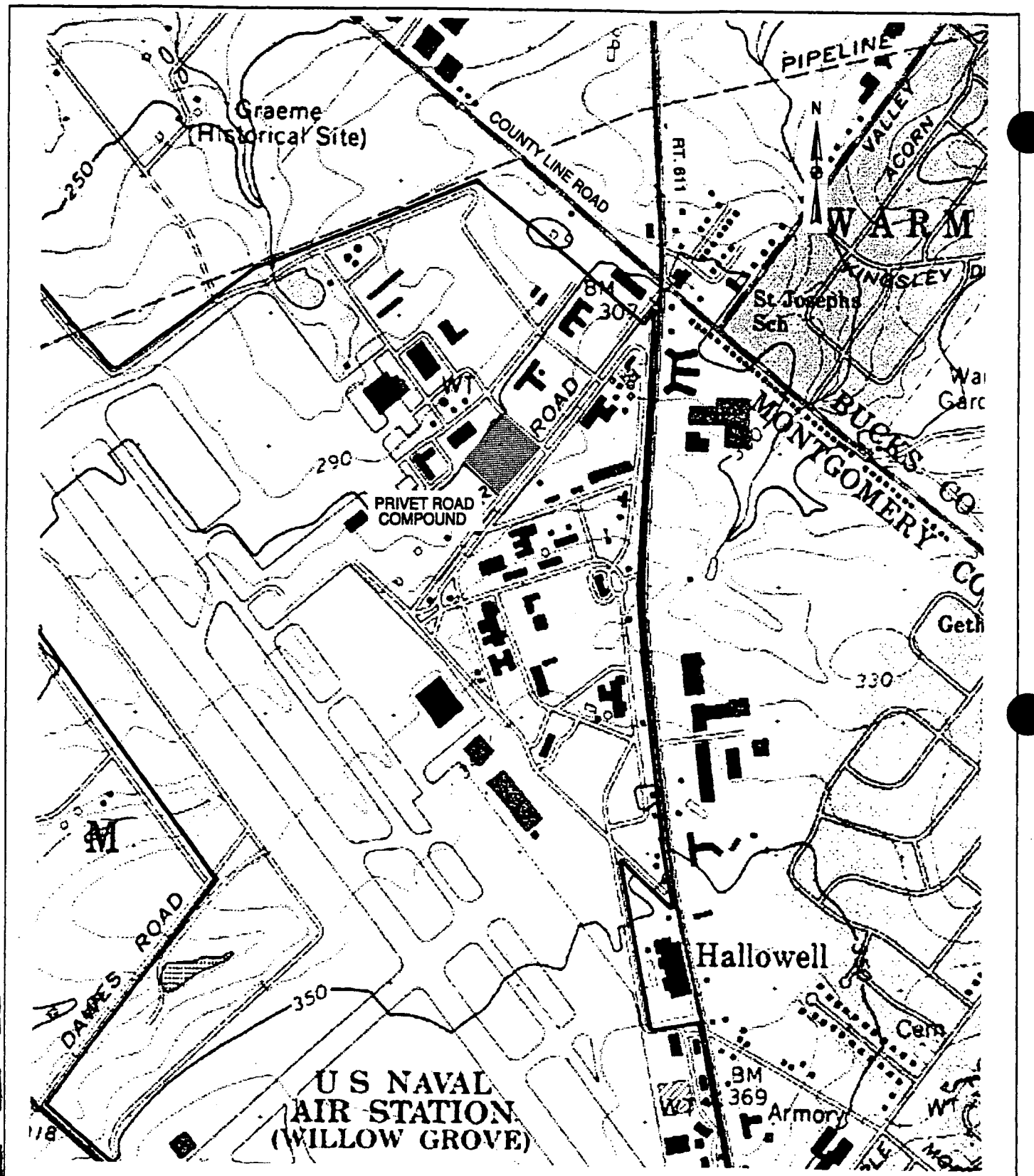
The removal action was required to remove soils contaminated with PCBs at the Privet Road Compound, in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300, and as identified in the "Action Memorandum" dated March 1999. The Final Work Plan detailing the activities required for the removal action was submitted to the Navy on May 28, 1999.

1.1 Site Location/Description

The Willow Grove NAS is located approximately 15 miles north of Philadelphia, PA, in Willow Grove, Montgomery County, PA (Figure 1). The NAS property is bordered to the north by the intersection of Keith Valley Road, County Line Road, and Graeme State Park. Easton Road (Route 611) borders the east and Horsham Road (Route 463) borders the southwest side of the NAS property.

The Privet Road Compound covers approximately 3 acres within a heavily developed portion of the NAS, adjacent to the Willow Grove Air Reserve Facility. Based on information indicating electrical transformers were historically stored at the Compound, and a concern over the possibility that the transformers may have leaked fluids containing PCBs, the Navy tested soils throughout Site 1. Analytical results indicated PCBs were present in surface and shallow subsurface soils.

The main excavation area (Site 1) is located adjacent to the Bowling Alley on Privet Road. The area is approximately 70 feet wide by 155 feet long. There were also six (6) smaller hotspot areas located north, east, and south of the Bowling Alley that required soil removal due to elevated concentrations of PCBs (Figure 2). Overburden soils (4-9 feet thick) consisting of sandy silt, silty sand, and silty clay, overly weathered sandstone bedrock at the Compound.



U.S. Navy RAC
Willow Grove NAS

Figure 1

Site Location Map

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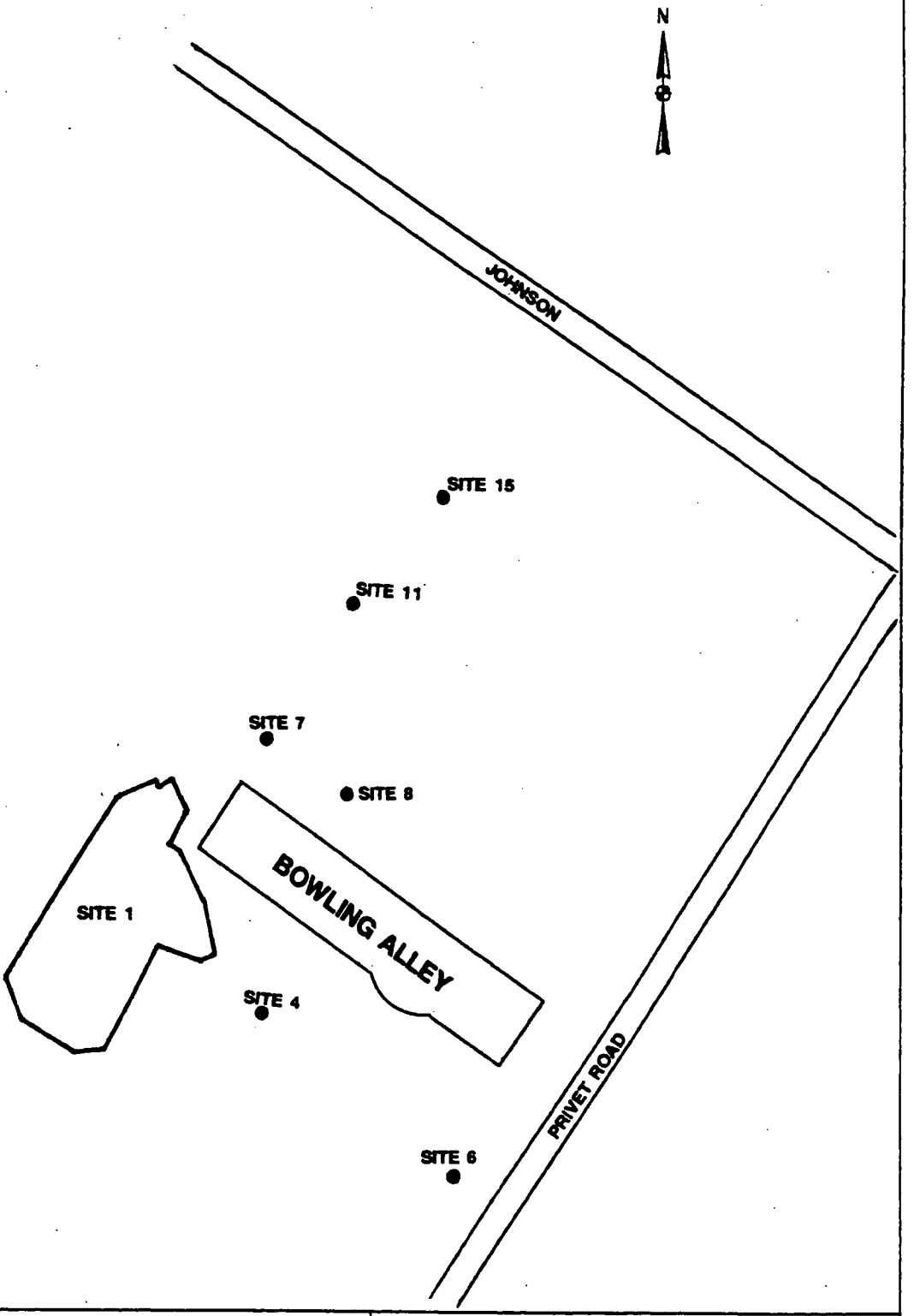

NOT TO SCALE

U.S. Navy RAC
Willow Grove NAS

Figure 2

Site Basemap

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1.2 Project Description

The Scope of Work for the removal action included:

pre-excavation soil sampling for waste characterization purposes;
establishment of work zones to meet the excavation requirements;

- installation of erosion barriers (silt fencing);
- removal of two Honey Locust trees located within the footprint of Site 1;

excavation and off-site disposal of PCB-impacted soils from each identified area of concern, with subsequent confirmational sampling to ensure all soils containing PCBs in excess of 1 ppm (parts per million) were removed;
surveying of the seven excavation areas, plus an additional 20ft x 20ft area around Site 1 sample location 01SB03 that had been identified as potentially containing TSCA waste; and,
backfilling, regrading, and seeding of impacted areas.

2.0 CHRONOLOGY OF EVENTS

Contract Modifications/Deliverables:

October 1998	FWENC submitted 1st Draft Work Plan to Navy.
April 21, 1999	The Navy issued a Modification for removal of PCB contaminated soils exceeding 1 ppm from the Privet Road area at Willow Grove NAS.
May 12, 1999	FWENC issued revised Draft Work Plan.
May 28, 1999	FWENC issued Final Work Plan, including signed Action Memorandum entitled *Removal of Soils Contaminated with Polychlorinated Biphenyl's (PCBs), Site 1 - Privet Road Compound*, prepared by the Navy, May 1999.
July 6, 1999	FWENC received additional funding approval from the Navy to complete the PCB soil removal. Additional funding required due to soils being impacted slightly deeper than originally estimated.

Field Activities:

May 20, 1999	Collected waste characterization samples.
June 6, 1999	Eco-Tron performed waste profile analysis.
June 6-14, 1999	Performed initial removal effort at Site 1 and 6 hotspot areas. Removed approx. 814 tons (37 truck loads) of soil to Clean Earth, located in New Castle, DE
June 8, 1999	Performed removal at potential-TSCA waste hotspot within Site 1. Transported approx. 50 tons of soil to the Michigan Disposal Waste Treatment Plant, Belleville, MI for disposal.
June 6-8, 1999	Tetra Tech performed on-site immunoassay field testing of soils in of excavations to determine if additional excavation was needed.
June 9, 1999	FWENC performed initial confirmational soil sampling. Sampling was based upon those areas exhibiting PCB soil concentrations of less than 1 ppm, as measured in the field by Tetra Tech using immunoassay technology.
June 23, 1999	Received analytical results indicating cleanup objectives were not obtained in all areas.
July 7-9, 1999	Performed 2nd excavation effort. Removed approx. 308 tons (14 truck loads) of soil and transported to Clean Earth, located in New Castle, DE.
July 9, 1999	Performed second round of confirmatory soil sampling.
July 14, 1999	Received analytical results from 2nd round of excavation, indicating four areas still contained PCBs in excess of 1ppm.
July 16, 1999	Performed 3rd removal effort. Removed approx. 22 tons (1 truck load) of soil from hotspot areas 6, 11, 15, and Site 1. Transported excavated soils to Clean Earth, located in New Castle, DE
July 16, 1999	Performed 3rd round of confirmatory sampling.
July 23, 1999	Received analytical data indicating all excavated areas met cleanup objectives (< 1ppm PCBs).
July 27, 1999	Performed site layout survey of Site 1 and six nearby hotspot areas.
August 7, 1999	Backfilled excavations and regraded.
October 7, 1999	Hydroseeded regraded excavation areas.

3.0 CONTAMINATED SOIL REMOVAL ACTION ACTIVITIES

3.1 Limits of Soil Sampling

Prior characterization and investigation sampling conducted by the Navy CLEAN contractor defined the initial limits of excavation/removal at each site area. Based on these results, each area to be excavated was marked in the field, prior to soil removal activities.

3.2 Waste Characterization

Four composite soil samples were collected on November 24, 1998 and were laboratory-analyzed for PA Form U parameters (including TCLP organics, herbicides, pesticides, and metals; pH, ignitability, Reactive Cyanide and Sulfide; Paint Filter Test; PCBs; Total Solids; Total Volatile Solids; Chemical Oxygen Demand; Ammonia-N; and Oil & Grease). In addition, two composite soil samples (FW-PCB-01 and FW-PCB-02) were collected on May 20, 1999 and laboratory-analyzed for additional organic parameters (including BTEX, Total Petroleum Hydrocarbons [TPH], and Total Organic Halogens [TOX]). One composite sample was collected from 5 locations within Site 1; the other composite sample was collected from each of the hotspot areas. Both samples revealed no detectable concentrations for any of these constituents. This data was utilized by EcoTron-New Jersey, Inc. to characterize the excavated soils as non-regulated, non-hazardous. Laboratory analytical results and associated waste profile sheets are provided in Attachments A and B.

3.3 Pre-Excavation Activities

In accordance with the Final Work Plan, work zones were established around each excavation area and erosion barriers (silt fencing) were placed around the perimeter of each area. Two Honey Locust trees located within the proposed excavation area at Site 1 were removed and cut down into manageable pieces. The wood was staged nearby for future use by the Navy.

3.4 Excavation and Off-Site Disposal

A JCB backhoe with a one-half yard bucket was used to excavate/remove the contaminated soils from each of the impacted areas. In some cases, excavations were deepened using hand-tools.

A 20-foot by 20-foot area around sample location 01SB03 at Site 1 containing TSCA-level PCBs (>50 ppm) was excavated within the main excavation area at Site 1. This area was excavated to a depth of two feet below grade. Transport vehicles, equipped with sealed tailgates, were staged

along the perimeter of the excavation during the loading phase. The loading area was covered with visquene as a protection against any accidental spillage. After completing excavation activities at this area, the excavator bucket was dry-decontaminated before continuing with excavation activities at the remainder of the sites.

Following the initial excavation at Site 1, six samples were collected from the bottom of the two-foot deep excavation, and another six samples were collected from the sidewalls (Figure 3). These samples were submitted to Toxikon Laboratories for analysis of PCBs via Method SW8082.

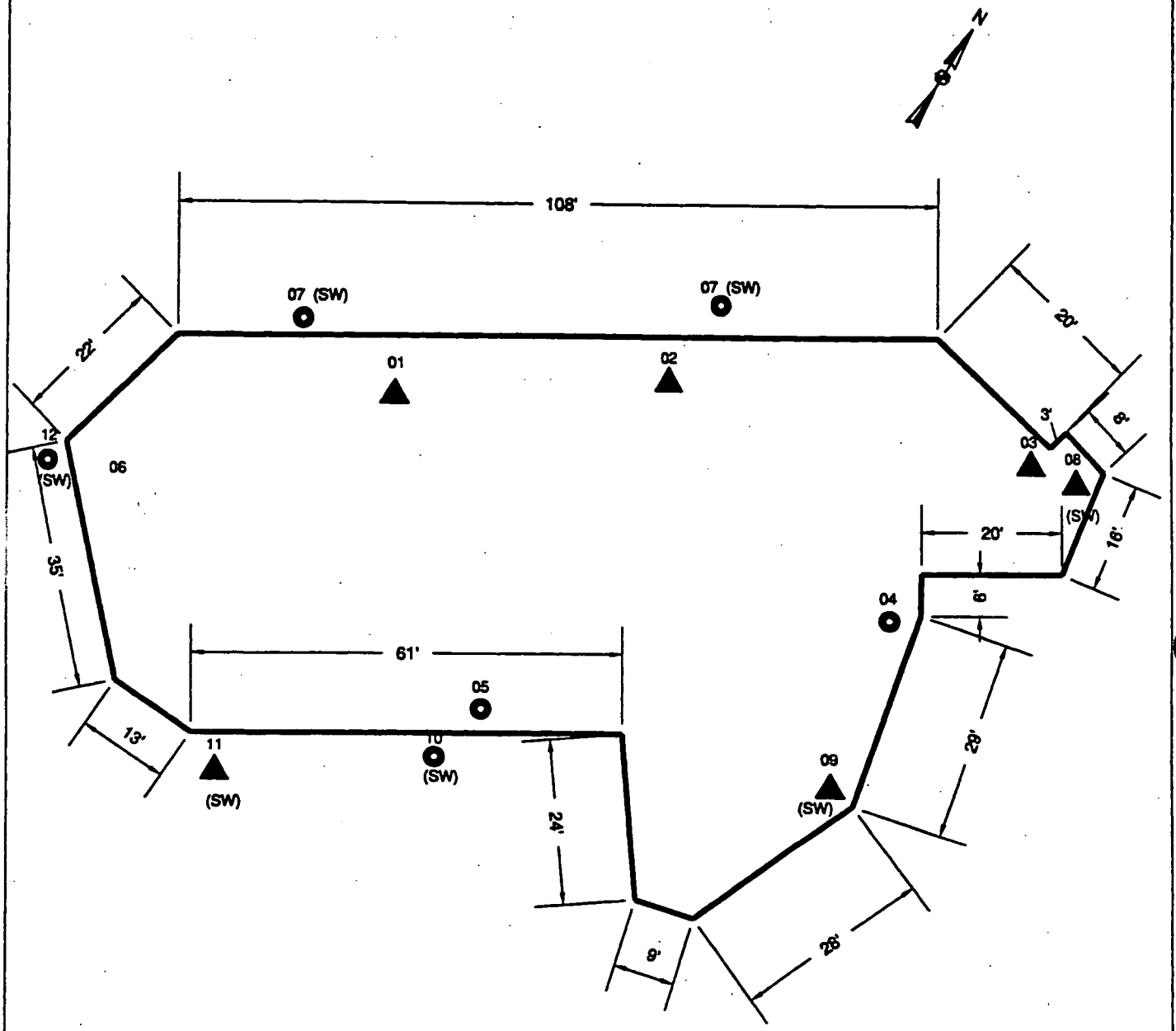
At each of the six hotspot areas, soils were excavated to a depth of 2 feet. The areal dimensions and confirmatory sample locations are shown in Figures 4 through 9. Analytical results for the initial confirmatory samples are provided in Table 1.

At each excavation area, several of the initial confirmatory samples revealed the presence of Aroclor-1260 in excess of the 1 ppm cleanup threshold. Therefore, a second round of excavation/sampling was conducted from July 7-9, 1999. Each excavation was deepened by one foot and a second round of confirmatory samples were collected for laboratory analysis (Table 2).

Confirmatory analytical results from the second round of excavation/sampling revealed portions of four areas (Site 1, and hotspot areas 6, 11, and 15) still exceeded the 1 ppm cleanup criteria. A 3rd (and final) round of excavation/sampling was conducted on July 16, 1999. Approximately 22 tons of soil was excavated from each of the final four areas. Confirmatory analytical results following the 3rd round of excavation indicated all soils containing PCBs in excess of 1 ppm had been removed (Table 3).

3.5 Surveying of Excavation Areas

The excavation areas and confirmatory sample locations were surveyed by Lippincott, Jacobs and Gouda (LJG), a professional surveying firm licensed for surveying in the Commonwealth of Pennsylvania. LJG conducted the field survey immediately following completion of the excavation and confirmatory sampling. A complete listing of sampling locations (in PA State Plane Coordinates), as well as a hardcopy survey map, has been included as Attachment D.



LEGEND

- ● CONFIRMATORY SAMPLE POINT
- ▲ CONFIRMATORY SAMPLE THAT EXCEEDED 1 PPM PCB
- (SW) SIDE WALL SAMPLE POINT

NOT TO SCALE

U.S. Navy RAC
Willow Grove NAS–Privet Road

Figure 3

Site 1 Excavation Plan with Sample Locations

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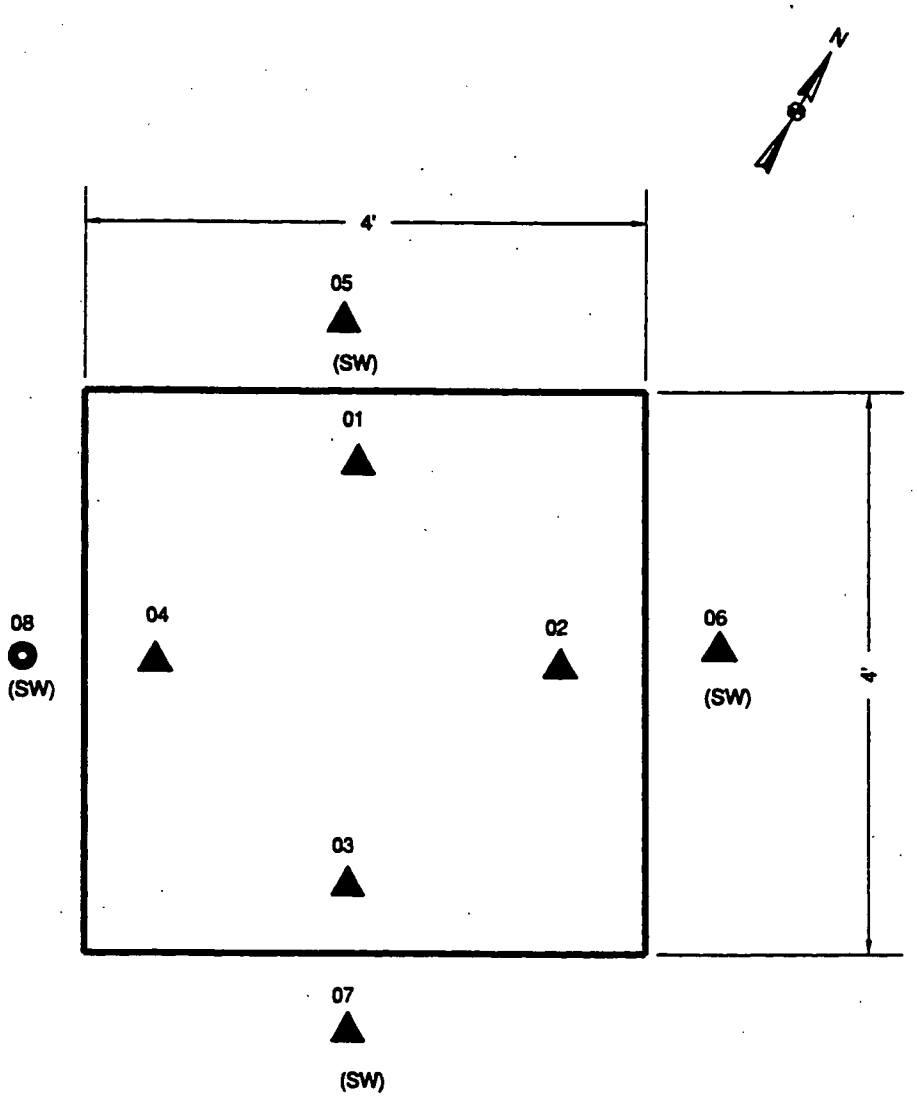

LEGEND

- CONFIRMATORY SAMPLE POINT
- CONFIRMATORY SAMPLE THAT EXCEEDED 1 PPM PCB
- (SW) SIDE WALL SAMPLE POINT

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Willow Grove NAS–Privet Road

Figure 4

Hotspot Area 4 Excavation Plan
with Sample Locations

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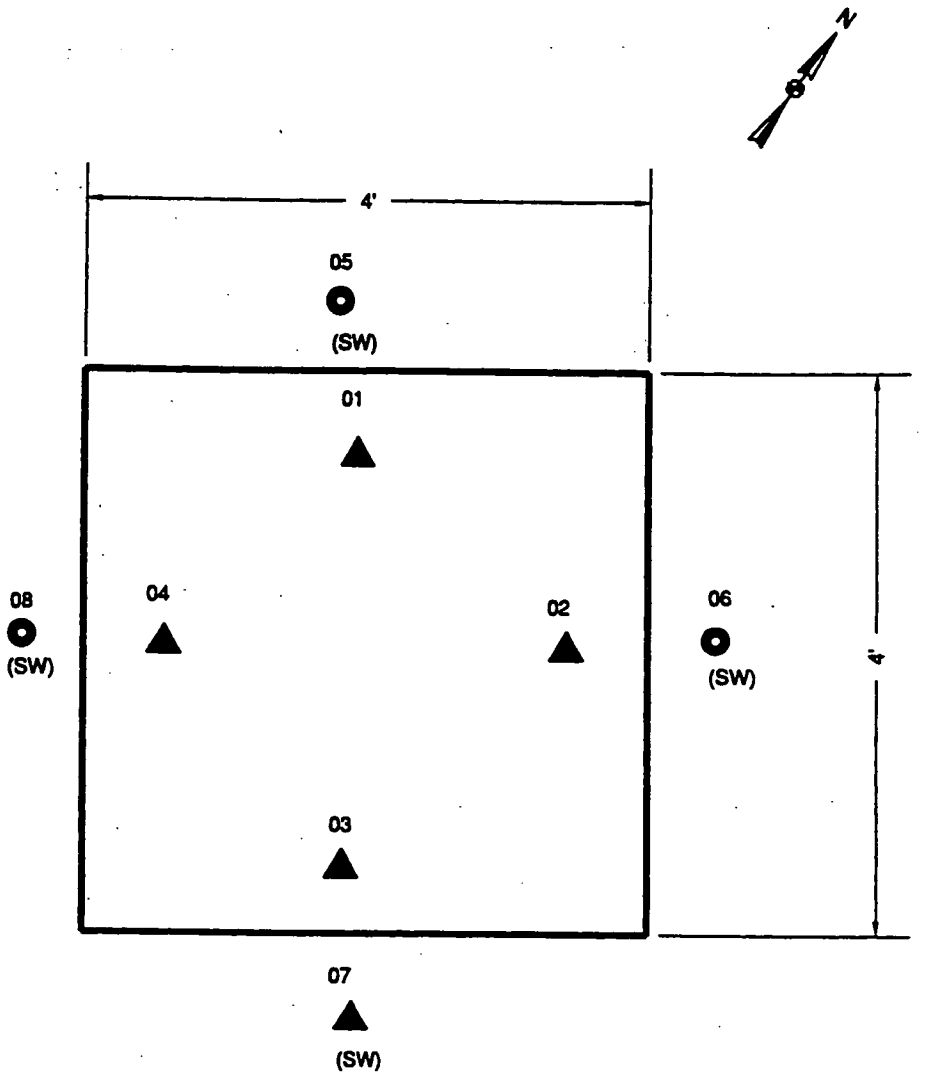

LEGEND

- CONFIRMATORY SAMPLE POINT
- CONFIRMATORY SAMPLE THAT EXCEEDED 1 PPM PCB
- (SW) SIDE WALL SAMPLE POINT

NOT TO SCALE

U.S. Navy RAC
Willow Grove NAS-Privet Road

Figure 5

Hotspot Area 6 Excavation Plan
with Sample Locations

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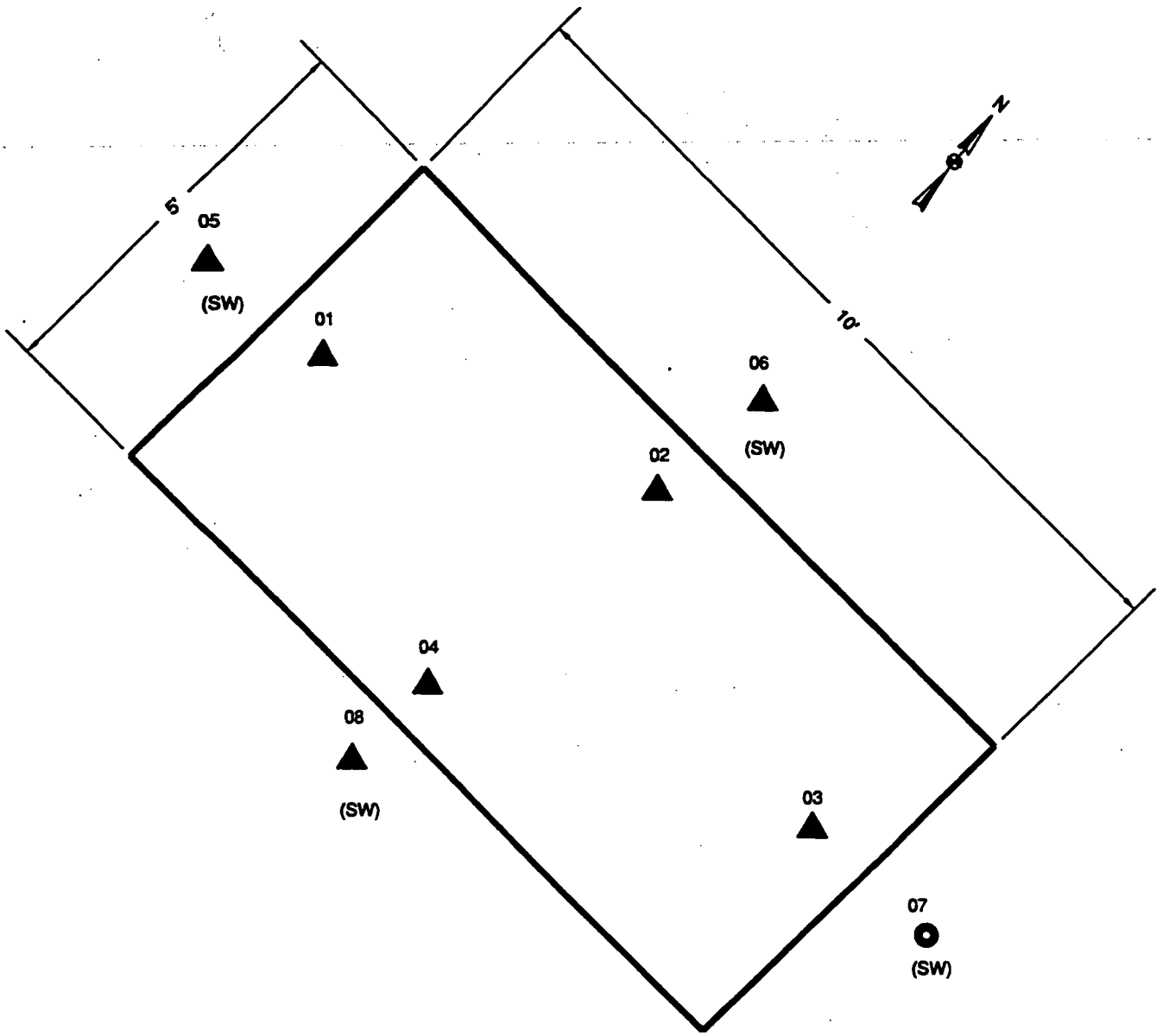

LEGEND

- CONFIRMATORY SAMPLE POINT
- CONFIRMATORY SAMPLE THAT EXCEEDED 1 PPM PCB
- (SW) SIDE WALL SAMPLE POINT

NOT TO SCALE

U.S. Navy RAC
Willow Grove NAS–Privet Road

Figure 6

Hotspot Area 7 Excavation Plan
with Sample Locations

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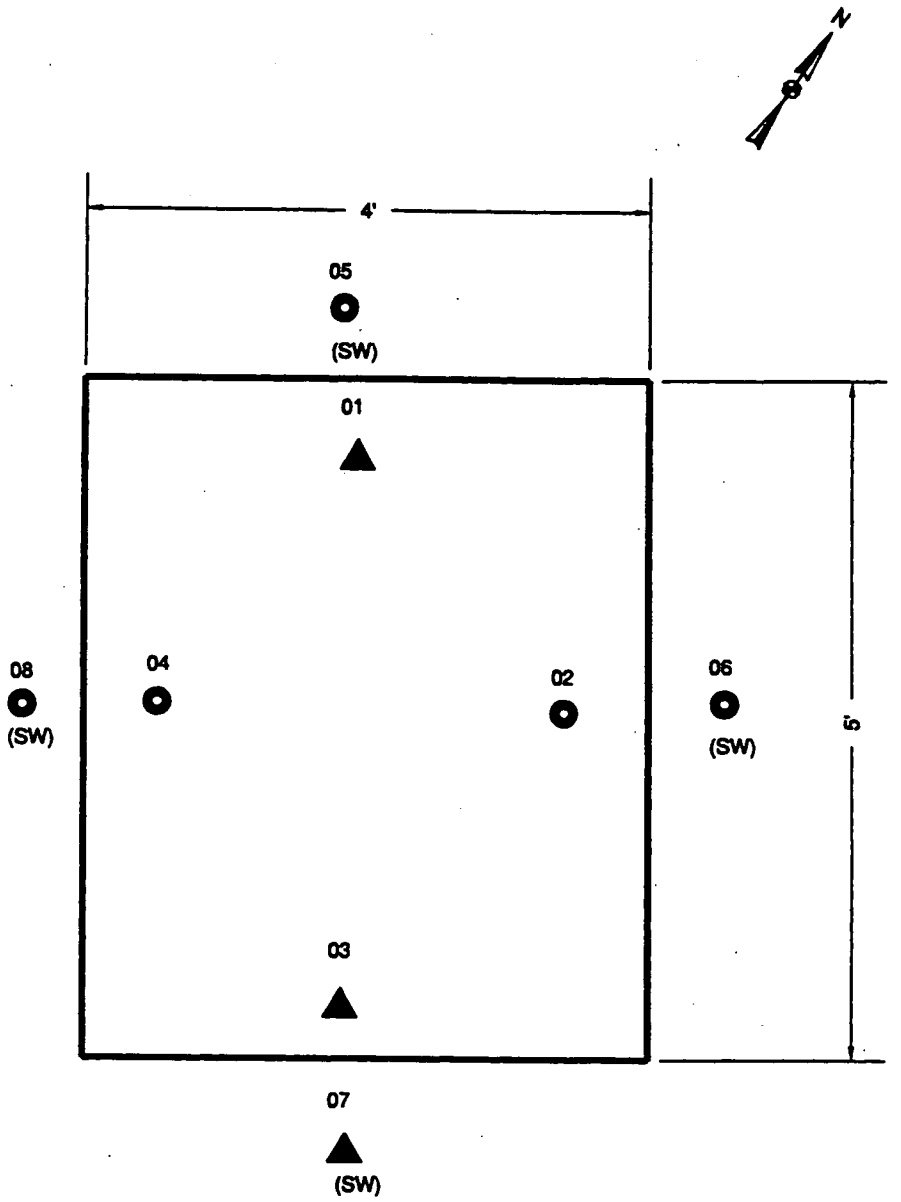

LEGEND

- CONFIRMATORY SAMPLE POINT
- CONFIRMATORY SAMPLE THAT EXCEEDED 1 PPM PCB
- (SW) SIDE WALL SAMPLE POINT

NOT TO SCALE

U.S. Navy RAC
Willow Grove NAS–Privet Road

Figure 7

Hotspot Area 8 Excavation Plan
with Sample Locations

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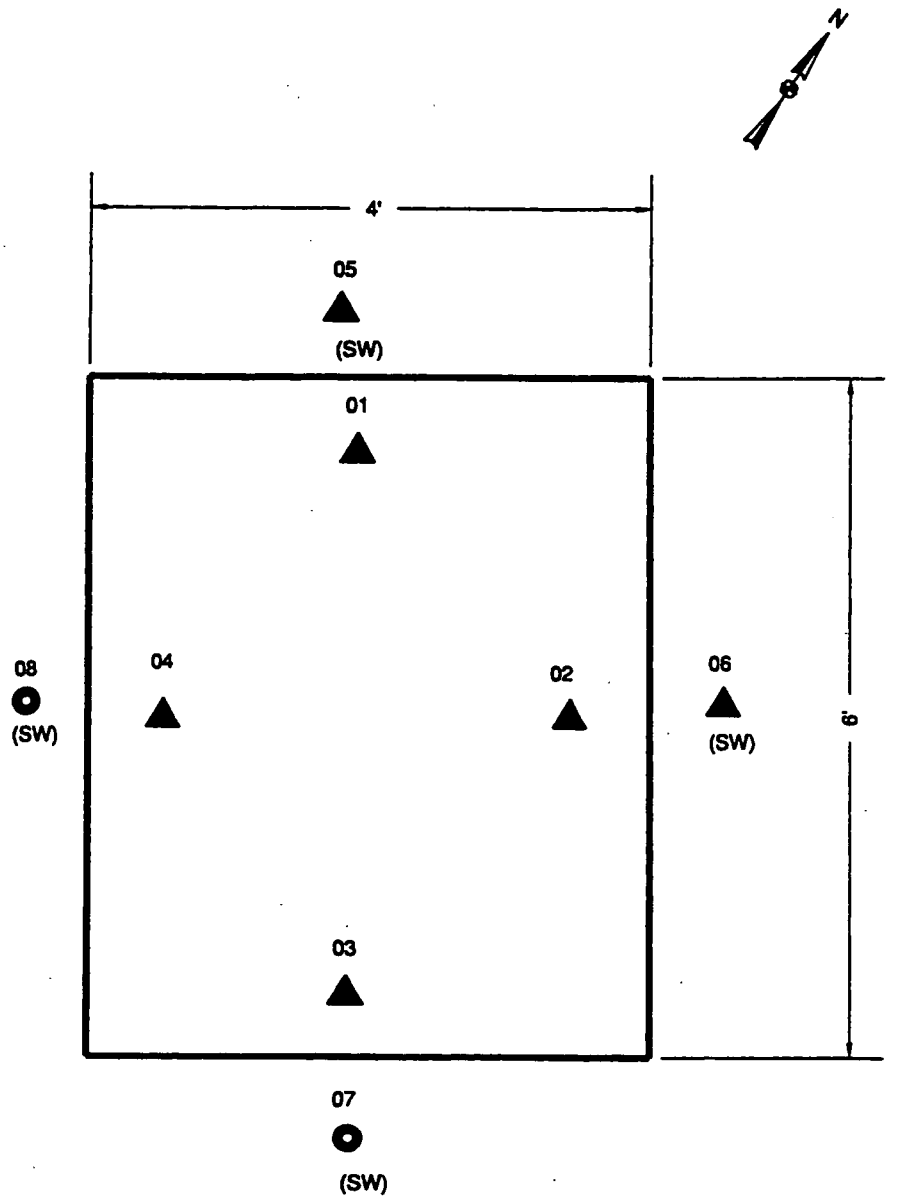

LEGEND

- ● CONFIRMATORY SAMPLE POINT
- ▲ CONFIRMATORY SAMPLE THAT EXCEEDED 1 PPM PCB
- (SW) SIDE WALL SAMPLE POINT

NOT TO SCALE

U.S. Navy RAC
Willow Grove NAS–Privet Road

Figure 8

Hotspot Area 11 Excavation Plan
with Sample Locations

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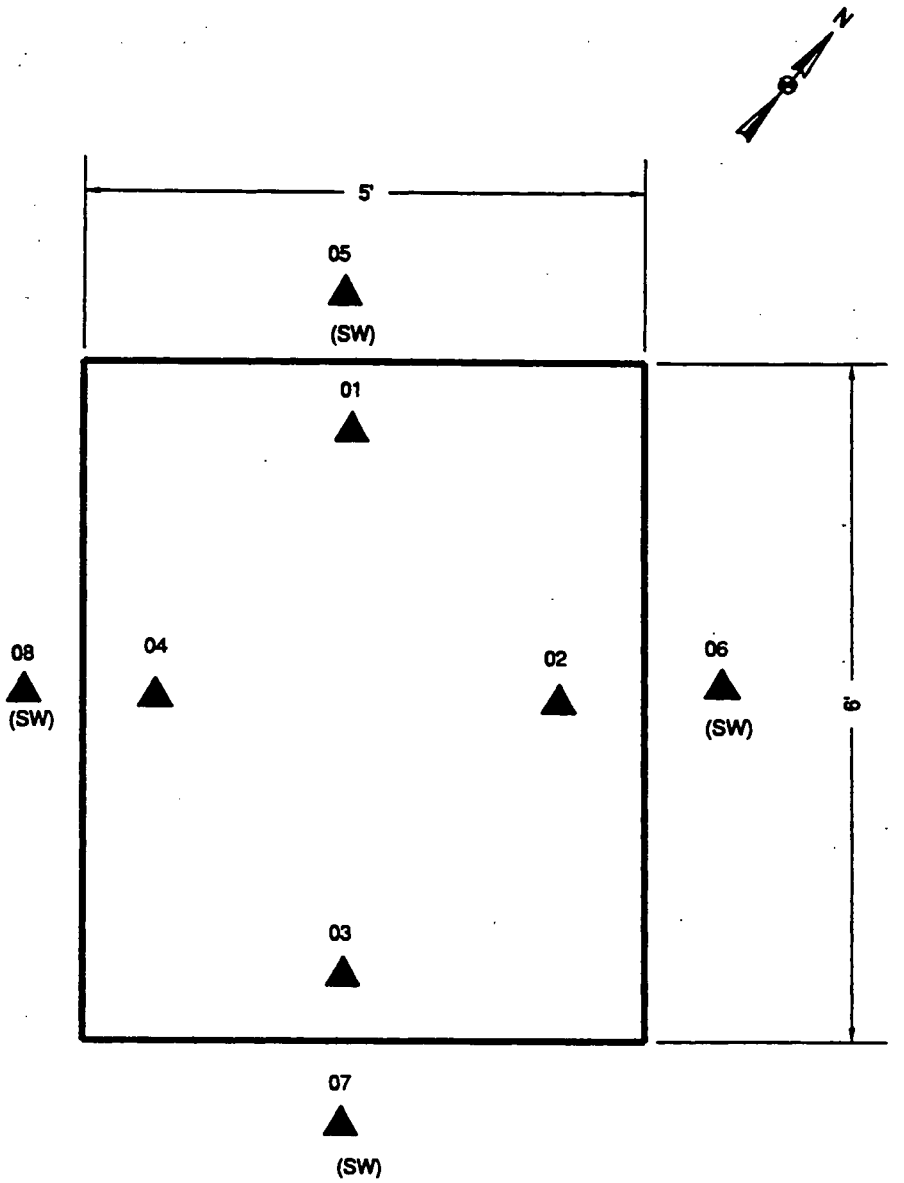

LEGEND

- ● CONFIRMATORY SAMPLE POINT
- ▲ CONFIRMATORY SAMPLE THAT EXCEEDED 1 PPM PCB
- (SW) SIDE WALL SAMPLE POINT

NOT TO SCALE

U.S. Navy RAC
Willow Grove NAS-Privet Road

Figure 9

Hotspot Area 15 Excavation Plan
with Sample Locations

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TABLE 1
US NAVY - NORTHERN DIVISION RAC
WILLOW GROVE NAS - PRIVET ROAD
PCB Results from Round 1 Excavation/Sampling

SITE 1

Sample ID	CS-9901	CS-9902	CS-9903	CS-9904	CS-9905	CS-9906	CS-9907	CS-9908	CS-9909	CS-9910	CS-9911	CS-9912
Lab Sample Number	9906224-17A	9906224-18A	9906256-01A	9906256-02A	9906224-19A	9906224-20A	9906224-21A	9906224-22A	9906224-23A	9906256-03A	9906224-24A	9906224-25A
Aroclor 1016	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1221	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1232	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1242	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1248	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1254	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1260	13000	13000	5600	510	380	590	110	1300	15000	500	2800	130

SITE 4

Sample ID	CS-0401	CS-0402	CS-0403	CS-0404	CS-0405	CS-0406	CS-0407	CS-0408
Lab Sample Number	9906223-01A	9906223-02A	9906223-03A	9906223-04A	9906223-05A	9906223-06A	9906223-07A	9906223-08A
Aroclor 1016	500 U	500 U	500 U	500 U	500 U	500 U	500 U	250 U
Aroclor 1221	500 U	500 U	500 U	500 U	500 U	500 U	500 U	250 U
Aroclor 1232	500 U	500 U	500 U	500 U	500 U	500 U	500 U	250 U
Aroclor 1242	500 U	500 U	500 U	500 U	500 U	500 U	500 U	250 U
Aroclor 1248	500 U	500 U	500 U	500 U	500 U	500 U	500 U	250 U
Aroclor 1254	500 U	500 U	500 U	500 U	500 U	500 U	500 U	250 U
Aroclor 1260	7100	6400	4600	10000	6400	4500	3800	900

SITE 6

Sample ID	CS-0601	CS-0602	CS-0603	CS-0604	CS-0605	CS-0606	CS-0607	CS-0608
Lab Sample Number	9906223-09A	9906223-10A	9906223-11A	9906223-12A	9906223-13A	9906223-14A	9906223-15A	9906223-16A
Aroclor 1016	500 U	500 U	500 U	500 U	250 U	100 U	250 U	100 U
Aroclor 1221	500 U	500 U	500 U	500 U	250 U	100 U	250 U	100 U
Aroclor 1232	500 U	500 U	500 U	500 U	250 U	100 U	250 U	100 U
Aroclor 1242	500 U	500 U	500 U	500 U	250 U	100 U	250 U	100 U
Aroclor 1248	500 U	500 U	500 U	500 U	250 U	100 U	250 U	100 U
Aroclor 1254	500 U	500 U	500 U	500 U	250 U	100 U	250 U	100 U
Aroclor 1260	3100	5400	6100	10000	750	220	1400	300

SITE 7

Sample ID	CS-0701	CS-0702	CS-0703	CS-0704	CS-0705	CS-0706	CS-0707	CS-0708
Lab Sample Number	9906223-17A	9906223-18A	9906223-19A	9906223-20A	9906223-21A	9906223-22A	9906223-23A	9906223-24A
Aroclor 1016	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Aroclor 1221	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Aroclor 1232	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Aroclor 1242	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Aroclor 1248	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Aroclor 1254	500 U	500 U	500 U	500 U	500 U	500 U	500 U	500 U
Aroclor 1260	6800	9000	6100	12000	4600	1400	500 U	3200

SITE 8

Sample ID	CS-0801	CS-0802	CS-0803	CS-0804	CS-0805	CS-0806	CS-0807	CS-0808
Lab Sample Number	9906223-25A	9906223-26A	9906223-27A	9906223-28A	9906223-29A	9906223-30A	9906223-31A	9906223-32A
Aroclor 1016	500 U	500 U	500 U	50 U	50 U	50 U	50 U	500 U
Aroclor 1221	500 U	500 U	500 U	50 U	50 U	60 U	50 U	500 U
Aroclor 1232	500 U	500 U	500 U	50 U	50 U	50 U	50 U	500 U
Aroclor 1242	500 U	500 U	500 U	50 U	50 U	50 U	50 U	500 U
Aroclor 1248	500 U	500 U	500 U	50 U	50 U	60 U	50 U	500 U
Aroclor 1254	500 U	500 U	500 U	50 U	50 U	50 U	50 U	500 U
Aroclor 1260	3500	500 U	1800	150	200	100	1300	660

SITE 11

Sample ID	CS-1101	CS-1102	CS-1103	CS-1104	CS-1105	CS-1106	CS-1107	CS-1108
Lab Sample Number	9906224-01A	9906224-02A	9906224-03A	9906224-04A	9906224-05A	9906224-06A	9906224-07A	9906224-08A
Aroclor 1016	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1221	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1232	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1242	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1248	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1254	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1260	5900	5400	2100	1300	4500	4000	600	980

SITE 15

Sample ID	CS-1501	CS-1502	CS-1503	CS-1504	CS-1505	CS-1506	CS-1507	CS-1508
Lab Sample Number	9906224-09A	9906224-10A	9906224-11A	9906224-12A	9906224-13A	9906224-14A	9906224-15A	9906224-16A
Aroclor 1016	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1221	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1232	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1242	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1248	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1254	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Aroclor 1260	1700	3400	2400	4800	2000	4200	9500	3100

All Samples Collected on June 9, 1999. Analyzed for PCBs via Method SW8082
Units = ug/Kg. Outlined results exceed 1ppm cleanup criteria.

TABLE 2
US NAVY - NORTHERN DIVISION RAC
WILLOW GROVE NAS - PRIVET ROAD
PCB Analytical Results from Round 2 Excavation/Sampling

SITE 1

Sample ID	CS-9901A	CS-9901ADL	CS-9902A	CS-9902ADL	CS-9903A	CS-9904A	CS-9905A	CS-9906A	CS-9907A	CS-9908A	CS-9909A	CS-9910A	CS-9911A	CS-9912
Lab Sample Number	77493	77493D	77494	77494D	77495	77496	77497	77498	77499	77500	77501	77502	77503	77504
Aroclor 1016	34 U	170 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1221	68 U	340 U	68 U	340 U	67 U	67 U	67 U	67 U	67 U	67 U	67 U	66 U	66 U	66 U
Aroclor 1232	34 U	170 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1242	34 U	170 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1248	34 U	170 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1254	34 U	170 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1260	2400 E	2800 D	1580 E	2200 D	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U

SITE 4

Sample ID	0401A	0402A	0403A	0404A	0405A	0406A	0407A	0408A
Lab Sample Number	77537	77538	77539	77540	77541	77542	77543	77544
Aroclor 1016	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1221	66 U	66 U	67 U	67 U	67 U	67 U	67 U	67 U
Aroclor 1232	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1242	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1248	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1254	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1260	33 U	33 U	33 U	33 U	33 U	33 U	33 U	33 U

SITE 6

Sample ID	0601A	0601ADL	0602A	0602ADL	0603A	0603ADL	0604A	0604ADL	0605A	0606A	0607A	0608A
Lab Sample Number	77545	77545D	77546	77546D	77547	77547D	77548	77548D	77549	77550	77551	77552
Aroclor 1016	34 U	170 U	34 U	170 U	34 U	170 U	33 U	160 U	33 U	33 U	33 U	33 U
Aroclor 1221	68 U	340 U	67 U	340 U	68 U	340 U	66 U	330 U	66 U	67 U	67 U	67 U
Aroclor 1232	34 U	170 U	34 U	170 U	34 U	170 U	33 U	160 U	33 U	33 U	33 U	33 U
Aroclor 1242	34 U	170 U	34 U	170 U	34 U	170 U	33 U	160 U	33 U	33 U	33 U	33 U
Aroclor 1248	34 U	170 U	34 U	170 U	34 U	170 U	33 U	160 U	33 U	33 U	33 U	33 U
Aroclor 1254	34 U	170 U	34 U	170 U	34 U	170 U	33 U	160 U	33 U	33 U	33 U	33 U
Aroclor 1260	3000 E	3400 D	1360 E	1480 D	1960 E	2400 D	1900 E	2400 D	33 U	33 U	33 U	33 U

SITE 7

Sample ID	CS-0701A	CS-0702A	CS-0703A	CS-0704A	CS-0705A	CS-0706A	CS-0707A	CS-0708A
Lab Sample Number	77521	77522	77523	77524	77525	77526	77527	77528
Aroclor 1016	33 U	34 U	34 U	34 U	33 U	33 U	33 U	33 U
Aroclor 1221	67 U	67 U	67 U	67 U	65 U	67 U	66 U	66 U
Aroclor 1232	33 U	34 U	34 U	34 U	33 U	33 U	33 U	33 U
Aroclor 1242	33 U	34 U	34 U	34 U	33 U	33 U	33 U	33 U
Aroclor 1248	33 U	34 U	34 U	34 U	33 U	33 U	33 U	33 U
Aroclor 1254	33 U	34 U	34 U	34 U	33 U	33 U	33 U	33 U
Aroclor 1260	33 U	34 U	34 U	34 U	33 U	33 U	33 U	33 U

SITE 8

Sample ID	CS-0801A	CS-0802A	CS-0803A	CS-0804A	0805A	0806A	0807A	0808A
Lab Sample Number	77529	77530	77531	77532	77533	77534	77535	77536
Aroclor 1016	33 U	33 U	33 U	33 U	34 U	34 U	34 U	34 U
Aroclor 1221	67 U	67 U	67 U	67 U	67 U	67 U	67 U	67 U
Aroclor 1232	33 U	33 U	33 U	33 U	34 U	34 U	34 U	34 U
Aroclor 1242	33 U	33 U	33 U	33 U	34 U	34 U	34 U	34 U
Aroclor 1248	33 U	33 U	33 U	33 U	34 U	34 U	34 U	34 U
Aroclor 1254	33 U	33 U	33 U	33 U	34 U	34 U	34 U	34 U
Aroclor 1260	33 U	33 U	33 U	33 U	34 U	34 U	34 U	34 U

SITE 11

Sample ID	CS-1101A	CS-1101ADL	CS-1102A	CS-1103A	CS-1104A	CS-1105A	CS-1106A	CS-1107A	CS-1108A
Lab Sample Number	77505	77505D	77506	77507	77508	77509	77510	77511	77512
Aroclor 1016	34 U	170 U	34 U	34 U	33 U	33 U	33 U	34 U	33 U
Aroclor 1221	68 U	340 U	67 U	67 U	67 U	67 U	67 U	67 U	67 U
Aroclor 1232	34 U	170 U	34 U	34 U	33 U	33 U	33 U	34 U	33 U
Aroclor 1242	34 U	170 U	34 U	34 U	33 U	33 U	33 U	34 U	33 U
Aroclor 1248	34 U	170 U	34 U	34 U	33 U	33 U	33 U	34 U	33 U
Aroclor 1254	34 U	170 U	34 U	34 U	33 U	33 U	33 U	34 U	33 U
Aroclor 1260	1500 E	1620 D	34 U	34 U	33 U	33 U	33 U	34 U	33 U

SITE 15

Sample ID	CS-1501A	CS-1502A	CS-1502ADL	CS-1503A	CS-1504A	CS-1505A	CS-1506A	CS-1507A	CS-1508A
Lab Sample Number	77513	77514	77514D	77515	77516	77517	77518	77519	77520
Aroclor 1016	34 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1221	67 U	68 U	340 U	67 U	67 U	67 U	67 U	66 U	66 U
Aroclor 1232	34 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1242	34 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1248	34 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1254	34 U	34 U	170 U	33 U	33 U	33 U	33 U	33 U	33 U
Aroclor 1260	34 U	1120 E	1240 D	33 U	33 U	33 U	33 U	33 U	33 U

All samples collected on July 9, 1999. Analyzed for PCBs via Method SW8082.
Units = ug/KG. Outlined results exceed 1ppm cleanup criteria.

TABLE 3
US NAVY - NORTHERN DIVISION RAC
WILLOW GROVE NAS - PRIVET ROAD
PCB Analytical Results for Round 3 Excavation/Sampling

Site Location	SITE 1		SITE 6				SITE 11	SITE 15
Sample ID	9901B	9902B	0601B	0602B	0603B	0604B	1101B	1502B
Lab Sample ID	78309	78310	78305	78306	78307	78308	78311	78312
Aroclor 1016	340 U	340 U	340 U	340 U	330 U	340 U	330 U	340 U
Aroclor 1221	670 U	670 U	670 U	670 U	650 U	670 U	650 U	670 U
Ar clor 1232	340 U	340 U	340 U	340 U	330 U	340 U	330 U	340 U
Ar cl r 1242	340 U	340 U	340 U	340 U	330 U	340 U	330 U	340 U
Ar cl r 1248	340 U	340 U	340 U	340 U	330 U	340 U	330 U	340 U
Ar clor 1254	340 U	340 U	340 U	340 U	330 U	340 U	330 U	340 U
Ar cl r 1260	340 U	340 U	340 U	340 U	330 U	340 U	330 U	340 U

All samples collected on July 17, 1999.
Units = ug/KG. Cleanup Criteria = 1000 ug/KG (1ppm)

3.6 Backfilling and Regrading

Upon receipt of the 3rd round of confirmation samples, each excavation was backfilled and regraded to match surrounding topography. Clean fill was brought in from off-site (purchased from Better Materials) and used to backfill within 6 inches of surface grade. The remainder of each excavation was filled with topsoil and hydroseeded. Due to the Summer 1999 drought, hydroseeding was delayed until October 7, 1999.

4.0 TRANSPORTATION AND DISPOSAL

Foster Wheeler subcontracted TAT Trucking Company, based in Bear, Delaware, to transport non-hazardous contaminated soil and associated waste to the Clean Earth disposal facility in New Castle, Delaware. Forty-eight (48) tons of TSCA-classified soils were transported by the subcontractor, DART Trucking Company, Inc., to the Michigan Disposal Waste Treatment Plant, located in Belleville, Michigan. All wastes were characterized according to disposal facility requirements, and analytical results are included in Attachment B. Table 4 details waste transporters, facilities, technologies, and quantities. Waste manifests and weight ticket quantities are included in Attachment C.

TABLE 4

WILLOW GROVE NAS - PRIVET ROAD PCB REMOVAL

Summary of Quantities Transported, Transporters, Facilities

Material	Quantity	Transporter	Disposal Facility	Disposal Technology
(Non-hazardous) Contaminated Soil	1122 tons	TAT Trucking Company, Bear, Delaware	Clean Earth of New Castle, Inc. 94 Pyles Lane, PO Box 1049, New Castle, Delaware 19720 Phone: 302-427-6673	Solid Waste Landfill Cover
TSCA-classified Soil	48 tons	DART Trucking Company, Inc.	Michigan Disposal Waste Treatment Plant, Belleville, Michigan	Hazardous Waste Landfill Disposal

APPENDIX E

LONG TERM WATER LEVEL SURVEY

The data that formed the basis of the study are included in Appendix E of the Phase II RI Report. The water-level elevation data for each of the 13 monitoring wells over the 7-day period are also summarized in Figures 4-4 through 4-9 of this revised RI report for Site 1.

APPENDIX F

GEOPHYSICAL LOGS

Geophysical logs acquired before 1998 are included in Appendix E of the Phase II RI Report. Additional geophysical logs can be found in Appendix O of this revised RI report for Site 1.

APPENDIX G

SURVEY DATA

For survey data prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX H

CHAIN-OF-CUSTODY FORMS

For chain-of-custody forms prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX I

WASTE DISPOSAL RECORDS

For waste disposal records, see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX J

RISK ASSESSMENT DOCUMENTATION

For risk assessment documentation prior to 1997 see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX K

ECOLOGICAL RISK ASSESSMENT TOXICITY PROFILES

For ecological risk assessment toxicity profiles prior to 1997
see Phase II Remedial Investigation Report
Appendices (TtNUS, April 1998)

APPENDIX L

WASTE DISPOSAL RECORDS

For immunoassay test procedures, see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX M

LOW FLOW PURGE AND SAMPLE PROCEDURE

For low flow purge and sample procedures, see Phase II Remedial Investigation Report Appendices (TtNUS, April 1998)

APPENDIX N

RESPONSE TO U.S. EPA REGION III COMMENTS ON DRAFT PHASE II REMEDIAL INVESTIGATION REPORT

DEPARTMENT OF THE NAVY
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
10 INDUSTRIAL HIGHWAY
MAIL STOP, #82
LESTER, PA 19113-2090

IN REPLY REFER TO

5090
Code 09TB/JC

09 JAN 2001

Ms. Lisa Bradford
U.S. Environmental Protection Agency, Region III
Federal Facilities Section
1650 Arch Street
Philadelphia, PA 19103-2029

Dear Ms. Bradford:

SUBJ: NAVY'S RESPONSES TO USEPA REGION III COMMENTS ON DRAFT PHASE II REMEDIAL INVESTIGATION (RI) REPORT DATED APRIL 1998; NAVAL AIR STATION JOINT RESERVE BASE (NASJRB) WILLOW GROVE, PA

The Navy had issued a Draft Phase II RI Report in April 1998 for which comments were requested. At a technical meeting held at Northern Division, NAVFAC offices in Lester, PA in April 1999, representatives from the USEPA Region III office and Pennsylvania Department of Environmental Protection (PADEP) offered several comments and recommendations that the Navy took as Action Items.

Since that meeting, the Navy has been addressing each of the Action Items and is now forwarding enclosures (1) and (2) that basically serve as the Navy's responses to regulator comments on the Draft Phase II RI Report. Enclosure (1) contains nine attachments that address specific Action Items. Enclosure (2) is being re-issued and are the Navy's responses to comments submitted by the USEPA Region III's toxicologist that was assigned to this project at that time.

If found to be acceptable, the Navy will incorporate the information contained in enclosures (1) and (2) into Final versions of the Phase II RI Report. As explained at our last meeting held at the USEPA Region III offices on December 5, 2000, the Navy will finalize a separate Phase II RI Report for each individual site rather than a four-site package as was done for the Draft Report.

The Navy would like to request that enclosures (1) and (2) be reviewed and that the regulators be prepared to discuss each of the Action Items at our next technical meeting that has been scheduled for Wednesday, February 7, 2001 at Building 1 located at NASJRB Willow Grove.

If you have any questions regarding the enclosures, please give me a call at (610) 595-0567, extension 163.

Sincerely,

JAMES L. COLTER
Remedial Project Manager
by Direction of the
Commanding Officer

Enclosures: (1) Nine Attachments Addressing Specific Action Items
(2) Navy Responses to EPA Toxicological Comments on Draft Phase II RI Report

Copy to:
PADEP, April Flipse
NASJRB Willow Grove, Jim Edmond
Tetra Tech NUS, Russ Turner

STATUS OF NAVY ACTION ITEMS FROM TECHNICAL MEETING HELD ON 14 APRIL 1999

13 October 1999
4 January 2001 (Revision 1)

SITE 5 REMEDIAL INVESTIGATION:

ITEM 1: The Navy will generate a map that shows IR Sites 2, 3, and 5 and the surrounding area. The map should include building numbers, location of wells and water level readings.

RESPONSE: See Attachment (1) that includes three figures. Figure 1 shows the locations of all monitoring wells installed at Sites 2, 3 and 5 on a USGS Quadrangle. Figure 2 shows the same monitoring well locations on an aerial photo background. Figure 3 shows the potential locations for additional monitoring wells at Site 5.

ITEM 2: What are the effects of the geologic structure on the groundwater flow patterns at SITE 5? How are the dip and bedding planes influencing contaminant movement?

RESPONSE: See Attachment (2). Upon acceptance, this information will be made part of the Final RI for Site 5.

ITEM 3: The Navy will propose a plan to further characterize the groundwater in the area west of well cluster 11 at Site 5.

RESPONSE: Attachment (3) is the Navy's Remedial Investigation Workplan Addendum for Site Investigations at Site 5. This letter workplan was submitted for review on 26 May 2000 and no adverse comments were received.

Implementation of the workplan was completed in the Fall 2000. Attachment (4) is being submitted that is a compilation of the recently collected analytical data. The Navy is currently evaluating this data. The Navy's evaluation consists of using a GIS-based software program (EVS) that analyzes and portrays the data in a three-dimensional view. This effort is not yet completed but should be in the next couple of weeks. The Navy is expecting to be able to present this analysis at the upcoming technical meeting scheduled for February 7, 2001. At this meeting, the Navy will also discuss it's recommendations and conclusions for Site 5. If accepted, these recommendations and conclusions will be made part of the Navy's Final RI for Site 5.

ITEM 4: Navy is to approach Horsham Township Water District about conducting a Pump Test on municipal well #26 in order to assess the impacts, if any, that this well may have on groundwater near Site 5.

RESPONSE: Ralph McQuaid (Horsham Township Water District) was contacted on 7 June 1999. Water demand over the summer was high and other maintenance activities on other wells made running Well #26 more imperative. Fore these reasons, the District was reluctant to shut down the well. Mr. McQuaid suggested that a pump test on Well #26 may be possible in the Fall when demand is typically lower, the other maintenance work would be completed and construction of a new well (Well #40) in the same vicinity as Well #26 would als be completed and could be used to supplement water when #26 is shut down.

Russ Turner will follow up with Mr. McQuaid regarding the status of the above and the possibility of performing the pump test on Well #26 in the near future. This follow up was conducted on 13 October 1999 and it was suggested that the shutdown for Well #26 could take place after the first of the year when the water demand has been historically at its lowest.

The actual shutdown, and subsequent pump test for Horsham Well #26 was conducted during the week beginning 17 January 2000 and was concluded during the week of 22 February 2000. The collected data has been evaluated by the USGS and was presented to the members of Willow Grove's RAB on 7 June 2000. A copy of that presentation is enclosed and discussions regarding Well #26 begins on Page 5 f Attachment (5).

SITE 5 REMEDIAL INVESTIGATION (Continued):

ITEM 5: Navy will review EPIC photos for all of NASJRB Willow Grove received from EPA on 15 April 1999. The Navy will review the photos to see if there are other possible sources in the vicinity of the IR Sites.

RESPONSE: The Navy's review of the EPIC photos was completed for IR Site 5 ONLY in October 2000. The results of this analysis are presented in Attachment (6). Upon approval, the information will be made part of the Final RI for Site 5.

Subsequent conclusions for the other IR Sites will be made part of the Final RI's for each individual site.

ITEM 6: Navy will consider using USGS to investigate weathered bedrock layer as a source of continuing groundwater contamination. This will involve taking cores of the shallow bedrock layer and eluting any VOCs from the core.

RESPONSE: The Navy conducted the coring of the weathered bedrock during the week of 4 September 2000. The analytical results from that effort are presented in Attachment (7). A discussion of the rock core procedures and the results of the lab analysis will be part of the agenda for the next scheduled meeting of Willow Grove's RAB that is to be held on December 6, 2000.

ITEM 7: The Navy will consider whether a soil removal project is warranted either to remove as a source of groundwater contamination or to reduce Eco/human health risk.

RESPONSE: This evaluation will be made part of the Feasibility Study for Site 5 which is currently being developed. The FS will be forwarded concurrently with the submission of the Final RI for Site 5 or shortly thereafter.

LOW-FLOW SAMPLING PROCEDURES:

ITEM 1: EPA expressed concerns that the Low-Flow sampling protocols may not have been followed resulting in a question regarding usability of the analytical data. The following action items resulted:

- Review field logs to determine if protocols were followed
- Examine historical data and compare with the data in question
- Determine if the conceptual site model changes if the concentrations were higher (Assumption: the highest level ever detected or 2 times the latest concentration)
- Determine if multiple fractures present within the screened interval

RESPONSE: Tetra Tech NUS's responses to the first three bullets listed above are shown on Attachment (8). Discussions regarding the last bullet are shown on Attachment (9). If found to be acceptable, the Navy will include this information into the Final RI Report for each IR Site.

ITEM 2: The Navy will look at the effect the suspect data may have on the human health risk assessments.

RESPONSE: Tetra Tech NUS's review of the effects, if any, that the suspect data may have on the human health risk assessments conducted at each of the IR Sites is included in Attachment (8) which discusses data quality issues. If the discussions included in Attachment (8) are found to be acceptable, the Navy will include the information into the Final RI Reports for each IR Site.

From: Kevin C. Kilmartin
To: Russ Turner

Date: July 7, 1999

Re: NASJRB WILLOW GROVE: Analysis of Screened Intervals and Fracture Zones for Monitoring Wells Installed During the Phase II RI

TtNUS was tasked to determine whether any of the screened monitoring wells installed during the Phase II RI were completed in such a manner that the vertical position of the well pump could affect the analytical results when sampling the well under low-flow sampling procedures. In order for the vertical position of the pump to influence the sampling results, the groundwater for that well must be migrating or flowing from multiple, hydraulically isolated fractures that are spac d widely enough that the groundwater from one fracture could be preferentially sampled over the groundwater from the other fracture(s).

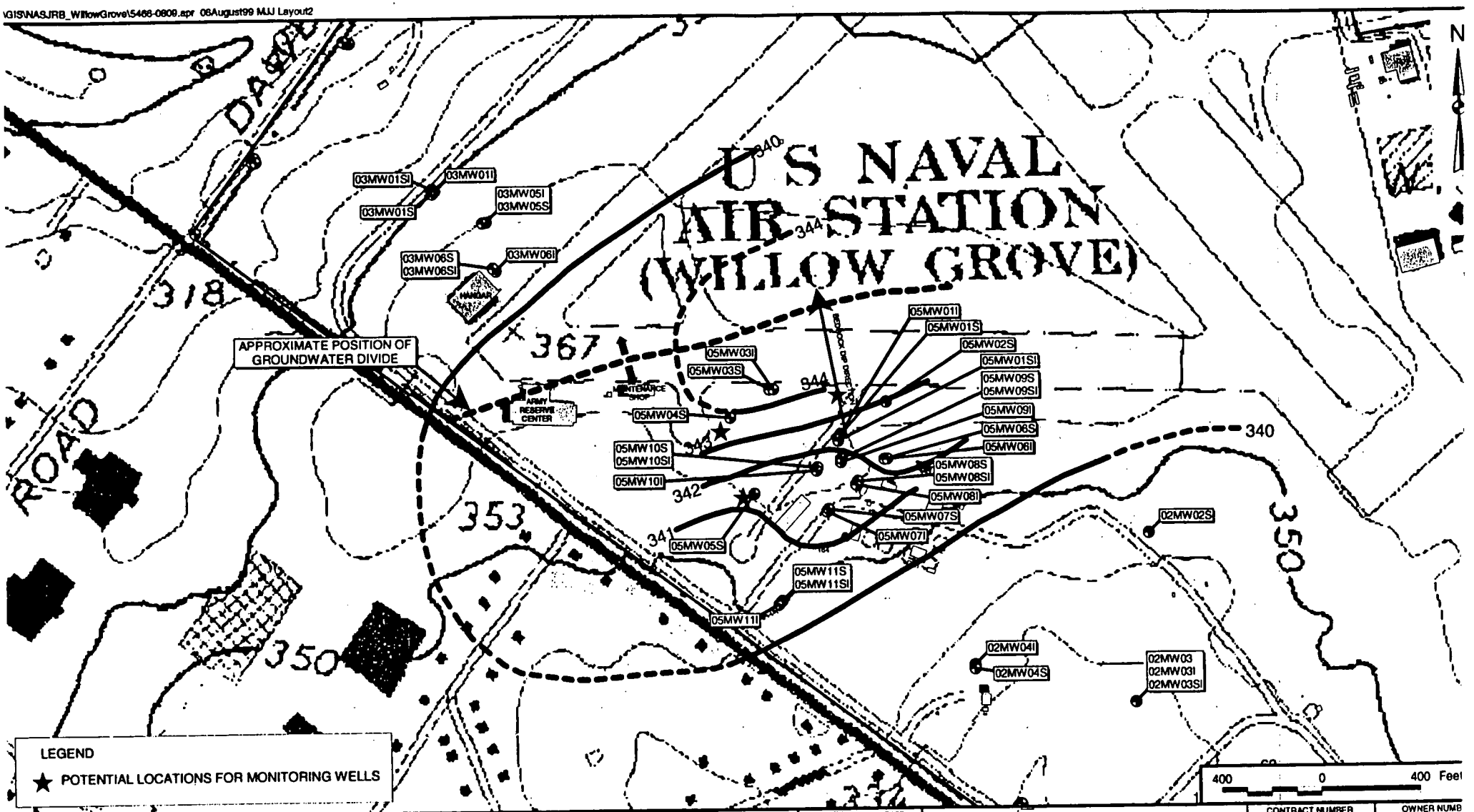
A top priority of the borehole retrofitting program was to construct the monitoring wells to obtain groundwater from only one groundwater zone and to not interconnect different groundwat r zones. To reach this goal, all boreholes were geophysically logged (including borehole flowmeters), and the potential construction plans were reviewed and discussed with the USGS. The resultant individual well plans were then presented to EPA prior to the construction of the wells. I have reviewed the borehole geophysical logs and the well construction details to reconfirm that the monitoring wells were properly constructed as originally scoped and are obtaining groundwater from only one zone. Therefore, the exact vertical position of the pump within the well screen should not matter, because water can only enter the well through the screen, and all the water entering the screen is from the same zone. Some of my observations that led to this conclusion include:

- The vast majority of wells are screened across only one fracture. Therefore, the groundwater can only be entering the screen through that fracture.

- Some wells are screened across a fracture zone, or a series of smaller fractures rather than one distinct larger fracture. These fractures (typically two or three fractures within a five-foot interval) are very closely spaced vertically (generally on the order of one or two feet), and there was no lithologic indications of confining layers between these fractures. Fractures that are spaced so closely vertically are almost certainly hydraulically interconnected; it would be very unusual for these fractures to be hydraulically isolated from each other. In fact, due to the presence of high-angle vertical fractures (from the television survey), some of these "fracture zones" may be the same fracture intercepted on opposite sides of the borehole walls.

- The flowmeter was carefully considered for each well construction. Screens were extended across multiple fractures only if there was no evidence of intraborehole flow between the respective fractures. In fact, some screens were constructed specifically to monitor one fracture(s) but not the other(s) because of evidence of intraborehole flow.

\GIS\NASJRB_WillowGrove\5466-0809.apr 06August99 MJJ Layout2



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

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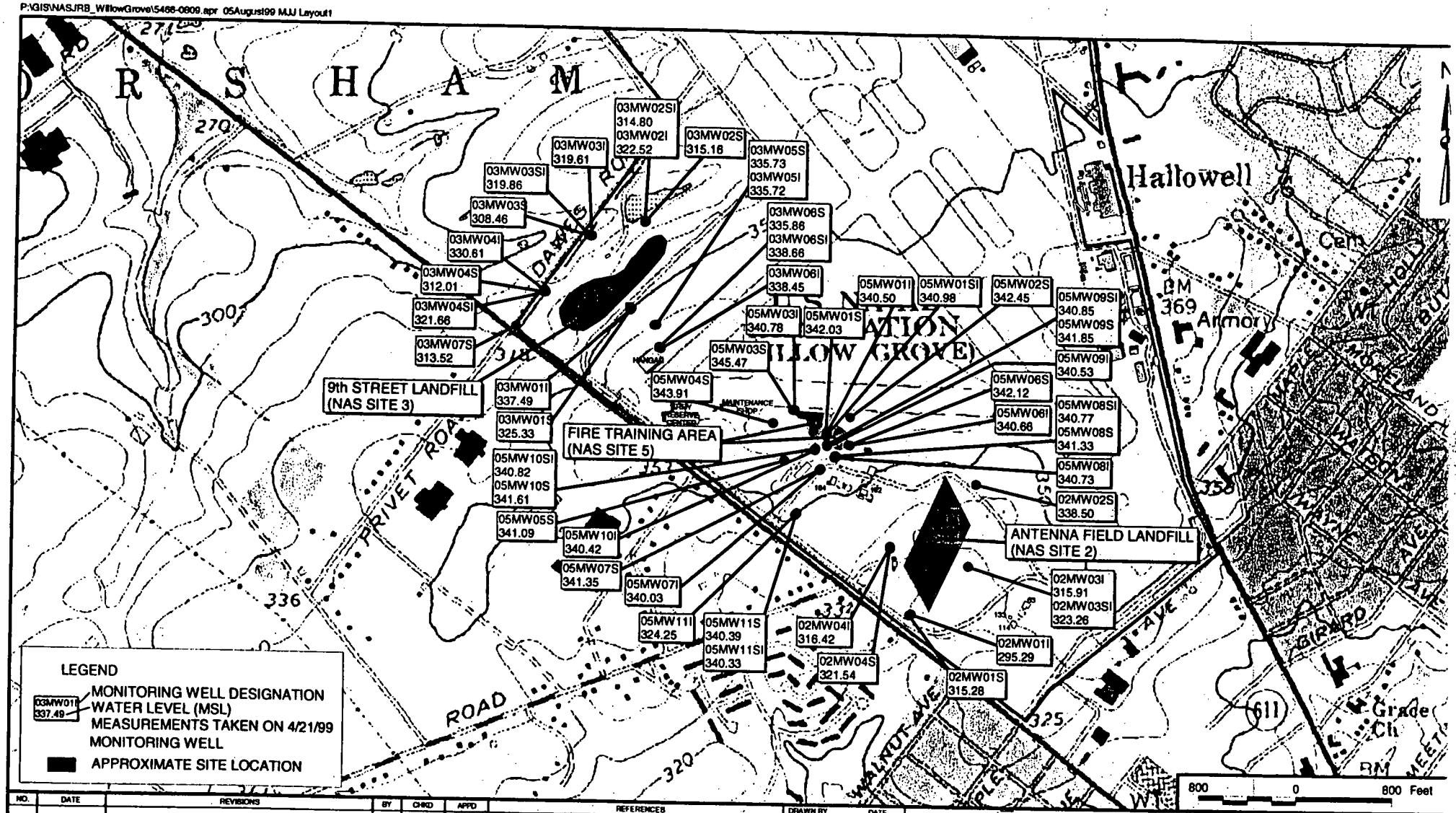
CHECKED BY — DATE
COST/SCHEDULE-AREA
SCALE: AS NOTED

Tetra Tech NUS, Inc.

SITES 5 FIRE TRAINING AREA
HYDROLOGICAL FEATURES
NASJRB WILLOW GROVE
WILLOW GROVE, PA

CONTRACT NUMBER: 5466
OWNER NUMB
APPROVED BY — DATE
APPROVED BY — DATE
DRAWING NO. FIGURE 2

P:\GIS\NASJRB_WillowGrove\5466-0809.apr 05August99 MJJ Layout1



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

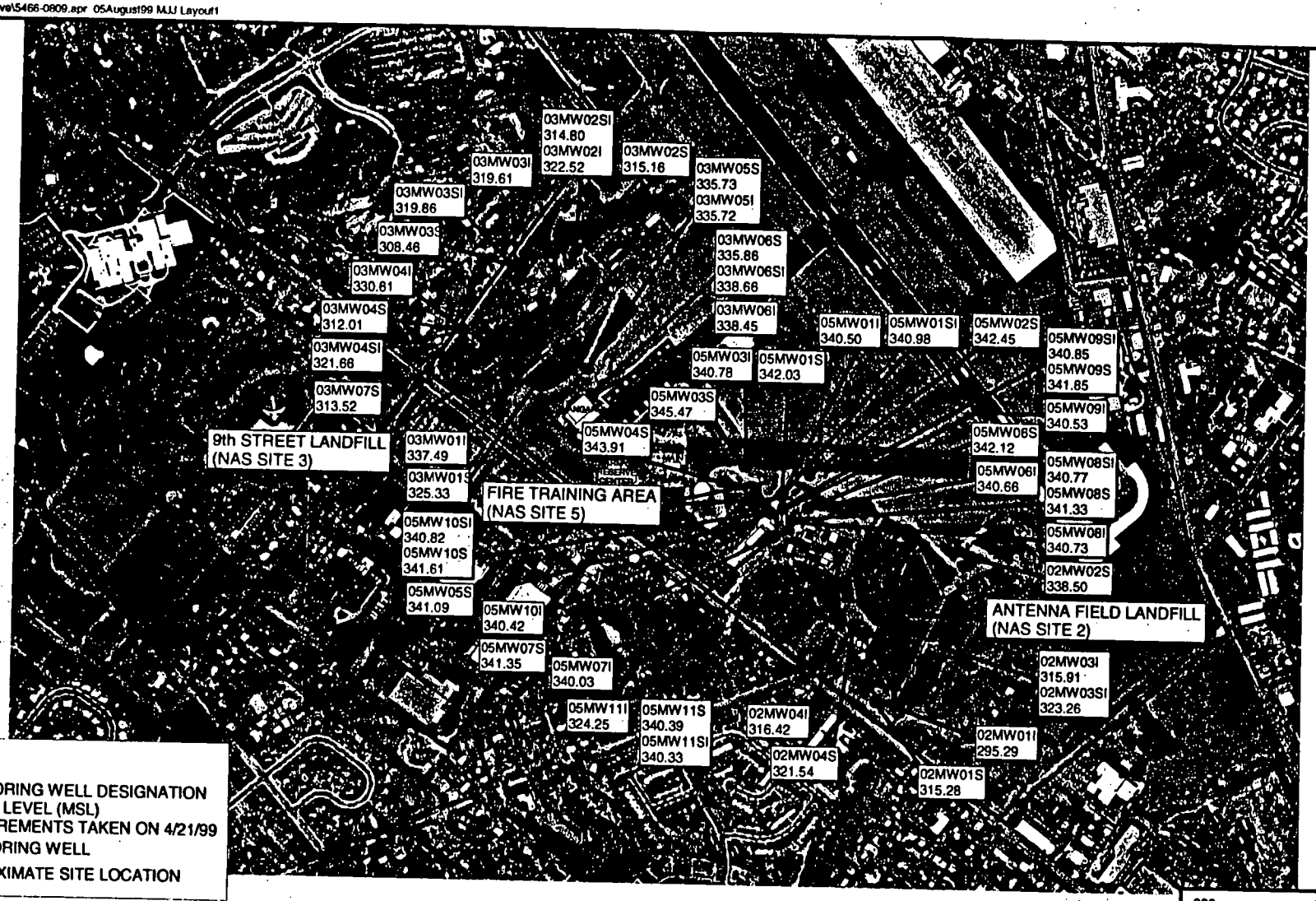
DRAWN BY: MJJ DATE: 05August99
CHECKED BY DATE
COST/SCHEDULE-AREA
SCALE: AS NOTED

Tetra Tech NUS, Inc.

INSTALLATION RESTORATION
SITES 2, 3 AND 5 COMBINED AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PA

CONTRACT NUMBER 5466 | OWNER NUMBER
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 1

P:\GIS\NASJRB_WillowGrove\5466-0809.apr 05August99 MJJ Layout1



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY: MJJ — DATE: 03August99
CHECKED BY — DATE
COST/SCHEDULE-AREA
SCALE: AS NOTED

Tetra Tech NUS, Inc.

INSTALLATION RESTORATION
SITES 2, 3 AND 5 COMBINED AREA
NASJRB WILLOW GROVE
WILLOW GROVE, PA

CONTRACT NUMBER: 5466 — OWNER NUMBER: —
APPROVED BY: — DATE: —
APPROVED BY: — DATE: —
DRAWING NO.: FIGURE 1 — REV: 0

(1) An Evaluation of the Effects f Geol gic Structure on Groundwater Plume Migration at Site 5

and

(2) A Recommendation for a New Monitoring Well Location To Address the Hydrogeological Data Gap in the Southwestern Portion of the Site

NASJRB Willow Grove

1.0 An Evaluation of the Effects of Geologic Structure on Groundwater Plume Migration at Site 5

1.1 Background

TtNUS was tasked to investigate the effects of the geologic structure on the groundwater flow and plume migration at Site 5, the Fire Training Area. Specifically, EPA asked if the dip of the sedimentary bedrock units (to the northwest) caused either the dissolved-phase groundwater plume or a separate-phase DNAPL to migrate from the source area located near monitoring well cluster location 05MW01 to the northwest toward monitoring well cluster 05MW03, where approximately 50 ug/L of various chlorinated solv nts were detected in the intermediate well but none were detected in the shallow (water table) well. The intermediate well (05MW03I) is screened just above a very fine-grained claystone unit. TtNUS had earlier concluded that the solvents detected in 05MW03I were not part of the main plume that has been delineated at Site 5.

1.2 Discussion

The hydrogeologic cross-section (Figure 1) indicates that monitoring well cluster location 05MW03 is hydraulically upgradient from the source area for chlorinated solvents that is located near monitoring well cluster location 05MW01. Figure 1 also indicates that the shallow groundwater at 05MW03 does not contain any chlorinated solvents, which indicates that this well cluster is not located within the source area of the solvents. Therefore, the occurrence of the solvents in monitoring well 05MW03I may be due to either:

- An unknown source located hydraulically upgradient from 05MW03, with the solvents migrating as a dissolved phase with the groundwater along the hydraulic gradient, and to deeper depths due to the downward-oriented vertical gradient; or

- The known source (the VOCs in the soils) located near 05MW01, with the solvents migrating to deeper depths down the geologic dip of the bedrock (but against the hydraulically gradient) to 05MW03.

TtNUS believes the data indicate that the source of the solvents in 05MW03I is an unknown source located hydraulically upgradient from that monitoring well location. The following discussions are presented in support of this hypothesis:

- The siltstones and claystone encountered in the subsurface near the source area (at 05MW01) do not appear to function as effective semi-confining layers to the depths at which they are encountered. Investigations at other base sites (Site 1 and Site 3) where confining conditions were encountered suggest that it is the cumulative effect of multiple fine-grained units that ultimately create the confining conditions at greater depths rather than any particular bed creating th confining conditions at any (including shallow) particular depth. This hypothesis is supported at Site 5 by the observation that upward groundwater flow was noted on the thermal-pulse flow log from the bottom of the 05MW03I borehole (from below the bottom claystone unit) prior the retrofitting of the open borehole with the monitoring well.

ATTACHMENT (2)

The geologic structure (bedrock dip) does not appear to influence the groundwater flow patterns to the total depth of the hydrogeologic investigation at Site 5. As depicted in Figure 1, both the groundwater and the dissolved-phase groundwater plume are migrating in a generally southward direction, while the dip of the bedrock is to the northwest. The hydrogeologic data are indicative of an unconfined groundwater flow system. Specifically:

- There are no major changes in the hydraulic head values across the potential semi-confining layers. The vertical gradients are relatively low and are oriented downward. Higher vertical gradients and more pronounced deflections in the groundwater flow patterns would normally be expected at the bed boundaries if the finer-grained layers were functioning as effectiv semi-confining units.

- Monitoring wells screened below the potential semi-confining layers contain chlorinated solvents, indicating that the geologic layers are not effectively retarding the migration of these chemicals. The gradational changes in chemical concentrations with depth appear to reflect typical attenuation/dilution processes rather than sharp changes across lithologic and hydrogeologic boundaries.

- The concentrations of the solvents at the source area do not suggest the presence of a DNAPL. An examination of the historical analytical data reveals that no compound approaches even one percent of its solubility in groundwater; the highest recorded concentration is for 1,1,1-TCA (2800 ug/L in 1991). Even if the siltstones and claystone functioned as effective semi-confining layers, the presence of a DNAPL would be required for the solvents to migrate to the northwest (down the bedrock structural dip and against the hydraulic gradient) rather than in a dissolved-phase plume migrating with the groundwater along the hydraulic gradient.

It is noted that monitoring well cluster 05MW03 is not located directly downdip from the source area located near well cluster 05MW01. As can be seen on Figure 2, well 05MW03I was installed about 38° west of true dip. Well 05MW03I was placed directly downdip from the source area based on the regional geology and the limited site-specific subsurface information that was available prior to the drilling of the borehole. The site-specific strike and dip directions were subsequently determined through the correlation of the subsurface geophysical logs at the conclusion of the drilling program. Therefore, it is possible that DNAPL c uld hav migrated directly downdip, with the concentrations at 05MW03I representing the edge of a dissolved plume that is migrating downgradient (and updip) after migrating upgradient (but downdip) as a DNAPL, although as discussed above, the hydrogeological evidence does not indicate the likely presence of DNAPL in this area. To completely confirm this hypothesis, a borehole could be installed downdip from 05MW01 and near th runway (see Figure 2). Based on a rate of dip of 7°, the top of the finer-grained units encountered in 05MW01 at subsurface depths of 0 feet, 82 feet, and 106 feet (which is the unit that 05MW03I is screened above) would be encountered at the new location at subsurface depths of 32 feet, 114 feet, and 138 feet, respectively.

1.3 Other Potential Source Areas

Monitoring well location 05MW03 is located near the runway. The runway basically lies along a topographic high or ridge that bisects the base, and multiple hydrogeologic investigations have indicated that this ridge is both a surface water and a groundwater divide. Therefore, if the source of the solvents detected in 05MW03I is from an upgradient location (since there are no detections in 05MW03S) the potential sources should be limited to the area generally between the runway and the 05MW03 monitoring well cluster location. Th nearest structure in this vicinity is part of the Army Reserve complex and is reportedly a maintenance-type facility.

The Army Reserve complex has also been identified as a potential source of the chlorinated solvent detected in the groundwater at the adjacent Site 3 (9th Street Landfill). The buildings at this complex either straddle or are located on either side of the groundwater divide (Figure 2). It is interesting to note, however, that a common source located on the complex could not account for both the Site 3 groundwater plume and th

solvents detected at Site 5 well 05MW03I because of the chemical dissimilarity of the detections (only PCE was detected at Site 3 while many different solvents were detected at Site 5). It is still possible, however, that two different sources could be located on the Army Reserve complex, with the sources located on opposite sides of the groundwater divide.

2.0 A Recommendation for a New Monitoring Well Location to Address the Hydrogeological Data Gap in the Southwestern Portion of the Site

2.1 Background

TtNUS was tasked to recommend a drilling location for an additional monitoring well cluster in the southwestern portion of the site designed to fill a data gap noted by EPA. The available data indicate that there is a component of groundwater flow in that direction and that the groundwater quality has been impacted immediately to the southwest of the source area (at monitoring well cluster 05MW10), but there are limited monitoring wells downgradient of 05MW07 from which to obtain water quality data. The only existing monitoring wells in that quadrant are the shallow wells 05MW05S (40 feet deep) and 05MW04S (30 feet deep).

2.2 Potential Well Locations

An intermediate monitoring well clustered with existing well 05MW05S would close the data gap to the southwest. A well in this location would provide additional hydraulic head and water quality data in a direction potentially downgradient from the source area near 05MW01 and downgradient from the impacted groundwater at 05MW10. Monitoring well 05MW05S has been sampled during both phases of the RI and has never had a positive detection of any VOC, but it is possible that the groundwater plume could be migrated through this area at some depth below the total depth of the shallow well. Due to the rather steep vertical hydraulic gradient at Site 5 (Figure 1), the new monitoring well should be installed at a depth of approximately 250 feet.

A second potential well location would involve the installation of an intermediate monitoring well clustered with existing well 05MW04S. Although this location is actually slightly northwest (rather than southw st) f the source area, the hydraulic head data collected during the Phase II RI did indicate a component of groundwater flow in this direction in the intermediate groundwater zone (because of a lower hydraulic head in monitoring well 05MW03I). Alternatively, the lower hydraulic heads could have resulted from the southward migration of the water level divide to a position just south of the 05MW03 location. Subsequent water level measurement rounds conducted after the RI have not found this same pattern. In these later rounds, the hydraulic head measured in 05MW03I is consistently higher than the head measured in the other intermediate wells, creating the south-to-southwest pattern of groundwater flow. An intermediate well installed to approximately the same depth as 05MW03I (128 feet) would provide useful hydraulic h ad data and possibly provide information helpful to the evaluation of the potential for an additional source area in this vicinity, as discussed above in Section 1.

DEPARTMENT OF THE NAVY
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
10 INDUSTRIAL HIGHWAY
MAIL STOP, #82
LESTER, PA 19113-2090

IN REPLY REFER TO

5090
Code 09TB/JC

26 MAY 2000

MEMORANDUM

FOR THE MEMBERS OF THE RESTORATION ADVISORY BOARD (RAB) FOR THE INSTALLATION RESTORATION PROGRAM AT NAVAL AIR STATION JOINT RESERVE BASE (NASJRB) WILLOW GROVE, PENNSYLVANIA

The Navy is enclosing a Workplan to conduct additional environmental investigations at Installation Restoration (IR) Site 5 - Fire Training Area, located at NASJRB Willow Grove, for your review and information.

Development of this workplan was in response to comments and requests made by the U.S. Environmental Protection Agency, Region 3 regarding the Navy's Draft Phase 2 Remedial Investigation Report, dated April 1998.

It is anticipated that upon completion of this supplemental fieldwork effort, the Navy will have enough information to adequately characterize the nature and extent of groundwater contamination at Site 5 and can then proceed with development of a Feasibility Study to evaluate potential groundwater remedies.

Due to funding availability, the Navy will be able to begin implementation of the enclosed workplan during the week of June 19, 2000. Therefore, any comments regarding the workplan should be submitted as soon as possible so that relevant comments can be incorporated.

If you have any questions or would like to discuss the enclosed document further, please give me a call at (610) 595-0567, extension 163.

Sincerely,

JAMES L. COLTER
Remedial Project Manager
By direction of the
Commanding Officer

Enclosure: (1) Remedial Investigation Workplan Addendum for Site 5

ATTACHMENT (3)

Distribution:

U.S. EPA Region III, Lisa Bradford (3 copies)
PADEP, April Flipse/Pam Reigh (2 copies)
NASJRB Willow Grove, Jim Edmond (3 copies)
Community Co-Chair, Liz Gemmill (3 copies)
Restoration Advisory Board, Community Members Mailing List (1 copy each)

ADDENDUM REMEDIAL INVESTIGATION WORK PLAN
FOR SITE INVESTIGATIONS AT SITE 5 - FIRE TRAINING AREA

PHASE II REMEDIAL INVESTIGATION
NASJRB WILLOW GROVE, PENNSYLVANIA

INTRODUCTION

T tra tech NUS (Tt NUS) has prepared this Work Plan for environmental site investigation on NASJRB Willow Grove property in the vicinity of Site 5 - Fire Training Area. These investigations are planned in response to comments/requests from the Environmental Protection Agency (EPA). EPA comments/requests are based on review of the draft Phase 2 Remedial Investigation (RI) Report for NASJRB Willow Grove Pennsylvania (Brown & Root Environmental, April 1998) and subsequent hydrogeological investigations and reports prepared for the Site 5 vicinity. The Navy has requested Tt NUS to perform additional remedial investigation at Site 5 under Contract Task Order No. 277 under Contract N62472-90-D-1298, Comprehensive Long - Term Environmental Action-Navy (CLEAN).

SUMMARY OF PREVIOUS REMEDIAL INVESTIGATIONS

Findings from the Phase II RI Report (draft) for NASJRB Willow Grove, Pennsylvania continue under review by the regulatory agencies. The findings appear to demonstrate that no off-post groundwater impact from past practices at or near Site 5 - Fire Training area has occurred. Th EPA has (informally) questioned this conclusion.

To help determine if there is any potential for contaminated groundwater to migrate off-base, the Navy performed two water level studies in monitoring wells to the southwest of Site 5. Monitoring wells monitored included 05MW11S, 05MW11SI, 05MW11I, 05MW07S, and 05MW07I. See Figure 1 for a map of this area. Monitoring wells 05MW11S, 05MW11SI and 05MW11I were installed as near as possible to the facility boundary in a direct line between the nearest off-station municipal groundwater supply well and the former fire training and drum storage area. Monitoring wells 05MW07S, and 05MW07I are also along the approximate line between the nearest off-station municipal groundwater supply well and the former fire training and drum storage area, but are located closer to Site 5 (Figure 1). The second water level monitoring study involved a

groundwater recovery test resulting from a planned shutdown of the nearest municipal groundwater supply well (Number 26), owned by the Horsham Township Water Authority. Horsham production well No. 26 (H-26) is located approximately 1,500 feet southwest of monitoring wells 05MW11 (Figure 2). Water levels in wells both on and off of the Air Station were monitored for one week before the H-26 pump shutdown, the week of the H-26 pump shutdown, and for one week after the H-26 pump shutdown.

The results of the water level monitoring tests indicate that H-26 does have some influence on movement of groundwater in the vicinity of the known solvent plume at Site 5. Although groundwater originating at or flowing through Site 5 ultimately will reach the vicinity of H-26, the analytical data indicate that the plume may have reached steady-state conditions and does not leave the base property due to dilution and dispersion processes.

BACKGROUND

Tt NUS was assigned to address several perceived data gaps resulting from the regulatory review of the draft Phase II RI. These tasks include the following:

- Tt NUS was assigned to investigate the effects of the geologic structure on the groundwat r flow and plume migration at Site 5. EPA questioned if the dip of the sedimentary bedrock units (to the northwest) caused either the dissolved-phase groundwater plume or a separate-phase DNAPL to migrate from the source area located near monitoring well cluster location 05MW01 to the northwest toward monitoring well cluster 05MW03, where approximately 50 ug/L of various chlorinated solvents were detected in the intermediate well but none were detected in the shallow (water table) well. The intermediate well (05MW03I) is screened just above a very fine-grained claystone unit. Tt NUS had earlier concluded that the solvents detected in 05MW03I were not part of the main plume that has been delineated at Site 5. An additional monitoring well is considered necessary to address EPA queries.

- Tt NUS was also assigned to recommend drilling locations for additional monitoring wells in the southwestern portion of the site to fill a gap noted by EPA in the existing solvent plume delineation. The available data indicate that there is a component of groundwater flow to the southwest and that the groundwater quality has been impacted immediately to the southwest of the source area (at monitoring well cluster 05MW10). EPA stated that there are insufficient monitoring wells downgradient of 05MW07 from which to obtain water quality data to accurately map the full extent of the plume. The only existing monitoring wells in that

quadrant are the shallow wells 05MW05S (40 feet deep) and 05MW04S (30 feet deep). Additional monitoring wells are considered nec ssary to allay concerns voiced by EPA.

- Tt NUS was assigned to investigate the possibility that bedrock in the vicinity of the solvent plume source area (near cluster 05MW01) is impregnated with chlorinated solvents and acting as a continuing solvent source.

SUMMARY OF PLANNED FIELD INVESTIGATIONS

The objective of this study is to conduct an environmental investigation of bedrock and groundwater quality on Navy property near Site 5 in order to fill data gaps identified by regulatory community members. Information will be used to more accurately delineate the current nature and extent of the known contaminant plume near the former fire training area on Navy property. All field activities will be governed by the Work Plan, and Health and Safety Plan (Brown & Root Environmental 1997) and Addenda prepared for phase II remedial activities at NASJRB Willow Grove, Horsham Township, Pennsylvania.

Rock Core Investigation

One rock core will be obtained from the assumed historical solvent plume source area near 05MW01 (see Figure 3 for the approximate location of the planned coring). The actual boring location will be marked in the field. The drilling subcontractor will obtain a 2 inch diameter core sample from the bottom of soil/fill to an approximate depth of 25 feet below ground surface. The soil/rock core will be transferred to clean polyethylene sheeting for immediate photo record, examination, and handling/sampling by USGS. Samples will be obtained at a minimum of 5 foot intervals, and at major fractures. USGS will supply equipment to cut samples from the rock core and crush the samples. At each sample interval, USGS will obtain six slices (approximately 2 inches of length) from the rock core. Two of the slices will be crushed and placed in sealed vials; two will be crushed and placed in vials with methanol; and two will be placed in airtight glass/ teflon containers for possible future analysis. Rock core samples will be analyzed at the USGS National Laboratory. The crushed rock core sample placed in vials will be analyzed using a water extraction procedure developed by USGS. The water and methanol extract solutions from the crushed rock core samples will be analyzed for VOC's using EPA approved methods. Appendix A is a copy of a field verification study of TCE in fractured bedrock developed by Beth Parker (see Appendix A).

Monitoring Well Installati n

Figure 1 shows the proposed locations for additional monitoring wells. Actual locations will be marked in the field before drilling activities begin. After boreholes are installed, USGS will perform geophysical analyses on the open borehole. The Tetra Tech NUS lead geologist and the USGS geophysicist will confer to make recommendations for monitoring well construction in each borehole based on known features.

To investigate the effects of the geologic structure on the groundwater flow and potential plume migration against groundwater flow gradient at Site 5, a borehole (05MW12) will be installed downdip (north of) 05MW01 near the runway (see Figure 1). Based on a rate of dip of 7°, the top of the finer-grained units encountered in 05MW01 at subsurface depths of 0 feet, 82 feet, and 106 f t (which is the unit that 05MW03I is screened above) would be encountered at the new location at subsurface depths of 32 feet, 114 feet, and 138 feet, respectively.

A new intermediate monitoring well (05MW05I) clustered with existing well 05MW05S will be installed to close the data gap in the measured plume extent to the southwest. A well in this location will provide additional hydraulic head and water quality data in a direction potentially downgradient from the source area near 05MW01 and downgradient from the impacted groundwater at 05MW10. Monitoring well 05MW05S has been sampled during both phases of the RI and has never had a positive detection of any VOC, but it is possible that the groundwater plume could have migrated through this area at some depth below the total depth of the shallow well. Due to the rather steep vertical hydraulic gradient at Site 5 the new monitoring well should be installed at a depth of approximately 250 feet.

A third new monitoring well (05MW04I) will be installed clustered with existing well 05MW04S. Although this location is actually slightly northwest (rather than southwest) of the source area, the hydraulic head data collected during the Phase II RI did indicate a component of groundwater flow in this direction in the intermediate groundwater zone (because of a lower hydraulic head in monitoring well 05MW03I). Alternatively, the lower hydraulic heads could have resulted from the southward migration of the water level divide to a position just south of the 05MW03 location. Subsequent water level measurement rounds conducted after the RI have not found this same pattern. An intermediate well installed to approximately the same depth as 05MW03I (128 feet) would provide useful hydraulic head data and possibly provide information helpful to the evaluation of the potential for an additional source area in this vicinity.

Surv y

The horizontal locations and the elevations (at the top of casing for monitoring wells) relative to mean sea level for the three monitoring wells and one rock coring will be measured and recorded by a land surveyor licensed in the Commonwealth of Pennsylvania.

Monitoring Well Water Level Measurements

All Site 5 monitor wells will be gauged to determine piezometric elevations, groundwater flow direction, and gradient.

Groundwater Sampling

Groundwater samples from all Site 5 monitoring wells, field duplicates, and quality control samples will be obtained after well development. All samples will be analyzed for volatile organic compounds (VOCs) and monitored natural attenuation (MNA) parameters. All pertinent field data will be recorded in a field logbook and on the appropriate sample log sheet.

Groundwater sampling will be conducted in accordance with the low-flow sampling procedure based on USEPA Region III amended Groundwater Sampling Procedure Low-Flow Purge and Sampling Guidance. Monitoring wells will be purged and sampled using a low-flow submersible pump and disposable polyethylene tubing. Groundwater will be directed into a flow-through cell with a multi-probe water quality meter. Each well will be purged until the monitored parameters (pH, temperature, conductivity, turbidity, and dissolved oxygen) of three consecutive readings were within 10 percent.

Field Decontamination

All drilling equipment and sampling equipment will be decontaminated before use, between individual samples, and after drilling and sampling activities.

The down-hole drilling equipment and sampling tools will be cleaned using a high pressure steam generator (steam jenny) before beginning work, between boring and well locations, and at the end of the drilling/well installation program. A temporary decontamination pad will be constructed at the study area in to complete this work. NASJRB will provide potable water for decontamination and cleaning.

The sampling equipment used for collecting samples will be decontaminated before field sampling and between samples (a full discussion of sampling requirements are provided in the Phase II RI Work Plan (Brown & Root Environmental, May 1997). The following decontamination steps will be followed:

- Alconox or liquinox detergent solution wash.
- Potable water rinse.
- Deionized water rinse.
- Air dry.

Fi ld analytical equipment such as pH, conductivity, temperature, and turbidity instrument probes will be first rinsed with Deionized water and then with a portion of the sample liquid.

Investigative Derived Waste

Investigative derived wastes including drill cuttings, development water, purge water, and decontamination fluids will be handled and disposed in accordance with procedures described in the Phase 2 RI Work Plan.

Drill Cuttings

Drill cuttings generated during the rock coring and well installation program will be field screened with a PID. If no elevated organic vapor readings are generated at the rock coring location, the drilling cuttings will be backfilled and the coring hole will be filled with grout. If the drill cuttings from the new well boring locations do not indicate any significant PID readings, the cuttings will be spread around the immediate area of the well.

Development Water

Development water from the newly installed monitoring wells will be directed away from the wellhead and discharged to the ground surface and allowed to infiltrate the soil. If PID readings elevated (above background) are noted at any monitoring well, development water from that well will be containerized, sampled and stored on site pending test results for disposal.

Purge Wat r

Purge water from the newly installed monitoring wells will be directed away from the wellhead and discharged to the ground surface and allowed to infiltrate the soil. The purge water from newly installed wells will be containerized if the development water from those wells was containerized. Purge water from wells with a known history of VOC compounds will be containerized because VOC compounds are not found in Site 5 soils.

APPENDIX A

Field Verification of TCE Matrix Diffusion in a Fractured Sandstone and Implications for Natural Attenuation and Remediation

Beth L. Parker and Sean N. Sterling
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200 University Avenue West, Waterloo, ON, Canada, N2L 3G1
blparker@sciborg.uwaterloo.ca.

Sedimentary rocks such as sandstones, siltstones, mudstones and shales are referred to as fractured porous media because of their appreciable primary porosity (intergranular porosity) in the matrix between fractures. The primary porosity of lithified sediments generally ranges from a few per cent up to 25%, several orders of magnitude greater than the secondary porosity due to the presence of fractures. Although the matrix has appreciable porosity, the permeability is governed by pore size, and these lithified sediments are referred to as dual permeability media given that the matrix generally has very low permeabilities compared to the fractures, which provide the main avenues for water and DNAPL flow, especially below the water table where the matrix pores are completely filled with water. This large difference between fracture and matrix porosities is an important feature of fractured sedimentary rocks and greatly influences the distribution of chlorinated solvent mass in these deposits in terms of DNAPL persistence as well as solute movement.

Groundwater samples collected from conventional monitoring wells represent a mixture of waters from various fractures, which can be biased in several ways. In some cases, one fracture with exceptionally high concentrations can cause an appearance of relatively high concentrations throughout the open interval in the borehole if this fracture has high hydraulic conductivity; or fractures with high hydraulic conductivity but low concentration levels can mask the presence of high concentration zones. There is no way to determine from monitoring well data alone whether the water samples from the well provide a representative average or a severely biased result. In addition, these groundwater samples are rarely in equilibrium with the pore water concentrations in the matrix and therefore, tell us nothing about the distribution of chemical mass between the relatively immobile pore water of the matrix as compared to the free-flowing water in the fractures. The contaminants such as trichloroethene (TCE) migrate into these low permeability yet porous matrix blocks between fractures by molecular diffusion, which is driven by the chemical's concentration gradient in the aqueous (groundwater) phase. The matrix blocks between the fractures serve as large reservoirs for contaminant mass allowing matrix diffusion alone to cause complete dissolution of immiscible-phase solvents initially present in fractures. Therefore, matrix diffusion diminishes concentrations within plumes, which is a form of natural attenuation.

To investigate this form of natural attenuation, the distribution of TCE in a sandstone matrix was determined by chemical analysis of rock core subsamples taken from two boreholes at an industrial site in southern California. Use of TCE over several decades has resulted in contamination in the underlying Cretaceous Age arkosic sandstone, which contains occasional

beds of siltstone and claystone. Estimated hydraulic conductivities of this formation range from 1.5×10^{-5} to 8.5×10^{-11} cm/s and matrix porosities range from 5 to 16% based on measurements on 11 core samples. The two corehole locations were selected where existing monitoring wells installed within the upper 100-ft of the formation yielded groundwater concentrations of TCE in excess of 10 mg/L. Continuous cores were collected from top of rock (at or near groundsurface) to a depth of 360 ft into rock. Using a field protocol developed specifically for this project, small subsamples (15-180 grams wet-weight) were taken from the core for immediate preservation in 120 ml glass VOA bottles containing a pre-weighted amount of high purity methanol. Three hundred and fifty-nine subsamples were collected and preserved in methanol in the field, of which 271 samples were analyzed. The vertical spacing between discrete-depth subsamples generally ranged between 5 and 10-ft, with 0.5 to 1-ft spacing near many apparent fractures identified during core inspection. The methanol-extract analysis provides total concentrations for TCE per unit-weight of water-saturated rock. These data for the two locations are presented in Figures 1 and 2. Calculations using parameter values for matrix porosity and sorption convert these concentrations to equivalent groundwater concentrations in the matrix pore water.

The rock core concentrations with depth shown in Figures 1 and 2 exhibit large contrasts in TCE distribution. At the location in Figure 1, which is closest to a historical TCE release location, the highest TCE concentrations occur in the vadose zone between 30 and 70-ft depths. At this location, the water typically fluctuates between 70 and 80ft below ground surface (bgs). Almost no TCE was found greater than 130-ft bgs. However, at the second location (Figure 2), no detectable concentrations were obtained in the vadose zone, but high concentrations are observed to a maximum depth of 250-ft bgs. The detection limit for rock core analyses, expressed as equivalent groundwater concentration, varies from sample to sample and ranges from 100-500 ug/L. The highest concentration measured in the matrix pore water was 40 mg/L using a representative retardation factor of 3.75 and matrix porosity of 12%. There is considerable variability in measured concentrations over short distance intervals, indicating the location of contaminant pathways. The profiles of TCE concentration vs. depth show thick zones of TCE at relatively high concentration. Therefore, because the matrix porosity is very large relativ to the fracture porosity and because sorption occurs primarily in the matrix, it is apparent that nearly all of the TCE mass at the two locations exists in the rock matrix where groundwater flow has minimal influence. This TCE mass in the matrix serves as a reservoir causing long-term groundwater contamination.

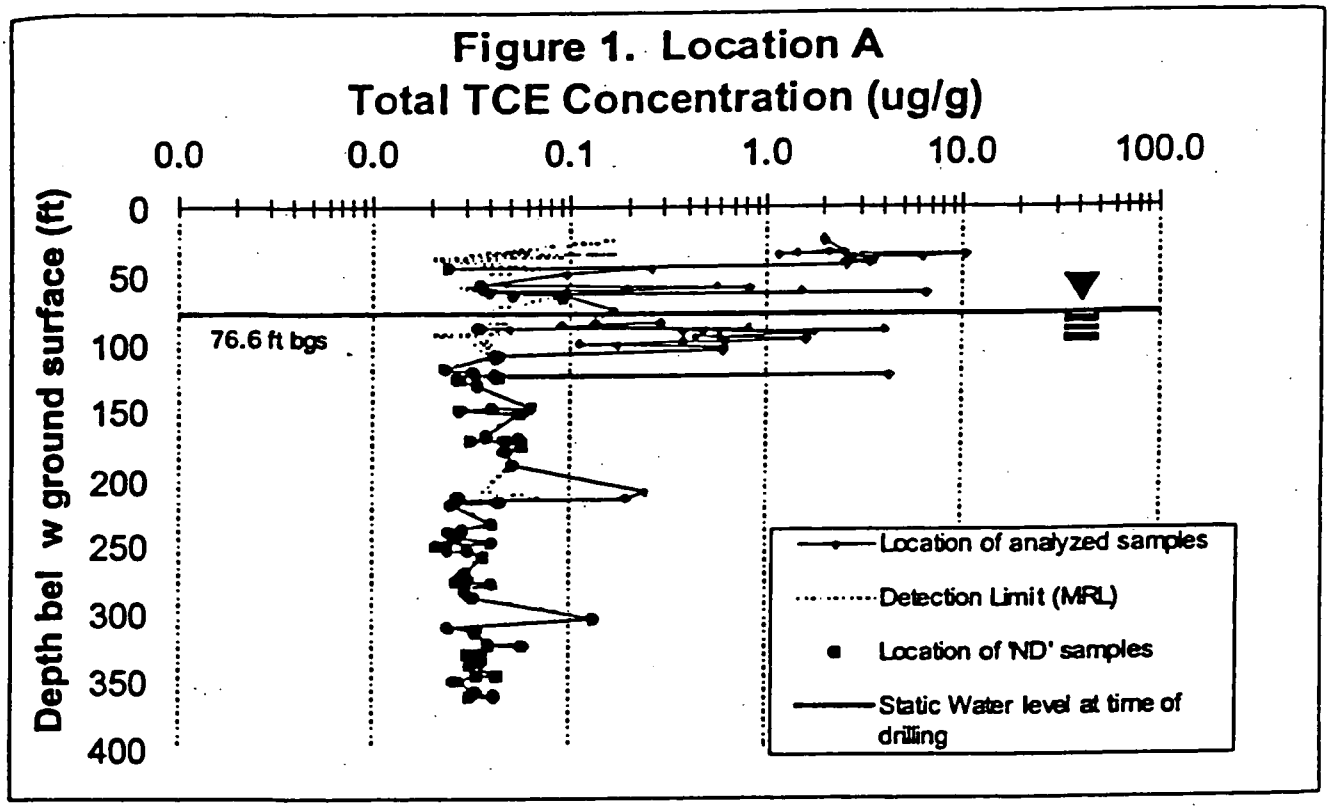


Figure 1. Location A
Total TCE Concentration (ug/g)
0.0
0.0
0.1
1.0
10.0
100.0
Depth bel w ground surface (ft)
0
50
100
150
200
250
300
350
400
76.6 ft bgs
Location of analyzed samples
Detection Limit (MRL)
Location of 'ND' samples
Static Water level at time of drilling

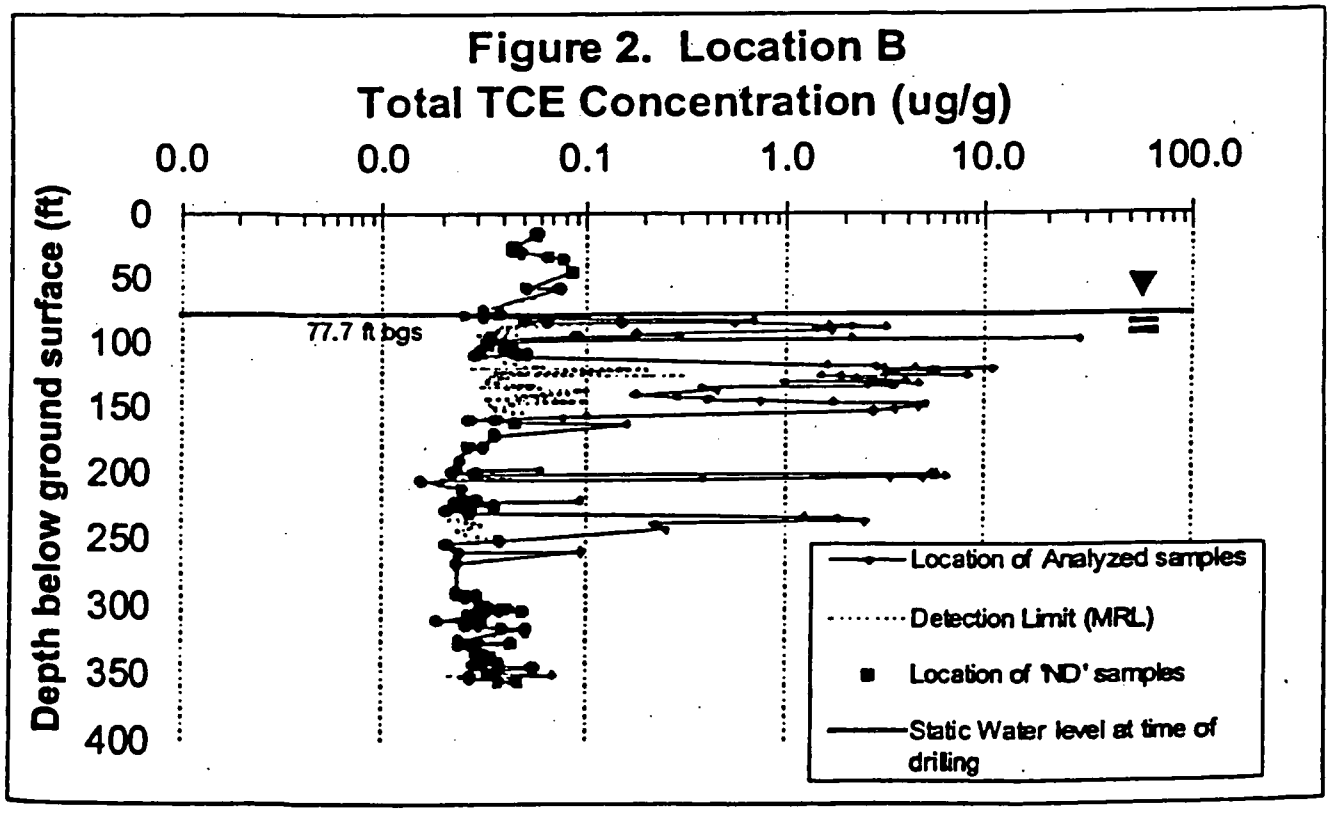


Figure 2. Location B
Total TCE Concentration (ug/g)
0.0
0.0
0.1
1.0
10.0
100.0
Depth below ground surface (ft)
0
50
100
150
200
250
300
350
400
77.7 ft bgs
Location of Analyzed samples
Detection Limit (MRL)
Location of 'ND' samples
Static Water level at time of drilling

LBNL-42718

Proceedings of the International Symposium on
DYNAMICS OF FLUIDS IN FRACTURED ROCKS
Concepts and Recent Advances

In Honor of Paul A. Witherspoon's 80th Birthday

February 10–12, 1999

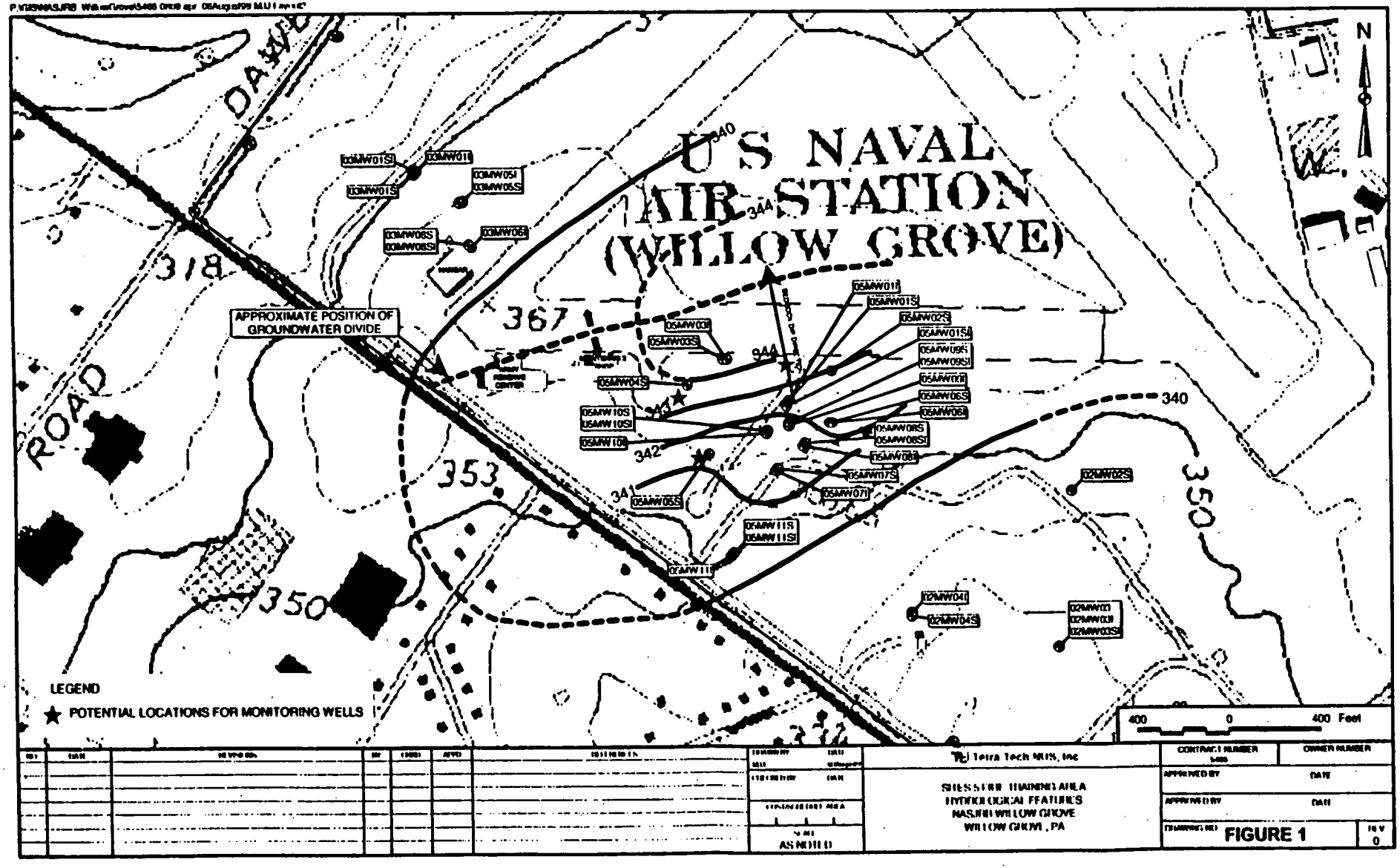
Edited by

Boris Faybishenko

Earth Sciences Division
Ernest Orlando Lawrence Berkeley National Laboratory
University of California
Berkeley, California 94720
U.S.A.

Ernest Orlando Lawrence Berkeley National Laboratory is administered for the U.S. Department of Energy by the University of California under Contract No. DE-AC03-76SF00098.

FIGURES


U.S. NAVAL AIR STATION (WILLOW GROVE)
DAM
ROAD
APPROXIMATE POSITION OF GROUNDWATER DIVIDE
03MW01SI
03MW01
03MW01S
03MW05I
03MW05S
03MW06S
03MW06SI
03MW06I
05MW01I
05MW01S
05MW02S
05MW01SA
05MW09S
05MW09SI
05MW06I
05MW06S
05MW06I
05MW08S
05MW08SI
05MW08I
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05MW04S
05MW10S
05MW10SI
05MW10I
05MW05S
05MW11S
05MW11SI
05MW11I
02MW02S
02MW04I
02MW04S
02MW00
02MW03I
02MW03S
318
367
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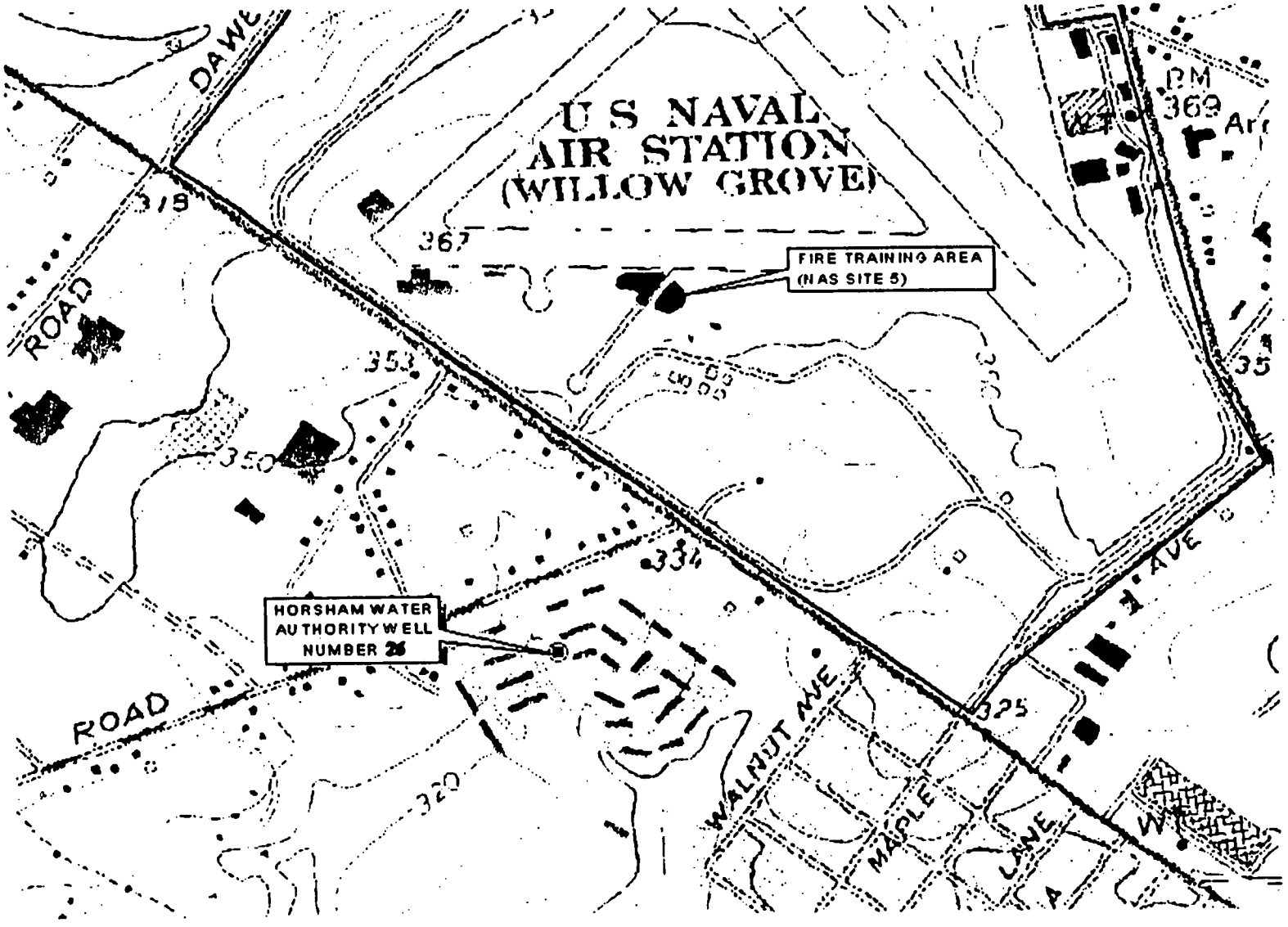
340
344
342
341
N
LEGEND
POTENTIAL LOCATIONS FOR MONITORING WELLS
400 0 400 Feet
Tetra Tech NUS, Inc
SITE STUDY HAINNI AREA
HYDROLOGICAL FEATURES
NASRW WILLOW GROVE
WILLOW GROVE, PA
AS NOTED
CONTRACT NUMBER
OWNER NUMBER
APPROVED BY
DATE
FIGURE 1
REV 0



NASJRB WILLOW GROVE SITE 5 - FIRE TRAINING AREA
HORSHAM WELL 26 LOCATION

FIGURE 2

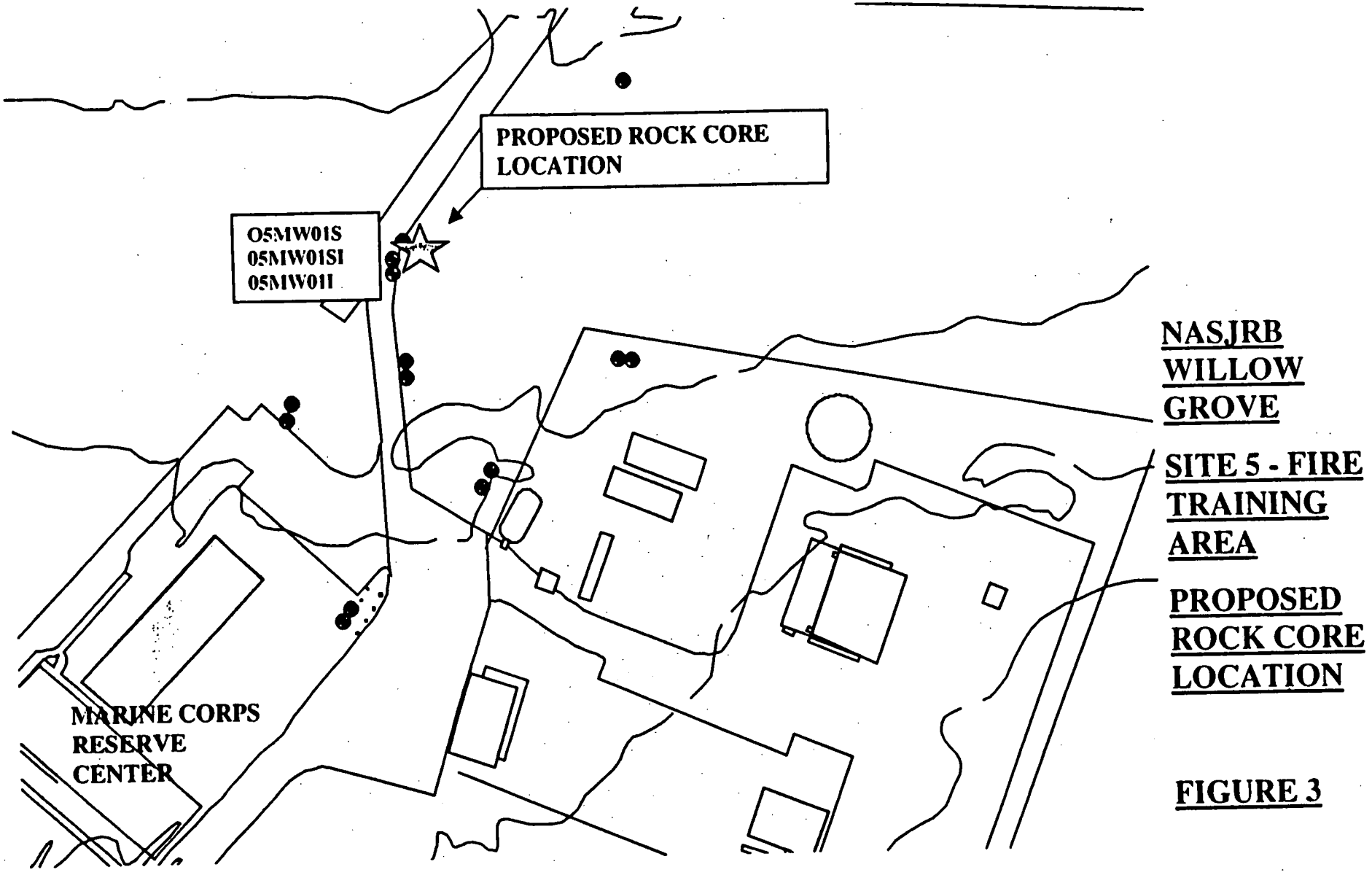

PROPOSED ROCK CORE LOCATION
O5MW01S
05MW01SI
05MW01I
MARINE CORPS RESERVE CENTER
NASJRB WILLOW GROVE
SITE 5 - FIRE TRAINING AREA
PROPOSED ROCK CORE LOCATION

FIGURE 3

Recent USGS Work

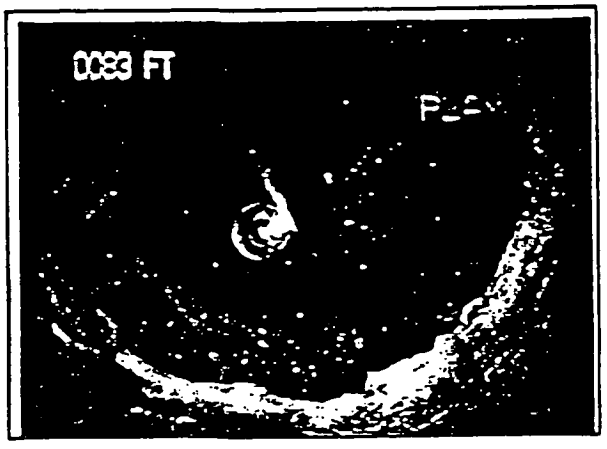
- Production Wells
  - Monitoring during Aquifer Tests
  - Geophysical Logging
  - Packer Testing
- Regional 'Water Table' Mapping
- Horsham Well #26 Shutdown

USGS

Navy Production Wells

- Geophysical Logging
- Monitoring during Aquifer Tests
  - Testing by TetraTechNUS
  - Continuous water levels
- Packer Testing

USGS

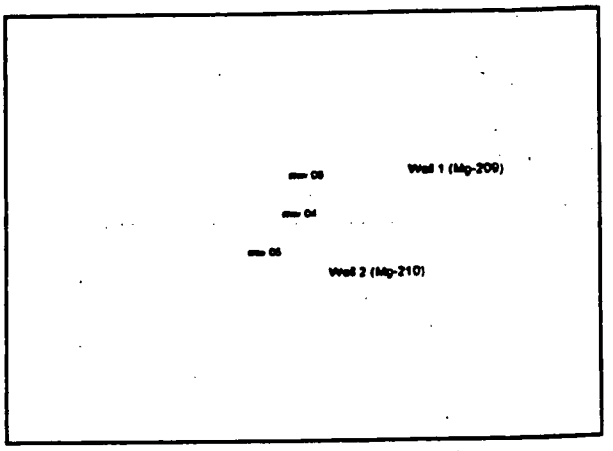


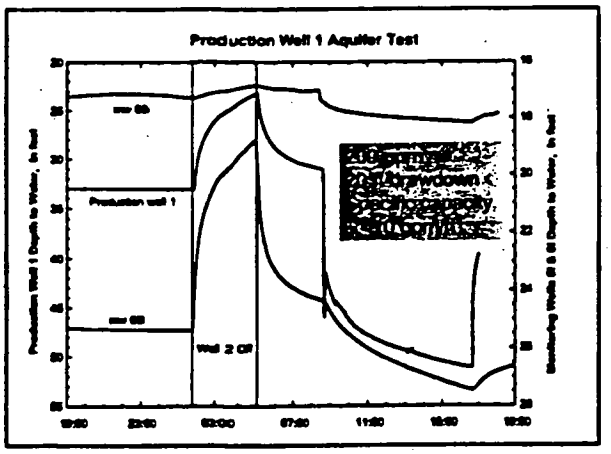
Attachment (5)

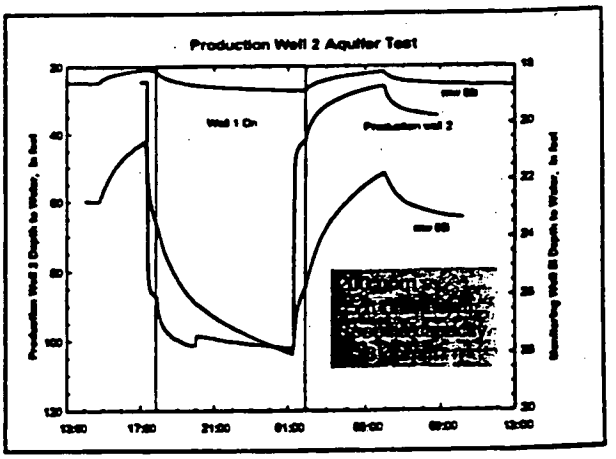
Navy Production Wells

- Geophysical Logging
- Monitoring during Aquifer Tests
  - Testing by TetraTechNUS
  - Continuous water levels
- Packer Testing

USGS



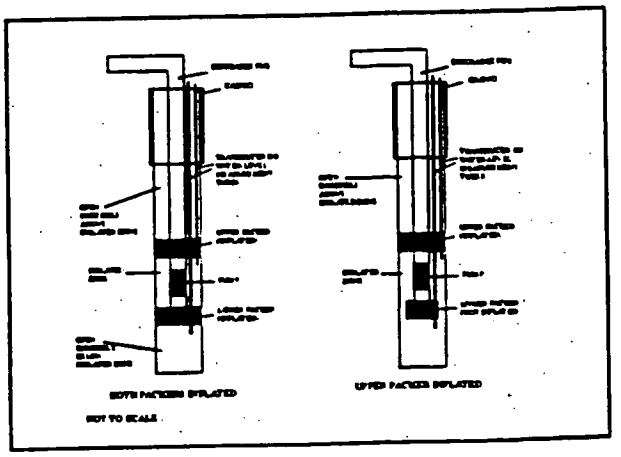


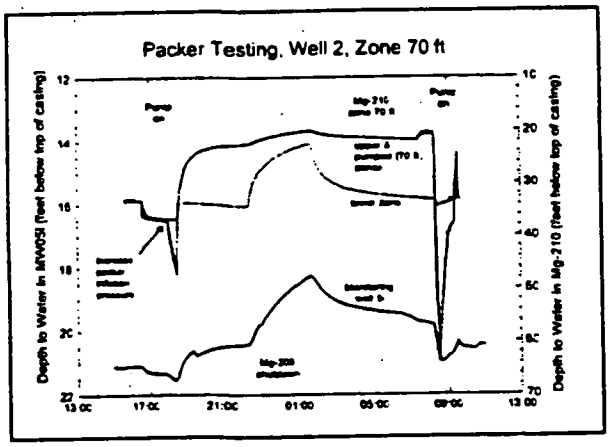


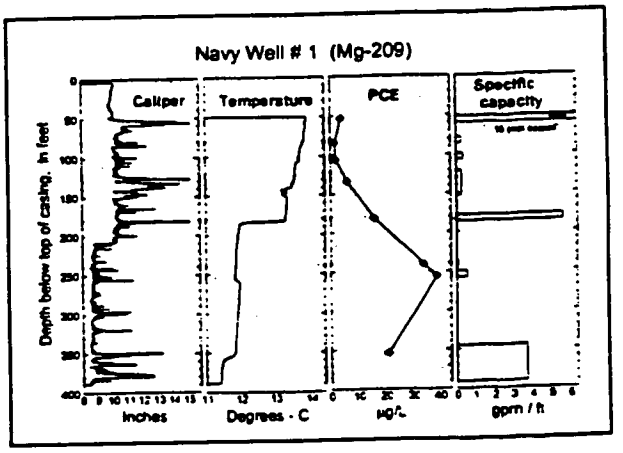
Navy Production Wells

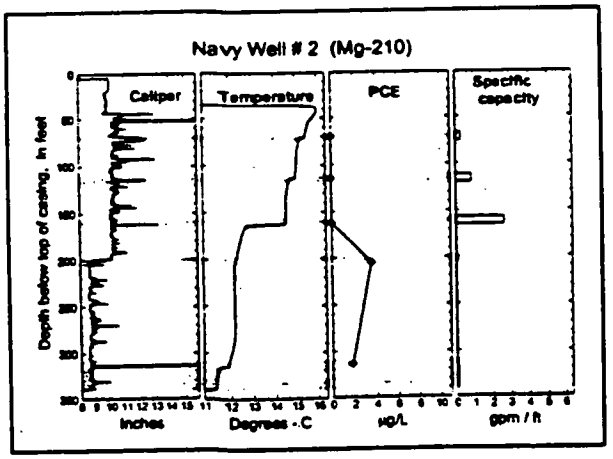
- Geophysical Logging
- Monitoring during Aquifer Tests
  - Testing by TetraTechNUS
  - Continuous water levels
- Packer Testing

USGS





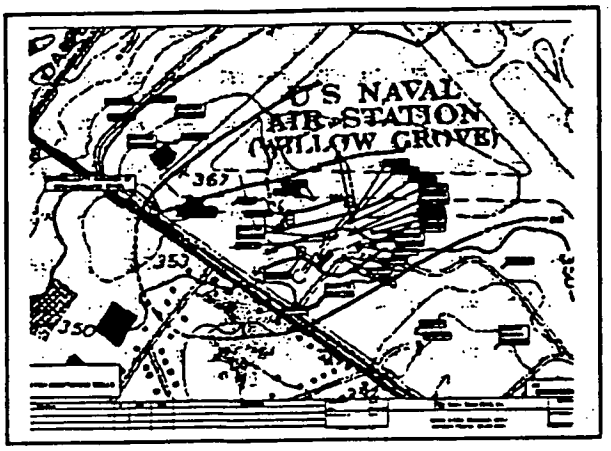


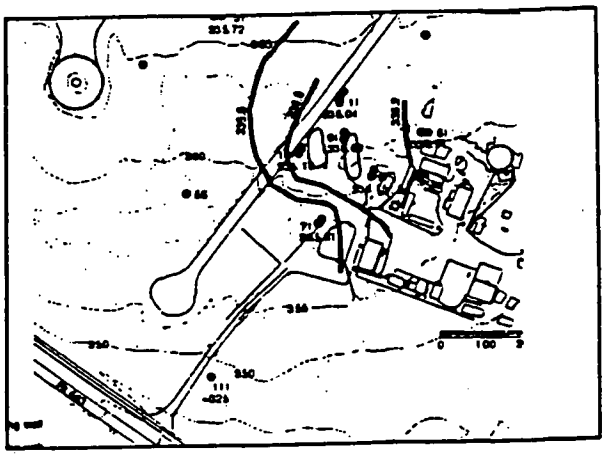


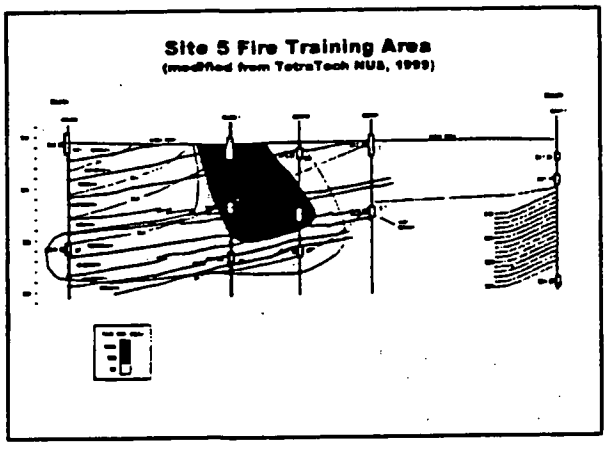
Water Table Mapping

- Monitoring indicator levels
- Regional levels and flow directions

USGS



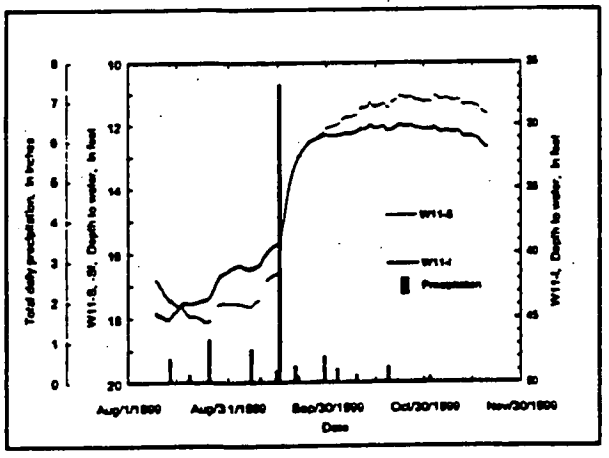


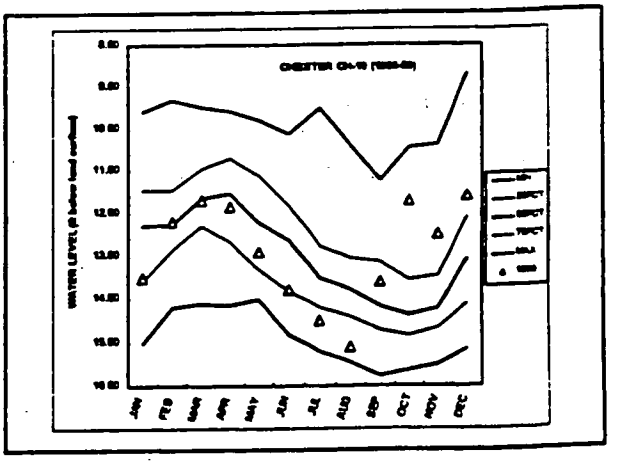


Water Table Mapping

- Monitoring indicator wells
- Regional levels and flow directions

USGS

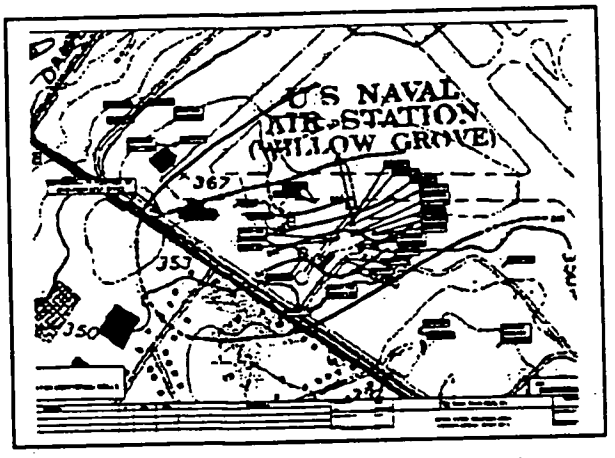




Water Table Mapping

- Monitoring indicator wells
- Regional levels and flow directions

USGS



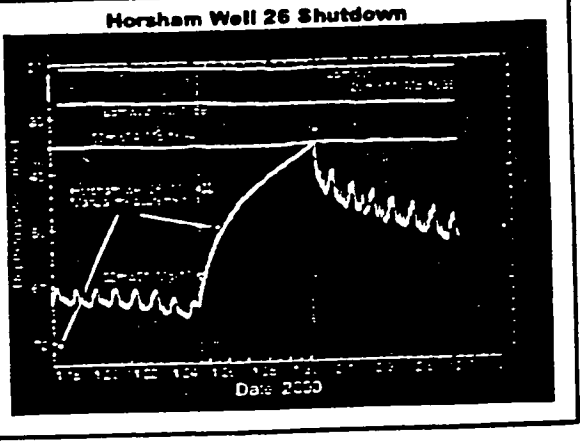
Shutdown Test of Horsham Well 26

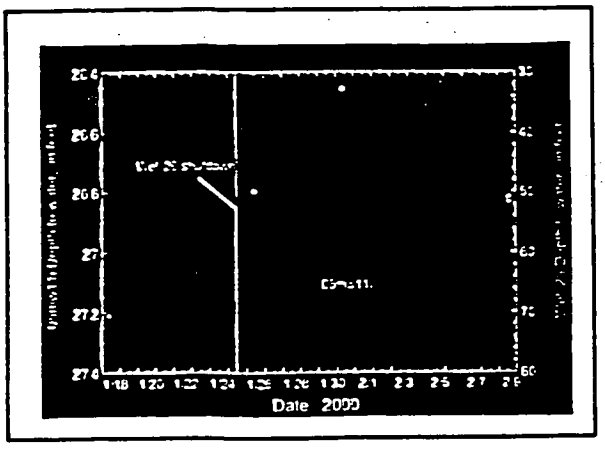
- Public-supply well on tank level switch
- Remove well from service for 6 days
- Monitor water levels
  - TetraTech NUS onsite wells
  - USGS well 26 & homeowner well
- Identify response to shutdown

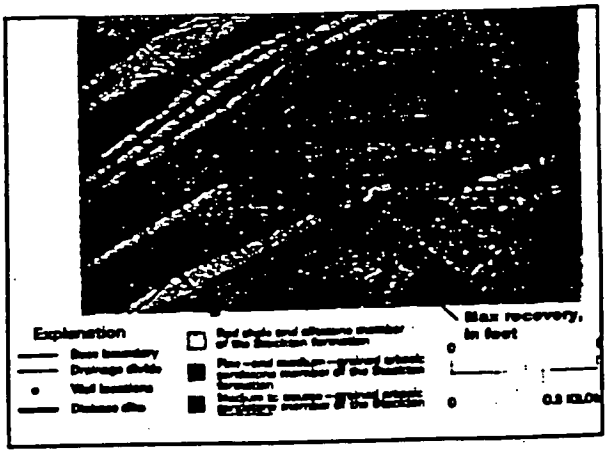
USGS

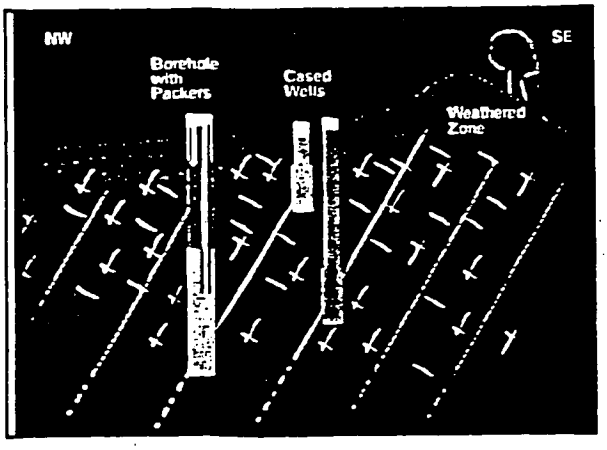
Maximum Recovery after 6 days

- Horsham # 26 37-40 ft
- 02 mw 01i 28 ft
- 05 mw 11i 0.5 ft
- 02 mw 01s 0.3 ft
- 02 mw 04i 0.3 ft
- All other wells had negative recovery, i.e., the water level dropped





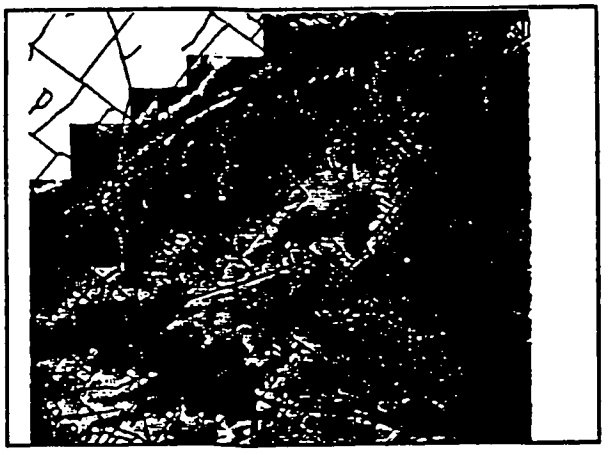


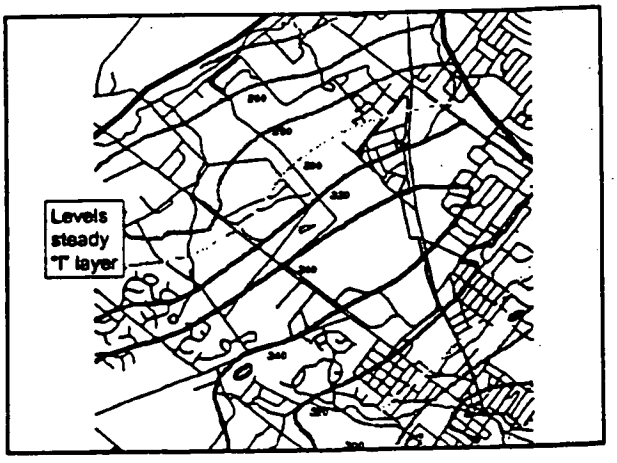


Quantitative Interpretation Ground-Water Flow Model

- Match simulated and measured water levels
- Steady state, pre-shutdown
- Transient response to shutdown
- Simulate contributing areas to streams and wells, average steady-state.

USGS





The End

- Hydrologic Atlas (1 sheet) for w.t. map
- Production well testing report
- Shutdown test report
- Near-term plans
  - Log new monitoring boreholes, Site 5
  - Measure VOC's in shallow core, Site 5

USGS

NAVY REVIEW OF EPIC PHOTOS
FORWARDED BY USEPA REGION III

IR SITE 5 – FIRE TRAINING AREA

INTRODUCTION

In April 1999, the USEPA Region III forwarded a Microsoft Powerpoint file showing a series of anomalies for each of the Navy's Installation Restoration (IR) Sites. These anomalies were identified as a result of the EPA's review of a series of aerial photos known as an EPIC Study. The Navy was requested to review the anomalies at each of the IR Sites and show that soil sampling was conducted in the area of an anomaly or provide rationale for why they are not an environmental concern. Although anomalies were identified f r each of the Navy's four main IR sites, the information below will only focus on those anomalies associated with IR Site 5 – Fire Training Area. As each Remedial Investigation (RI) is finalized for each of the IR Sites, a separate rationale, similar to what is provided below, will be provided for each separate IR site and included into the Final RI for that particular site.

ANALYSIS OF EPIC PHOTOS

The first step in the Navy's review of the EPA's EPIC Photos was to independently review each EPIC feature to determine when the feature was first identified. This enabled the Navy to collect background information regarding the potential cause of the feature. A site visit was then conducted and environmental personnel interviewed to try and determine what the anomaly actually might have been. The site visit for IR Site 5 was conducted on October 24, 2000.

The features identified by the USEPA as being of potential concern at IR Site 5 were divided into three categories; (1) those features that are actually within the site boundaries of IR Site 5, (2) those features that are to the south of IR Site 5 and fall within the boundaries of IR Site 6, and (3) those features that are within the boundary of the former Marine Corps Reserve Training Compound.

FEATURES WITHIN IR SITE 5

These features are limited to those on the northern half of the powerpoint slide for Site 5. By overlaying the locations of soil sampling that was conducted as part of the Navy's Phase I and II RI's, it has been determined that each of these anomalies has been subjected to soil sampling and for those areas where the sample result is above a soil cleanup standard, it will be dealt with accordingly. Please note that soil cleanup standards have not yet been established for this site.

26GS appears present in August 17, 1971 as areas of high reflectivity. They appear similar in nature to the sand traps at the golf course, and may represent sand piles. One alternate explanation is the three light colored objects could be aircraft fuselages that were staged in this area and used as part of the fire fighting training effort.

TR6A may exist in the May 5, 1964 photo, but appears to be a part of a longer linear feature, most likely a road. No other evidence of this feature was found during the site visit.

TR6 (there are two, this is the eastern one) is most visible in May 5, 1964. It appears to be a linear trench or drainage ditch filled with water. There are other similar features (water filled ditches) evident on the photo. The photo was likely taken during a wetter period. The feature is visible in the June 1978 photo but appears as an area of different color. The most likely explanation for this could be a lack of vegetation. It is not discernable in the August 1971 photo. According to Jim Edmond, NASJRB Willow Grove Environmental department, this feature was a drainage ditch that was necessary to divert surface runoff during the time that re-grading was underway to raise the runway. This ditch bends south and directed flow towards the fence at the Marine Training Area. A lighter colored feature can be seen in the 1977 photo that looks like an drainage utlet from this surface water runoff system.

The other TR6 feature (the west one) and 19DG are co-located. The area is evident as early as August 17, 1971 and may represent storage piles for sand or airplanes. The area appeared to be sparsely covered with trees in May 5, 1964. By 1977, the area is more cleared of vegetation. The ground areas of TR6 and 19DG, and 26GS and 38DG are evident. Part of 19DG is dark in color and parallel to the roadway in the false color July 13, 1984 photo. By 1992, the roadway seems out of service and is now accessed from the south.

GS40 appears to be the burn area located at IR Site 5. This area was sampled during the Navy's Phase I RI effort.

DB6 is visible in many of the photos. It is the primary staging area for the FFTA, and has been extensively investigated during the Navy's Phase I and II RI efforts.

ST2 could not positively be identified, however it's location is very close to the approximate location of a trailer that is shown in figure 4.5.1 of the SI. This anomaly was found in the May 5, 1964 photo and again in July 13, 1984 photo. This anomaly was not located during the October 2000 site visit.

FEATURES WITHIN IR SITE 6

The southern half of the area are less evident features, usually of shorter duration. This second area includes IRP Site 6 – Former Rifle Range #1. This entire area has been re-worked between 1992 and is the present location of a newly constructed Marine Corps Reserve Training Building with an associated paved parking area surrounding the building.

10OS may be a feature visible on the August 17, 1971 photo Frame 5. It seems to be casting a shadow to the Northeast. This could be a parked vehicle, whatever the feature is, it is on a paved area.

7DG is difficult to discern on the photos. It could be part of the larger 38DG in the June 1, 1978 photos, frame 2 in particular. That may be the only set of photos of scale large enough to identify a feature of this size.

1DG is not evident in the photos, but may represent regrading for the parking area described in TR6. This would have occurred between 1984 and 1992.

DG 29 is visible in the August 17, 1971 photos, frame 5 but does not appear to be of a significant environmental concern.

38DG is most evident in the 1942 photos and appears to be the location of the raised rifle range berm for the Former Rifle Range #1 (IR Site 6). In the 1958 photos, the area is being regraded. In the 1978 photos, these two areas just appear to be bare ground. By 1984, the eastern feature is paved or gravel. It was reported that this area was cleared of bullet fragments prior to re-grading in 1965. This location, along with those to the south such as 7DG, 1DG, and DG 29 were re-graded to construct a parking area for recreational vehicles, and later in the 1990's to construct Buildings 176, 177, and 178. Lead sampling was conducted during construction of these new buildings and the results indicated that concentration of lead were detected but were below established background levels for the installation (memo from Jim Colter dated 05 May 1994).

DB6 appears in the June 1, 1978 photos. It also appears to be a feature in August 17, 1971 photo.
It is observed that the 1978 photo set is of the largest scale, enabling identification of numerous small ground scars in the vicinity of site 5. This photo set also clearly identifies a large construction project that appears to be the expansion of the TARMAC. The pond at the NW edge of the Air force's aircraft parking area also appears to be undergoing maintenance of some sort. Due to this construction, a number of larger ground scars and evidence of dirt staging can be found throughout the facility. The June 1978 photos appear to be from a drier period, as many dry areas appear as scars also.

FEATURES WITHING FORMER MARINE CORPS RESERVE TRAINING CENTER

The third area is the former Marine Corps Reserve Training Compound, a fenced area where no disposal activities were reported to have taken place. In general, the features are discussed in a north to south direction.

ST6 appears in June 1, 1978 as three large objects stored south of the fire fighter area. This area was describes as containing a number of small storage buildings of different sizes and construction methods built over a period of time and nicknamed the Marine Shanty-town. The construction of Buildings 638 and 639 eliminated the need for the shanty-town and the structures were removed. No disposal is reported to have taken place within the Marine compound.

OS3/OS5, 10OS appear to be within the Marine reserve area within the fence, where no disposal has been reported.

CONCLUSION

It has been concluded that all of the anomalies identified at IR Site 5 during the EPA's EPIC Study have had some level of soil sampling associated with it. It is further concluded that the other anomalies that are not directly associated with IR Site 5 are features that are not associated with disposal activities and are, therefore, not of any environmental concern.

EVALUATION OF GROUNDWATER SAMPLE DATA QUALITY
NASJRB WILLOW GROVE
PHASE II REMEDIAL INVESTIGATION

Problem Definition

Based on spot review of some of the groundwater sampling data from the phase II remedial investigation (RI), EPA expressed concerns that the proper low-flow protocol may not have been followed for groundwater sample collection. EPA requested that the Navy investigate the method used for each groundwater sample taken. EPA requested that a comparison to historical analytical result values from the same monitoring well, and an evaluation of data usability evaluation be performed for any sample obtained outside of conformance with the low-flow protocol. The objective was to identify potential impacts on the site conceptual model (and the associated human health risk evaluation) at any study site.

Summary of Investigation

Evaluation of data quality for groundwater samples obtained and analyzed in the RI has been completed. Several samples were not obtained in strict conformance with the "low-flow" procedure in the approved work plan. Analytical results from each sample obtained outside of strict procedural conformance were evaluated using a procedure discussed and agreed to between the Navy and EPA. The data quality evaluation procedure was designed to identify the highest reasonable conservative analyte concentration that could be expected for that sample point. There were cases where the imputed ("new") concentration at a particular groundwater sampling point (either the highest historical value or two times the phase II RI result) exceeded the concentration used to evaluate human health or ecological risk. However, there was no substantial change to the site conceptual model in any case. No changes are being recommended for the RI risk evaluations or overall conclusions as a result of the data quality evaluation. However, recommendations for additional investigative/confirmatory activities at individual sites are presented below. A summary of the sample result review procedures and conclusions follow.

ATTACHMENT (8)

R sults

Site 1 – Privet Road Compound Area

VOCs – The highest historical value for PCE in monitoring well 01MW02S (110 ug/l in 1989) exceeds the 1997 RI result (ND) and the risk-based concentration (RBC [1.6 ug/l]). However, the 1991 RI result (non-detect [ND]) and the 1998 Air Force result (ND) agree well with the 1997 RI result.

Although in this case the site conceptual model would be changed by imputing the highest historical value, the 1997 RI result agrees well with other samples obtained in this decade, so no changes to the RI conclusions or human health risk assessment are recommended.

Metals – No metals analyses were performed on groundwater samples in the 1997 RI.

Site 2 – Antenna Field Landfill

VOCs - The highest historical value for TCE in monitoring well 02MW02S (3J ug/l in 1989) exceeds the 1997 RI result (ND) and the RBC (1.6 ug/l). However, four consecutive samples (including the 1997 RI result), obtained after the 3J value, are all ND.

Although in this case the site conceptual model would be changed by imputing the highest historical value, the 1997 RI result agrees well with three other samples obtained after the 1989 3J value, so no changes to the RI conclusions or human health risk assessment are recommended.

Metals – No metals results from the 1997 RI were significantly lower than available historical results. Metals were generally in the range of available historical results for each location.

Site 3 – Ninth Street Landfill

VOCs – The 1997 RI tetrachloroethene (PCE) analytical results obtained from 03MW03S (5J ug/l), 03MW03SI (18 ug/l), 03MW04S (21 ug/l), 03MW06S (29 ug/l), and 03MW06I (39 ug/l) all exceed the RBC (1.1 ug/l) and four of five exceed the MCL (5 ug/l). The corresponding historical high concentration found in existing monitoring wells 03MW03S (13 ug/l), 03MW03SI (37 ug/l), and 03MW04S (84 ug/l) is higher than the corresponding 1997 RI concentration and also exceeds reference criteria. Two times the concentration found in new monitoring wells would be

03MW06S (58 ug/l), and 03MW06I (74 ug/l), which also exceed the corresponding RBC and MCL.

If these imputed higher concentrations were used, the representative concentration used for calculating estimated human health risk would be higher. However, the site conceptual model (approximate extent of the plume) would not change, and the RI conclusions, to perform a feasibility study to investigate ways to mitigate potential health effects and to perform additional groundwater investigations in the vicinity of the Army Reserve Complex, would not change.

RECOMMENDATION: Some or all of these monitoring wells should be sampled again as ongoing surveillance of plume movement or as part of pre-remedial action activities during or after the feasibility study phase.

Metals – The highest historical value for arsenic in monitoring wells 03MW03S and 03MW04S (3J ug/l in 1989) exceeds the 1997 RI result (ND) and the RBC (0.45 ug/l) but is lower than the MCL (50 ug/l). The highest historical value for nickel in monitoring well 03MW03S (1140J ug/l in 1989) exceeds the 1997 RI result (ND) the tap water RBC (73 ug/l) and the MCL (100 ug/l).

Two times the concentration of chromium found in new monitoring well 03MW06I (90.9 ug/l [RBC 18 ug/l; MCL 100 ug/l]), iron (8170 ug/l [RBC 1100 ug/l]), manganese (457 ug/l [RBC 84 ug/l]) and nickel (84 ug/l [RBC 73 ug/l; MCL 100 ug/l]) would exceed the reference criteria noted.

If these imputed higher metals concentrations were used, the representative concentration used for calculating estimated human health risk from groundwater would become higher and the site conceptual model (extent of the plume) would change. However, the two additional "hits" of arsenic from the historical investigations would have limited impact on the calculation of the estimated human health risk because they are near the value of the representative concentration for arsenic used in the risk assessment (1.98 ug/l). Also, using the imputed 2 times the concentrations of chromium, iron, and manganese found in 03MW06I may be considered ov rly conservative because these metals were not encountered at levels of concern in historical sampling events, and the sample endpoint turbidity value (~400 NTU) encountered in this newly-installed monitoring well indicates the type of sampling difficulty that could result in metals results biased high (due to non-dissolved metals). The RI conclusions to perform a feasibility study to investigate ways to mitigate potential health effects and to perform additional groundwater investigations in the vicinity of the Army Reserve Complex would not change.

RECOMMENDATION: Monitoring well 03MW06I should be sampled using low-flow techniques and analyzed for metals during the next sampling activity in the vicinity of the Army Reserve Complex.

Site 5 – Fire Training Area

VOCs – The 1989 1,1,1-trichloroethane (1,1,1-TCA) analytical result obtained from 05MW01I (260 ug/l), exceeds the 1997 RI result (54 ug/l) as well as the lowest drinking water advisory reference criterion (200 ug/l) and the MCL (200 ug/l). However, three other historical samples from 05MW01I were all ND. In this case the highest historical concentration does not exceed the RBC (790 ug/l).

In the (new) monitoring well samples where no historical results are available, application of the imputed 2 times the 1997 RI concentrations would result in some "hits" being higher for the human health risk assessment estimation, but no new "hits" would result.

In this case, the site conceptual model would change by imputing the highest historical value for 1,1,1-TCA. However, the 1997 RI result agrees well with three other historical samples obtained from 05MW01I. The conceptual model change would only be the addition of another exceedence in 05MW01I, where a more significant exceedence of PCE has already been noted. Therefore, no changes to the RI conclusions, which recommend an FS to evaluate options for Site 5 groundwater, or to the human health risk assessment are recommended.

Metals – No change to the site conceptual model would result from applying the highest historical concentration or two times the 1997 RI value (in the case where no historical value is available).

From: Kevin C. Kilmartin
To: Russ Turner

Date: July 7, 1999

Re: NASJRB WILLOW GROVE: Analysis of Screened Intervals and Fracture Zones for Monitoring Wells Installed During the Phase II RI

TtNUS was tasked to determine whether any of the screened monitoring wells installed during the Phase II RI were completed in such a manner that the vertical position of the well pump could affect the analytical results when sampling the well under low-flow sampling procedures. In order for the vertical position of the pump to influence the sampling results, the groundwater for that well must be migrating or flowing from multiple, hydraulically isolated fractures that are spaced widely enough that the groundwater from one fracture could be preferentially sampled over the groundwater from the other fracture(s).

A top priority of the borehole retrofitting program was to construct the monitoring wells to obtain groundwater from only one groundwater zone and to not interconnect different groundwater zones. To reach this goal, all boreholes were geophysically logged (including borehole flowmeters), and the potential construction plans were reviewed and discussed with the USGS. The resultant individual well plans were then presented to EPA prior to the construction of the wells. I have reviewed the borehole geophysical logs and the well construction details to reconfirm that the monitoring wells were properly constructed as originally scoped and are obtaining groundwater from only one zone. Therefore, the exact vertical position of the pump within the well screen should not matter, because water can only enter the well through the screen, and all the water entering the screen is from the same zone. Some of my observations that led to this conclusion include:

- The vast majority of wells are screened across only one fracture. Therefore, the groundwater can only be entering the screen through that fracture.

- Some wells are screened across a fracture zone, or a series of smaller fractures rather than one distinct larger fracture. These fractures (typically two or three fractures within a five-foot interval) are very closely spaced vertically (generally on the order of one or two feet), and there was no lithologic indications of confining layers between these fractur s. Fractures that are spaced so closely vertically are almost certainly hydraulically interconnected; it would be very unusual for these fractures to be hydraulically isolated from each other. In fact, due to the presence of high-angle vertical fractures (from the television survey), some of these "fracture zones" may be the same fracture intercepted on opposite sides of the borehole walls.

- The flowmeter was carefully considered for each well construction. Screens were extended across multiple fractures only if there was no evidence of intraborehole fl w between the respective fractures. In fact, some screens were constructed specifically to monitor one fracture(s) but not the other(s) because of evidence of intraborehole flow.

ATTACHMENT (9)

July 2, 1999

NASJRB WILLOW GROVE
REPLY TO EPA TOXICOLOGICAL COMMENTS
DRAFT PHASE II REMEDIAL INVESTIGATION REPORT

GENERAL COMMENTS

1. The decision criteria employed for determination whether a compound is above background and PCOC and CPOC selection should be further explained. As written, the most useful information concerning the selection of a compound as a CPOC, PCOC or significance above background is shown on individual tables which summarize the results of statistical testing. The footnotes should be expanded upon in Section 2.3 of the report and a logic flowchart presented to identify the yes/no result of each test.

Reply: Concur. Selection criteria for chemicals of potential concern will be presented in more detail in Section 2.3. A logic flowchart and/or table will accompany the updated text to further clarify the selection process.

2. Section 3.1.1.4 indicates that representative concentrations were calculated based on both 1997 and 1991 RI data. Data from these two sampling events were pooled, but there is no indication whether sampling populations from each event were comparable. The text should be revised and an analysis presented to ensure that pooling of data for each contaminant was appropriate.

Reply: Concur. The text in Section 3.1 1.4 will be revised to better reflect what was done. Generally (for all media except groundwater) the data sets from 1991 and 1997 were combined because the Work Plan was formulated to obtain samples to further define extent of contamination (i.e., fill data gaps). At each site, the contamination of concern resulted from past practices ending 20 or more years ago, no new contamination has been deposited in the period of the investigation, and the sampling plan was predicated on filling data gaps in contiguous media within the area of concern.

In the case of groundwater, all existing monitoring wells were sampled and risk assessment was calculated based on the most recent (1997) data only. However, at Site 1, there was no metals data from the 1997 sampling round. Therefore, for Site 1, the two data sets were combined (inorganics and organics) to permit human health risk calculations to proceed. In the case of Site 1, the two groundwater data sets will be compared as suggested.

3. Tables are included in the document that present the results of a comparison of surface water analytical data to applicable or relevant and appropriate requirements (ARARs) and to be considered (TBC) values. There are no freshwater chronic ambient water quality criteria (AWQC) provided for aluminum, beryllium or iron (see, for example, Table 4-12). This is incorrect. The aluminum criterion is pH dependent and may be calculated based on site-

specific or proxy pH values. The iron criterion is 1,000 micrograms per liter (µg/L). The beryllium value is 5.3 µg/L (lowest observed effect level). All tables should be updated using applicable freshwater chronic AWQC.

Reply: Concur. All appropriate tables will be updated using chemical-specific freshwater chronic AWQC values.

4. References for citations in the human health risk assessment portions of the RI report are not provided. References for all citations located throughout the RI report should be provided.

Reply: Concur. References will be added or updated in the human health risk assessment portions of the report.

5. Section 3 presents a discussion of five potential receptors for the NASJRB Willow Grove sites. In addition, extensive risk calculations were prepared for each receptor for each site. However, the human health risk assessment conclusions for each site do not present the results for all five receptors and typically only discuss the results for one or two receptors (i.e., occupational workers and recreational child). It is unclear why the results for each receptor at each site are not discussed in the conclusions, especially when several receptors at each site usually meet EPA's acceptable risk criteria. The results of risk calculations performed for all receptors and all media at each site should be discussed in the conclusion sections for each site so that human health risks for all scenarios are clearly defined. If the results for all five receptor scenarios are not discussed because the scenarios are not applicable for each site (e.g., building residential homes on Site 2, Antenna Road Landfill, or Site 3, Ninth Street Landfill), then these receptors and scenarios should have been screened out in the exposure assessment (Section 3.1.3).

Reply: Concur. The conclusions for each of the site-specific human health risk assessments will be updated to include text concerning all of the carcinogenic and noncarcinogenic risks for all potential receptors that are exposed to media at that site.

6. The evaluation of the sites includes data collected from various media in 1991 during the Phase I Remedial Investigation in addition to the Phase II data. The use of different temporal data sets should be discussed and the figures should be revised to clearly distinguish between samples collected during the two events.

Reply: Data appearing on maps could pertain to the 1991 or 1997 remedial investigations. In the case of groundwater sample results reported on figures, the year the groundwater sample was obtained is noted with the result. For other media, such as sediments and soils, the text and tables provide the requested information.

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7. In order to avoid potentially unnecessary institutional controls to limit excavation, subsurface soil risk evaluations to potential receptors, including future residents should be performed. Similarly, residential rather than industrial RBCs should be used to screen for COPCs. Otherwise, an institutional control may be necessary to ensure that the property remains industrial/commercial and is not used for residential development at any time in the future.

Reply: Future land use at the base is known. The land use will remain as industrial/light industrial and NASJRB Willow will remain as an active military base. Residential and recreational land uses presented in each site-specific human health risk assessment are hypothetical in nature. No change is required to the risk assessment RBCs. Appropriate caveats will be inserted in the text to indicate that if the land use designation were to change in the future, the human health risk assessment selection criteria may need to be revised. — Residential RBCs must be used unless restrictions are already inplace (EPA, 2/7/01)

SPECIFIC COMMENTS

1. **Executive Summary, Site 1 - The Privet Road Compound, Page ES-1, Paragraph 2.** This paragraph states that "Consistent with United States Environmental Protection Agency (EPA) guidelines, the 'reasonable anticipated future land use' exposure scenario is Occupational Worker." It is unclear what these guidelines are and how this land use was determined. The human health risk assessment analyses for Site 1, as detailed in Tables 4-24, 4-25, 4-26, and 4-27, indicate that the following scenarios have acceptable carcinogenic and noncarcinogenic risks associated with them: adult/child trespasser, recreational child, and excavation worker. Risks to the occupational worker just slightly exceed EPA's acceptable carcinogenic risk criteria. Cancer and noncancer risks to residents exceed EPA's risk criteria. The paragraph should be revised to accurately reflect the results of all human health and ecological risk assessment analyses. This comment also applies to Section 4.9.

Reply: The subject EPA guidelines referred to, OSWER Directive No. 93555.7-4 (Land Use in the CERCLA Remedy Selection Process), and OSWER 9355.0-69 (Rules of Thumb for Superfund Remedy Selection) will be referenced in the text.

The current and future land use of this property is controlled by the United States Navy. The anticipated land use is described in the Master Plan for NASJRB Willow Grove. The anticipated future land use could change from the current military-type use if there were an Air Station property transfer. There are generally only two methods of transferring this type of Navy property, through BRAC (which would take an act of Congress) or through the GSA, (in the event that parcels were to be declared excess). Under BRAC, action would be taken in accordance with the legislation. Excess property transfers handled by GSA could be conveyed with deed restrictions as determined at the time of property transfer. In

any event, CERCLA 120(h) requirements would apply.

The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

This paragraph states that "human health risk assessment ... found that the site does not pose a threat to current or reasonably anticipated future human ... receptors." However, the human health risk assessment analyses indicated that the EPA's acceptable carcinogenic and noncarcinogenic risk criteria are exceeded for adult/child residents. In addition, the occupational worker just slightly exceeds EPA's acceptable carcinogenic risk value. This paragraph should be revised to clearly state the conclusions from the human health risk assessment. This comment also applies to Section 4.9.

Reply: The text will be corrected to reflect that the occupational worker scenario just slightly exceeds EPA's acceptable carcinogenic risk value.

2. **Executive Summary, Site 2 - The Antenna Field Landfill, Page ES-2, Paragraph 6.** This paragraph states that "Consistent with EPA guidelines, the 'reasonable anticipated future land use' exposure scenario is Occupational Worker." It is unclear what these guidelines are and how this land use was determined. The human health risk assessment analyses for Site 2, as presented in Tables 5-25, 5-26, 5-27, and 5-28, indicate that the following scenarios have acceptable carcinogenic and noncarcinogenic risks associated with them: occupational worker, adult/child trespasser, recreational child, and excavation worker. Cancer and noncancer risks to residents exceed EPA's risk criteria. The paragraph should be revised to accurately reflect the results of all human health and ecological risk assessment analyses. This comment also applies to Section 5.9.

Reply: The subject EPA guidelines referred to, OSWER Directive No. 93555.7-4 (Land Use in the CERCLA Remedy Selection Process), and OSWER 9355.0-69 (Rules of Thumb for Superfund Remedy Selection) will be referenced in the text.

The current and future land use of this property is controlled by the United States Navy. The anticipated land use is described in the Master Plan for NASJRB Willow Grove. The anticipated future land use could change from the current military-type use if there were an Air Station property transfer. There are generally only two methods of transferring this type of Navy property, through BRAC (which would take an act of Congress) or through the GSA, (in the event that parcels were to be declared excess). Under BRAC, action would be taken in accordance with the legislation. Excess property transfers handled by GSA could be conveyed with deed restrictions as determined at the time of property transfer. In any event, CERCLA 120(h) requirements would apply.

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The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

3. **Executive Summary, Site 2 - The Antenna Field Landfill, Page ES-3, Paragraph 1.** This paragraph states that "human health risk assessment found that the site does not pose a threat to current or reasonably anticipated future human receptors." However, the human health risk assessment analyses indicate that EPA's acceptable carcinogenic and noncarcinogenic risk criteria are exceeded for adult/child residents. This paragraph should be revised to clearly state the conclusions from the human health risk assessment. This comment also applies to Section 5.9.

Reply: This paragraph appears correct as it is written.

4. **Executive Summary, Site 3 - Ninth Street Landfill, Page ES-3, Paragraph 2.** This paragraph states that "Consistent with EPA guidelines, the 'reasonable anticipated future land use' exposure scenario is Occupational Worker and Recreational Child." It is unclear what these guidelines are and how these land uses were determined. The human health risk assessment analyses for Site 3, as detailed in Tables 6-23, 6-24, 6-25, and 6-26, indicate that the following scenarios have acceptable carcinogenic and noncarcinogenic risks associated with them: occupational worker, adult/child trespasser, recreational child, and excavation worker. However, the human health risk assessment analysis indicates that EPA's acceptable noncancer criteria is exceeded for adult/child residents. The paragraph should be revised to accurately reflect the results of all human health and ecological risk assessment analyses. This comment also applies to Section 6.9.

Reply: The subject EPA guidelines referred to, OSWER Directive No. 93555.7-4 (Land Use in the CERCLA Remedy Selection Process), and OSWER 9355.0-69 (Rules of Thumb for Superfund Remedy Selection) will be referenced in the text.

The current and future land use of this property is controlled by the United States Navy. The anticipated land use is described in the Master Plan for NASJRB Willow Grove. The anticipated future land use could change from the current military-type use if there were an Air Station property transfer. There are generally only two methods of transferring this type of Navy property, through BRAC (which would take an act of Congress) or through the GSA, (in the event that parcels were to be declared excess). Under BRAC, action would be taken in accordance with the legislation. Excess property transfers handled by GSA could be conveyed with deed restrictions as determined at the time of property transfer. In any event, CERCLA 120(h) requirements would apply.

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The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

5. **Executive Summary, Site 3 - Ninth Street Landfill, Page ES-3, Paragraph 2.** This paragraph states that the "human health risk assessment found that the site does not pose a threat to current or reasonably anticipated future human receptors." However, the human health risk assessment analyses indicated that EPA's acceptable noncarcinogenic risk criteria is exceeded for adult/child residents. This paragraph should be revised to clearly state the conclusions from the human health risk assessment. This comment also applies to Section 6.9.

Reply: This Paragraph appears correct as written. In an attempt to keep this summary concise, only pertinent information is presented. Other information is readily available elsewhere in the RI/FS documents.

6. **Executive Summary, Site 5 - The Fire Training Area, Page ES-4, Paragraph 7.** This paragraph states that "Consistent with United States Environmental Protection Agency (EPA) guidelines, the 'reasonable anticipated future land use' exposure scenario is Occupational Worker". It is unclear what these guidelines are and how this land use was determined. The human health risk assessment analyses for Site 3, as detailed in Tables 7-23, 7-24, 7-25, and 7-26, indicate that the following scenarios have acceptable carcinogenic and noncarcinogenic risks associated with them: occupational worker, adult/child trespasser, and recreational child. However, the human health risk assessment analysis indicates that EPA's acceptable cancer and noncancer risk criteria are exc eded for adult/child residents. In addition, the EPA's noncancer criteria are exceeded for a future excavation worker. The paragraph should be revised to accurately reflect the results of all human health and ecological risk assessment analyses. This comment also applies to Section 7.9.

Reply: The subject EPA guidelines referred to, OSWER Directive No. 93555.7-4 (Land Use in the CERCLA Remedy Selection Process), and OSWER 9355.0-69 (Rules of Thumb for Superfund Remedy Selection) will be referenced in the text.

The current and future land use of this property is controlled by the United States Navy. The anticipated land use plan is described in the Master Plan for NASJRB Willow Grove. The anticipated future land use could change from the current military-type use if there were an Air Station property transfer. There are generally only two methods of transferring this type of Navy property, through BRAC (which would take an act of Congress) or through the GSA, (in the event that parcels were to be declared excess). Under BRAC, action would be taken in accordance with the legislation. Excess property transfers handled by GSA could be conveyed with deed restrictions as determined at the

time of property transfer. In any event, CERCLA 120(h) requirements would apply.

The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

7. **Executive Summary, Site 5 - The Fire Training Area, Page ES-5, Paragraph 1.**
This paragraph states that "human health risk assessment found that the site does not pose a threat to current or reasonably anticipated future human. receptors." However, the human health risk assessment analyses indicated that EPA's acceptable carcinogenic and noncarcinogenic risk criteria are exceeded for adult/child residents. This paragraph should be revised to clearly state the conclusions from the human health risk assessment. This comment also applies to Section 7.9.

Reply: This paragraph appears to be correct as written.

8. **Executive Summary, Human Health Risk Assessment, Site 1 - The Privet Road Compound, Page ES-19, Paragraph 5.**
This paragraph states that "the total cumulative carcinogenic risk for the current occupational worker is equal to EPA's target carcinogenic risk range at Site 1 for the RME scenario." However, Table 4-24 indicates that the calculated total risk is 1.20E-4 which marginally exceeds the EPA target carcinogenic risk range of 1.0E-4 to 1.0E-6. Consideration of site-specific conditions, as well as risk management factors, should dictate the need for action (or not) in this instance. In addition, the results for human health risk assessment analyses for all receptors should be included in this paragraph.

Reply: The text will be corrected to reflect that the occupational worker scenario just slightly exceeds EPA's acceptable carcinogenic risk value.

9. **Executive Summary, Human Health Risk Assessment, Site 2 - The Antenna Field Landfill, Page ES-21, Paragraph 5.**
This paragraph states that "noncarcinogenic HIs for the potential receptors at Site 2 are less than 1.0". However, Tables 5-27 and 5-28 indicate that the total cumulative RME and CTE noncarcinogenic risk for adult/child residents exceed the EPA's noncarcinogenic HI value. The text should be revised so that it is consistent with the summary data tables. In addition, the results for human health risk assessment analyses for all receptors should be included in this paragraph.

Reply: This section appears to be correct as written. The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the

summary sections.

10. Executive Summary, Human Health Risk Assessment, Site 3 - Ninth Street Landfill, Page ES-24, Paragraph 5.

This paragraph states that "the total cumulative carcinogenic risk for the future residential receptor is 9E-05 under the RME" risk scenario. However, Table 6-23 indicates that the total cumulative carcinogenic risk for the future residential receptor is 4.54E-05 under the RME risk scenario. This paragraph also states that "the RME risk for groundwater consumption ... for a future residential receptor is 7E-05". However, Table 6-23 indicates that the carcinogenic risk for groundwater consumption for a future residential receptor is 1.51E-05. The text should be revised to correct these inconsistencies. In addition, the results for human health risk assessment analyses for all receptors should be included in this paragraph.

Reply: Concur. The text will be revised for numeric inconsistencies.

The objective of the Executive Summary and the Evaluation Summary sections is to summarize the pertinent information for a reviewer who may not be interested in studying the entire voluminous RI document. Therefore some information, available elsewhere in the RI/FS record, is not repeated in the summary sections.

This paragraph states that iron and barium in groundwater are main contributors to the RME and CTE noncarcinogenic risk at Site 3 for a future residential child and adult receptor. However, the results shown in Appendix J, Tables J-35 and J-36, appear to indicate that chromium and manganese are stronger contributors to risk in groundwater. In addition, this section also states that iron and dieldrin in surface soil are the main contributors to noncarcinogenic risk at Site 3. However, the individual contaminant results shown in Appendix J, Table J-5 and J-6 indicate that for a future residential child, the main contributor is iron followed by aluminum, manganese, and dieldrin. For a future residential adult, the main contributor is iron, followed by aluminum, dieldrin, and manganese. The text should be revised so that it is consistent with the data tables or an explanation as to how dieldrin was chosen as a main contributor should be included.

Reply: Concur. The text will be revised for risk driver inconsistencies.

11. Section 2.0, Field Investigation, Page 2-1.

Field activities and collection of samples which were conducted during the Phase I Remedial Investigation, 1991, should be discussed in this section.

Reply: The Phase I RI Report contains a complete discussion of these activities. Where appropriate, Phase I RI samples are discussed in the site-specific Nature and Extent of Contamination sections for each of the four IR sites in the Phase II RI.

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12. **Section 2.3, Establishment of Background Concentrations, Page 2-31.**
The limitations of using surface soil as a surrogate for subsurface background conditions should be discussed.

Reply: Concur. The limitations of using background surface soil as a surrogate data set for background subsurface soil will be discussed in the human health risk assessment uncertainty section.

13. **Section 2.3, Establishment of Background Concentrations, Page 2-31, Paragraph 2.**
This paragraph states that background sample analytical statistics for groundwater were not attempted. However, background sample analytical statistics for groundwater are presented for each site. The text and tables should be revised to correct this inconsistency. Also, note that in the specific comments for each site, as discussed below, that the groundwater background sample analytical statistic tables appear to be incorrect.

Reply: Concur. Text and tables concerning background analytical statistics related to groundwater data sets will be removed from each site-specific human health risk assessment.

14. **Table 2-13**
Many of the calculated means are the same as 95th percent UTLs. Please explain. Also, when the 95th percent UTL for background exceeds the maximum detection for a given compound, was the maximum detect used as the default comparison value?

Reply: Disagree. In Table 2-13, 95% UTLs were not calculated. Only the background means were listed. The text "95 % Upper Tolerance Limit (UTL)" is present as a divider section with only the very last column of the table actually showing the UTL value.

15. **Section 3.1.1.3, Page 3-4**
Contrary to the text on this page, it seems that background concentrations were considered for the screening of organics.

Reply: Disagree. Background concentrations were not considered for the screening of organic compounds. Information regarding background concentrations and organics were presented in the report for informational purposes only. Text and tables will be revised as appropriate to clarify that background comparison analysis was not used to eliminate organic chemicals as COPCs.

16. **Section 3.1.1.3, Identification of Chemicals of Potential Concern (COPC), Page 3-6, Paragraph 5.**
This paragraph explains the exceptions to the COPC selection for each medium described on Pages 3-4 to 3-6. However, due to the formatting of the text, it appears that these exceptions are only relevant to groundwater COPC selection. These exceptions should be

moved to the beginning of Section 3.1.1.3, so that it is clear that they are relevant to COPC selection for all media.

Reply: Concur. The text will be revised as appropriate to clearly explain COPC selection.

In addition, the tables in Section 4, 5, 6, and 7 which illustrate the COPC selection for each site appear to indicate that chemicals that do not have an RBC will not be selected as a COPC. However, this approach is not discussed in the text. All criteria that were used to include or exclude a chemical as a COPC should be discussed in the text. Chemicals lacking RBCs should be retained as COPCs or evaluated using structurally similar surrogates.

Reply: Chemicals without a quantitative RBC will be retained as COPCs and will only be discussed qualitatively in the uncertainty section of the human health risk assessment [surrogates will not be assigned to COPCs without quantitative toxicity values because of the high uncertainty associated with this procedure]. Text and tables will be revised as appropriate.

Also, on pages 3-5 and 3-6, screening benchmarks for sediment and surface water are based on professional judgement. This should be clearly stated in the text.

Reply: Concur. Selection of sediment and surface water exposure scenarios will be clarified in text.

17. **Table 3-1, Page 3-12.**
A number of discrepancies were found in a comparison between values presented in Table 3-1 and IRIS (on-line), HEAST (1997), Region III RBCs (April 1998), and Region III Oral ABS Values for Oral-to-Dermal Extrapolation (December 1996). Since no dates were provided in this Table 3-1 and no references were provided with the human health risk assessment, it was not possible to identify the source of the discrepancies. The following values obtained from the references listed above are different from those in Table 3-1.

A. Fraction of COPC Absorbed in the Gastrointestinal Tract N/A for carcinogenic PAHs.
0.89 for RfD; CSF see IRIS for PCBs.
0.02 for Vanadium.
0.025 for Zinc.

B. Oral RfD
2.0E-02 for 1,1,1-trichloroethane.
3E-02 for 1,2-dichloroethane.
3E-03 for benzene.

2E-03 for beryllium.

C. Dermal RfD and SFs
See following comment on Section 3.1.2.4., Page 3-14

D. Inhalation RfD
1.4E-03 for 1,2-dichloroethane
1.4E-01 for tetrachloroethene
5.7E-06 for beryllium

E. Inhalation SFs
1.4E-02 for Bis(2-ethylhexyl)phthalate
2.0E+00 for PCBs

Reply: The values for Oral RfD (Comment B), Inhalation RfD (Comment D), and Inhalation SF (Comment E) were all taken from Region 3 RBC Tables dated 3-14-97, which was the latest update at the time the risks were estimated. For Fraction of COPC Absorbed in GI Tract (Comment A), Table 3-1 lists the values as provided from ATSDR, which at the time the risks were estimated were considered to be representative of fraction of COPC absorbed in the GI Tract.

18. Section 3.1.2 Toxicity Assessment, Adjustment of Dose-Response Parameters, Paragraph 5, Page 3-14 and Table 3-1, Page 3-12.
The equations for deriving dermal RfDs and SFs from oral RfDs and SFs are correct in the text. However, the dermal RfDs and SFs are calculated incorrectly as shown in Table 3-1. It appears that in the table, the oral RfDs were incorrectly divided by the $ABSEFF_{oral}$ to derive the dermal RfDs, and the oral SFs were incorrectly multiplied by the $ABSEFF_{oral}$ to derive the dermal SFs. However, a spot check of the calculations in Appendix J indicates that the correct dermal RfDs and SFs were used.

Reply: Concur. Table 3-1 will be revised as appropriate for numeric inconsistencies.

19. Table 3-3, Page 3-17.
The absorption factors presented in Table 3-3 represent chemical-specific values to adjust site doses, not toxicity values. These factors apply only to soil and sediment and represent the "ABS" parameter for dermal pathway (e.g., in Table 3-12).

Reply: Concur. Table 3-3 will be revised as appropriate for numeric inconsistencies.

20. Section 3.1.3.2, Potential Receptors, Page 3-20, Paragraph 4.
This paragraph indicates that cancer and noncancer risks will be estimated separately for adolescent and adult trespassers. However, the summary tables for each individual site present the cancer risk results for adult/child trespassers combined. The text and tables

should be revised to correct this inconsistency. Adult and adolescent trespassers should be evaluated separately.

Reply: Concur. Adolescent and adult trespassers will be evaluated separately for non-carcinogenic effects and carcinogenic effects. Text and tables will be revised as appropriate

21. **Section 3.1.3.5.1, Exposure Estimates, Page 3-23, Paragraph 2.**
The text states that the "CTE is only to be run at a particular site when the total cancer risk exceeds 1E-04 (considered the upper bound of EPA's acceptable risk range) or when the noncarcinogenic HI is greater than 1.0." This approach evaluates the results of the RME scenario first, then determines which site, medium, and receptors require CTE calculations. However in the RI report, the CTE was run for all sites, receptors, and media, although in many cases the RME risks and HI were below EPA acceptable risk criteria. The text should be revised to correspond to the procedures followed in the BRA.

Reply: Concur. The text will be revised to state that "all RME and CTE risks were presented in this risk assessment, however, CTE should only be considered when RME cancer risks exceed 1E-04 or when RME noncarcinogenic HI's exceed 1.0.

22. **Section 3.1.3.5.1, Surface and Subsurface Soil Exposure, Page 3-23, Paragraph 4.**
This section cites EPA, 1989a as the source of the soil ingestion, dermal contact, and inhalation of fugitive dust equations. Since references are not provided, it has been assumed, based on other information presented in the RI report with the same citation, that the source is Risk Assessment Guidance on Superfund (RAGS). However, RAGS does not present the same equations as shown here. For example, the dermal contact equations in the RI report include a factor for EV (event frequency), which is not included in the equations found in RAGS. The correct references for each equation should be provided and if modifications to the referenced, standard equations are made, the modifications should be described. This comment also applies to the surface water, sediment, and groundwater exposure equations.

Reply: Concur. The correct references will be cited as appropriate for the equations and any modifications to the standardized equations will be noted and described.

23. **Table 3-10, Page 3-32**
According to this table, the RME exposure frequency for a recreational child is seven days per year. This is not very conservative. Please justify.

Reply: The 7 day/year exposure frequency value is taken from RAGs Part A, as the national average for swimming days per year. Swimming is not evaluated in this BRA, however, 7 days/year was thought to be representative of a typical recreational activities event and as such was applied to the recreational child.

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24. **Table 3-14, Page 3-36**
According to this table, the RME exposure frequency for an excavation worker is 30 days per year. The default value for this receptor is generally 250 days per year. Either the exposure frequency for this receptor should be replaced by a more realistic estimate, or strong justification should be provided.

Reply: Excavation workers are generally not going to be subjected to the same exposure frequency as the standard industrial worker (i.e. 250 day/year exposure). Excavation activities were assumed to last for approximately 1 month per year. Major excavation activities at Willow Grove (i.e., those lasting more than 1 month) are not anticipated.

25. **Section 3.1.3.6, Page 3-61, Paragraph 2**
According to this paragraph, an exposure frequency of 219 days per year was assumed in the adult lead model. Why wasn't the default of 250 days per year used?

Reply: Average exposure values should be input into the adult lead model. An exposure frequency of 219 days per year represents and average value for an industrial worker.

26. **Section 4-5, Nature and Extent of Contamination, Page 4-10.**
Revise the text to correctly refer to Figures 4-21A through C.

Reply: Concur. Text will be corrected.

27. **Table 4-5, Page T-4-4.**
A footnote should be included for the qualifier B. This comment pertains to similar tables in the report.

Reply: Concur. The qualifier B and its meaning (compound also found in blank sample) will be added to each table as appropriate.

28. **Section 4.6.1, Transport and Transformation of Detected Contaminants, Page 4-20.**
Revise text from "reference center" to "reference criteria".

Reply: Concur. Text will be corrected.

29. **Section 4.6.2, Conclusions, Page 4-22.** A discussion should be presented on the compound arsenic in this section. Arsenic was identified as COPC in soils, subsurface soils, sediments, and groundwater. It's presence in these media and elevated concentrations indicate that it is site related and future migration could occur.

Reply: Conclusions based on the discussion of arsenic in Section 4.6.1 will be added.

30. **Section 4.7.6, Conclusions, Page 4-31, Paragraph 4**
The section states that other than a future residential child receptor, the noncarcinogenic HIs for the other potential receptors at Site 1 are less than 1.0. However, Tables 4-26 and 4-27 indicate that the RME and CTE noncarcinogenic HIs for a future adult receptor are 1.95 and 1.38 respectively, which exceed the EPA's target HI. The text should be revised to reflect the results presented in Tables 4-26 and 4-27.

Reply: Concur. The risks presented in the text and risks presented in tables will be checked for accuracy and consistency. Appropriate text and/or table changes will be made.

31. **Table 4-17, Page T-4-87.**
This table presents background comparison test results for groundwater data for Site 1. The footnotes indicate that the overall decision for each groundwater pollutant is NA, if all individual background tests are NA. While the table indicates that all individual background tests are NA for each groundwater pollutant, the overall conclusion for each pollutant is not NA but evaluated as yes or no. This table should be revised so that either the correct overall conclusion for each pollutant is shown or the correct result for each individual background test is shown.

Reply: Concur. Table 4-17 will be changed as appropriate.

32. **Tables 4-19 to 4-23, page T-4-105 to T-4-114.**
These tables present the COPC selection for each contaminant in each medium at Site 1. However, the footnotes which explain the criteria for COPC selection are not complete. Since the criteria for COPC selection are already described in Section 3, the footnotes should be deleted and a reference to Section 3 should be added. In addition, a final column should be added to the table which describes the reason the contaminant was included as a COPC (i.e., exceeded RBC and background, exceeded RBC, chemical is break-down product of a COPC, etc.) so that it is clear why the chemical was selected as a COPC.

Reply: Concur. The footnotes regarding selection criteria will be taken off Tables 4-19 through 4-23 and a reference to Section 3 selection criteria text will be added. A column will be added to each table stating the reason for inclusion or exclusion of each chemical.

Tables 4-19 to 4-22 include the background results. However, Table 4-23 does not include background results. The format of Tables 4-19 to 4-23 should be consistent and background results should be added to Table 4-23.

Reply: Concur. Tables 4-19 through 4-22 will be checked for consistency and changes will be made as appropriate.

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33. **Table 4-23, page T-4-112.**
This table presents the selection of sediment COPCs for Site 1. However, Table 4-21 on page T-4-109 presents the same information. In addition, there is a second Table 4-23 on page T-4-113 that presents groundwater COPCs for Site 1. Table 4-23 on page T-4-112 should be removed from the report.

Reply: Tables 4-23 and 4-21 will be checked for content and accuracy and changes to the tables and or text that presents them will be made as appropriate.

34. **Table 4-23, page T-4-113.**
This table presents the selection of COPCs in groundwater at Site 1. However, some the data listed for the organic contaminants appear to be incorrect. The representative concentration listed for 1,2-dichloroethene (total) is 5. However, Table 4-16 lists the representative concentration as 4.35. The representative concentration listed for tetrachloroethene is 7.49. However, Table 4-16 lists the representative concentration as 9.2. The representative concentration listed for trichloroethene is 11. However, Table 4-16 lists the representative concentration as 12. In addition, Table 4-16 includes 1,1,1-trichloroethane, 1,1-dichloroethane, carbon tetrachloroethene, and toluene. However, these pollutants are not included in Table 4-23. The tables should be revised so that they are consistent.

Reply: Concur. The numbers will be checked concerning risks shown in Tables 4-16 and 4-23 and the numbers referred to in the text. Changes will be made as appropriate.

35. **Section 5.6.2 Conclusions, Page 5-12.**
A discussion should be presented on the potential for arsenic and dieldrin to migrate from the site. Arsenic and dieldrin were selected as a COPC in soils, subsurface soils, surface water, sediment, and groundwater and detected in seep samples. Erosion of soils was identified as a significant process at the site.

Reply: These issues will be further discussed, as requested.

36. **Section 5.7.6, Conclusions, Page 5-22, Paragraph 1.**
The section states that other than a future residential child receptor, the noncarcinogenic HIs for the other potential receptors at Site 2 are less than 1.0 However, Tables 5-27 and 5-28 indicate that the RME and CTE noncarcinogenic HIs for a future residential adult receptor are 1.56 and 1.27, which exceed the EPA's target HI. The text should be revised to reflect the results presented in Table 5-27 and 5-28. In addition an HI of 1.56 would round to a value of 2. This discrepancy should be corrected.

Reply: Text will be modified to discuss values found in the tables.

Risks will be presented in the text that are consistent in terms of significant digits.

37. Table 5-18, Page T-5-66.
This table presents background comparison test results for groundwater data for Site 2. The footnotes indicate that the overall decision for each groundwater pollutant is NA if all individual background tests are NA. While the table indicates that all individual background tests are NA for each groundwater pollutant, the overall conclusion for each pollutant is not NA but evaluated as yes or no. This table should be revised so that either the correct overall conclusion for each pollutant is shown or the correct result for each individual background test is shown.

Reply: Concur. Table 5-18 will be changed as appropriate.

38. Tables 5-20 to 5-24, page T-5-72 to T-5-83.
These tables present the COPC selection for each contaminant in each medium at Site 2. A final column should be added to the table which describes the reason the contaminant was included as a COPC (i.e., exceeded RBC and background, exceeded RBC, chemical is break-down product of a COPC, etc.), so that it is clear why the chemical was selected as a COPC.

Reply: Concur. A column will be added to each table stating the reason for inclusion or exclusion of each chemical.

Tables 5-20 to 5-23 include the background results. However, Table 5-24 does not include background results. The format of Tables 5-20 to 5-24 should be consistent and Table 5-24 should include background results.

Reply: Tables 5-20 through 5-23 will be checked for consistency and changes will be made as appropriate.

39. Table 5-25, page T-5-84.
The sum of the inhalation RME cancer risks for each medium for a future resident is incorrectly stated at 3.10E-07. The correct value is 4.85E-07. The table should be revised so that the correct sum is shown.

Reply: Concur. Table 5-25 will be changed as appropriate.

40. Section 5.5.1.2, Page 5-5.
The document states that TCDD-TEQs exceeded reference criteria in the two surface soil samples that were analyzed for dioxins. However, Table 5-5, which presents a comparison of detected compounds to ARARs and TBCs, does not present the results of the dioxin analyses. Further, it appears that the nature and extent of dioxin contamination may remain undefined. It is not clear that dioxin in surface water, seeps or sediments would have been identified in this evaluation. Therefore, the uncertainty associated with

potential dioxin contamination should, at a minimum, be evaluated as part of the site-specific uncertainty analysis.

Reply: Concur. The dioxin analysis and explanation will be updated in the human health risk assessment.

41. **Section 6.5, Nature and Extent of Contamination.**
Revise the text to correctly reference Figure 6-11 A through E.

Reply: Concur. These figures should be called Figures 6-12 A through E.

42. **Section 6.5, Nature and Extent of Contamination.**
According to the text, detections in surface and sediment at this site were determined to be statistically unrelated to the site. The methodology and tests employed to reach this conclusion should be discussed.

Reply: Concur. This issue will be further clarified.

43. **Table 6-16, Page T-6-68.**
This table presents background comparison test results for groundwater data for Site 3. The footnotes indicate that the overall decision for each groundwater pollutant is NA, if all individual background tests are NA. While the table indicates that individual background tests are NA for each groundwater pollutant, the overall conclusion for each pollutant is not NA. This table should be revised so that either the correct overall conclusion for each pollutant is shown or the correct result for each individual background test is shown.

Reply: Concur. Table 6-16 will be changed as appropriate.

44. **Tables 6-18 to 6-22, page T-6-81 to T-6-92.**
These tables present the COPC selection for each contaminant in each medium at Site 3. A final column should be added to the table which describes the reason the contaminant was included as a COPC (i.e., exceeded RBC and background, exceeded RBC, chemical is break-down product of a COPC, etc.), so that it is clear why the chemical was selected as a COPC.

Reply: Concur. A column will be added to each table stating the reason for inclusion or exclusion of each chemical.

Tables 6-18 to 6-21 include the background results. However, Table 6-22 does not include background results. The format of Tables 6-18 to 6-22 should be consistent and background results should be added to Table 6-22.

Reply: Tables 6-18 through 6-21 will be checked for consistency and changes will be made as appropriate.

45. Section 6.7.6, Conclusions, Page 6-24, Paragraph 4.

This section indicates that the total cumulative RME carcinogenic risk for a future residential receptor is 9E-05 and the RME carcinogenic risk for groundwater consumption for a future residential receptor is 7E-05. However, Table 6-23 indicates the results are 4.54E-05 and 2.35E-05, respectively. The text and table should be revised so that they are consistent.

Concur. The text and tables will be checked for accuracy and consistency and revised as appropriate.

This section states that iron and barium in groundwater are main contributors to the RME and CTE noncarcinogenic risk at Site 3 for a future residential child and adult receptor. However, the results shown in Appendix J, Tables J-35 and J-36, appear to indicate that chromium and manganese are stronger contributors in groundwater. In addition, this section also states that iron and dieldrin in surface soil are the main contributors to noncarcinogenic risk at Site 3. However, the individual contaminant results shown in Appendix J, Tables J-5 and J-6 indicate that for a future residential child, the main contributor is iron followed by aluminum, manganese, and dieldrin and for a future residential adult, the main contributor is iron, followed by aluminum, dieldrin, and manganese. The text should be revised so that it is consistent with the data tables or an explanation as to how dieldrin was chosen as a main contributor should be included.

Reply: The text will be revised to be consistent with the data tables.

46. Section 7.5, Nature and Extent of Contamination, Page 7-4.

Revise the text to correctly reference Figure 7-9 A through D.

Reply: Concur. Text will be corrected

47. Section 7.6.2, Conclusions

Examination of figures 7-9A and 7-9B shows soils contaminated with SVOCs and groundwater contaminated primarily with VOCs. The conclusion that "residual soil contamination is a continuing source of VOCs to groundwater" appears unfounded. The text should be revised.

Reply: Concur. This conclusion will be restated to reflect the dearth of VOCs found in soils.

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48. **Section 7.7.1, Data Evaluation, Surface Soils, Page 7-11, Paragraph 3.**
This section lists the organic and inorganic COPCs as presented in Table 7-18. However, dibenzofuran is listed as a COPC in Table 7-18, but is not included on the list. The text should be revised so that it is consistent with the results in Table 7-18.

Reply: Concur. The text will be revised to be consistent with the data tables.

49. **Section 7.7.6, Conclusions, Page 7-21, Paragraph 1.**
The section states that other than a future residential child receptor, the noncarcinogenic HIs for the other potential receptors at Site 5 are less than 1.0. However, Table 7-25 indicates that the RME noncarcinogenic HI for a future adult receptor is 2.24 and Table 7-26 indicates that the CTE noncarcinogenic HI for a future adult receptor is 1.76 and for a future excavation worker is 62.1. The text should be revised to reflect the results presented in Tables 7-25 and 7-26.

Reply: Text will be modified to discuss values found in the tables.

50. **Table 7-16, Page T-7-62.**
This table presents background comparison test results for groundwater data for Site 5. The footnotes indicate that the overall decision for each groundwater pollutant is NA if all individual background tests are NA but evaluated as yes or no. While the table indicates that individual background tests are NA for each groundwater pollutant, the overall conclusion for each pollutant is not NA. This table should be revised so that either the correct overall conclusion for each pollutant is shown or the correct results for each individual background test is shown.

Reply: Concur. Table 7-16 will be changed as appropriate.

51. **Tables 7-18 to 7-22, page T-7-73 to T-7-83.**
These tables present the COPC selection for each contaminant in each medium at Site 5. A final column should be added to the table which describes the reason the contaminant was included as a COPC (i.e., exceeded RBC and background, exceeded RBC, chemical is break-down product of a COPC, etc.) so that it is clear why the chemical was selected as a COPC.

Reply: Concur. A column will be added to each table stating the reason for inclusion or exclusion of each chemical.

Tables 7-18 to 7-21 include the background results. However, Table 7-22 does not include background results. The format of Tables 7-18 to 7-22 should be consistent and background results should be added to Table 7-22.

Reply: Tables 7-18 through 7-21 will be checked for consistency and changes will be made as appropriate.

52. **Table 7-24, page T-7-85.**
This table lists values for the estimated CTE total cancer risk for ingestion, dermal contact, and inhalation of subsurface soil for a future excavation worker at Site 5. However, Table J-16, which contains the backup calculations of estimated CTE cancer risks and noncarcinogenic hazard indices for a future excavation worker from subsurface soil exposure at Site 5, lists all the values as NA. The tables should be revised so that they are consistent.

Reply: Table 7-24 and the text presenting it will be checked for accuracy and revised as appropriate.

53. **Appendix J, Human Health Risk Assessment Documentation.**
Appendix J does not contain page numbers. Page numbers should be included throughout the report, including in Appendix J.

Reply: Concur. Page numbers will be added.

The equation for Surface Soil Exposure, Dermal Contact defines "ABS" as fraction from contaminated source for arsenic. "ABS" should be defined as the chemical-specific absorption factor for dermal contact.

Reply: Concur. The "ABS" term will be defined as appropriate.

The inhalation equation in Appendix J states R_{10} is equal to E_{10}/A. However, Section 3.1.3.5.1 presents R_{10} as equal to $E_{10} * A$. The inhalation equations should be revised to show the correct relationship between the variables and should be consistent throughout the RI report.

Reply: The inhalation equations will be revised as appropriate.

The equations presented in Section 3.1.3.5 and in Appendix J are not consistent. For example, the ingestion equation on Page 3-25 uses different units and includes a 365 days/yr conversion factor. The surface/subsurface soil lung inhalation equation on page 3-25 uses the variable X and IF_R; however these variables are not included in the inhalation equation in Appendix J. Instead, the inhalation equation in Appendix J uses the variables CA and FR-I. CA was previously defined as carcinogenic risk; however in this equation, it represents contaminant concentration. The sediment dermal intake equation on page 3-40 uses the variables BW, SA, ED, and EV; however, these variables are not used in the sediment dermal intake equations in Appendix J. Instead, the sediment dermal intake equation in Appendix J uses the variable AGE. Equations with

consistent nomenclature should be used throughout the RI report and should be consistent with those equations found in EPA reference documents.

Reply: Concur. Consistency regarding terminology will be provided throughout the revised HHRA.

3.2 ECOLOGICAL RISK ASSESSMENT APPROACH

Ecological receptors at NASJRB Willow Grove may be at risk from contaminants associated with Sites 1, 2, 3, and 5. Therefore, an ecological risk assessment (ERA) was performed to characterize the potential risks from site-related contaminants to ecological receptors that inhabit the installation. The ERA was based on laboratory analyses of surface soil, surface water, and sediment samples collected from each site. This section provides an outline of the approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment followed a two-step process:

Step 1: Preliminary Problem Formulation and Ecological Effects Evaluation (Section 3.2.1)

- Preliminary Problem Formulation - This is the first phase of an ERA, which discusses the goals, breadth, and focus of the assessment. It includes general descriptions of NASJRB Willow Grove sites with emphasis on the habitats and ecological receptors present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of analytes to be assessed. Assessment and measurement endpoints are also selected in this phase. In addition, a conceptual model is developed that describes how contaminants associated with the RI sites may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this phase, medium-specific ecological screening levels for each analyte (i.e., concentrations of each contaminant above which adverse effects to ecological r ceptors may occur) are identified. This step is undertaken concurrently with the exposure assessment described below.

Step 2: Preliminary Exposure Assessment and Risk Calculation (Section 3.2.2)

- Preliminary Exposure Estimate - This portion of the ERA includes the identification of contaminant concentration data used to represent ecological exposure in various media and the selection of exposure point contaminant concentrations from those data.

- Preliminary Risk Calculation - In this step, exposure point concentrations are compared to screening l vels in order to characterize potential risks to ecological receptors of concern. Analytes found to pose potential risk after these comparisons are selected as ecological chemicals of potential concern (COPCs).

When these two steps are completed, the results are interpreted and the uncertainties associated with the ERA are addressed. The above process, described in further detail below, represents the general approach recommended in the most recent U.S. EPA guidance for performing ecological risk assessments (U.S. EPA, 1997), which served as the basis for the ERA methodology. Additional guidance consulted for this ERA includes Department of the Navy ERA policy (DON, 1999), EPA Region III BTAG ERA guidelines (USEPA, 1994), and other ERA guidance documents and publications (Calabrese and Baldwin, 1993; Suter, 1993; Wentsel et al., 1996).

Due to the potential complexity of ERAs, they are usually conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs). SMDPs are meetings involving the risk managers and risk assessment team and are conducted to evaluate the work up to that point and to ensure that the ecological risk assessment is proceeding in an efficient manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met. The results are then used to identify th data required for the next tier, if necessary. The Tier 1 ERA is also known as a Screening Risk Assessment. The Screening Risk Assessment uses conservative (i.e. stringent) assumptions to evaluate site data and determine whether additional ecological risk assessment or accelerated site cleanup may be warranted, or that the site poses negligible ecological risks.

The second tier is a baseline ERA (BERA), which is conducted if the results of the screening-level ERA indicate that additional study is warranted. The BERA compris s Steps 3 through 7 of the 8-step ERA process, and is a more focused study of the initial COPCs. The beginning of the BERA also presents a more balanced evaluation of the conservativeness inherent in the first two steps of the ERA process (DON, 1999).

3.2.1 Preliminary Problem Formulation and Ecological Effects Evaluation

Section 3.2.1.1 discusses the components of problem formulation and Section 3.2.2.2 discusses the compon nts of ecological effects evaluation.

3.2.1.1 Preliminary Problem Formulation

Ec logical Setting

The preliminary problem formulation contains a description of the background of the site and a general description of the ecological setting at NASJRB Willow Grove. These topics are presented in Section 1.4. The main areas of interest at NASJRB Willow Grove for this ERA are Sites 1, 2, 3, and 5. These sites are described in detail in site-specific sections.

Habitat Types and Ecological Receptors

Descriptions of habitat types and ecological receptors were composed for Sites 1, 2, 3, and 5, and are present d in site-specific sections of this report. Data regarding habitats and ecological receptors were obtain d from previous reports and from biological characterizations conducted at the installation during this investigation. Information on the occurrence of threatened and endangered species on and near the four sites was obtained from the U.S. Fish and Wildlife Service, the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, the Pennsylvania Department of Environmental Protection, and the Natural Resources Manager at NASJRB Willow Grove.

Contaminant Sources, Release Mechanisms, and Migration Pathways

Site-specific contaminant sources, release mechanisms, and migration pathways are discussed in site-specific sections of this report. The general transport mechanisms that were investigated include combustion, volatilization, wind erosion, overland runoff, and infiltration of contaminants. Constituents in soil could volatilize from surficial material or become airborne through wind erosion. Contaminated fugitive dust could be generated during ground-disturbing activities such as construction or excavation. Contaminants could then be dispersed in the surrounding environment and transported to downwind locations, where th y could become deposited in surface soil, surface water, or sediment. Combustion was probably a major transport mechanism during the period when the landfills and fire training area were in use. However, combustion is assumed to currently represent a negligible transport mechanism at NASJRB Willow Grov since open burning activities have ceased.

Precipitation runoff could carry constituents to nearby surface water and sediment. Infiltrating precipitation could cause the contamination of subsurface soil and groundwater. Upon infiltrating the soil column and reaching the water table, a contaminant may be carried with the flow of groundwater to downgradient locations. Groundwater from the site may eventually discharge to surface water; contaminants could be subsequently deposited in sediment or accumulate in the tissues of aquatic organisms.

Exposure Routes

Terrestrial animals could be exposed to soil contaminants through the ingestion of contaminated food items. Animals can also incidentally ingest soil while grooming fur, preening f athers, digging, grazing close to the soil, or feeding on items to which soil has adhered (such as roots and tubers). T rrestrial vegetation could be exposed to contaminants via direct aerial deposition and root translocation. However, aerial deposition was not investigated, primarily because the contaminant sources at the sites under investigation are largely covered by vegetation. Terrestrial animal receptors may also come into contact with contaminants in surface water through drinking, although this exposure route represents a negligible portion of total exposure for most receptors. Exposure to contaminants in the soil via dermal contact may occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons minimize transfer of contaminants across dermal tissue.

Inhalation does not represent a significant exposure pathway because air contaminant concentrations are assumed to be quite low, even for burrowing wildlife. In addition, inhalation ecotoxicity data for chronic exposure are lacking. Therefore, the air pathway was not considered for ecological receptors.

Aquatic and semi-aquatic organisms at NASJRB Willow Grove could be exposed to contaminants via direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Aquatic and semi-aquatic organisms could also be exposed to constituents from contaminated groundwater that potentially discharges into nearby surface water.

Selection of Analytes to be Investigated

All analytes detected in surface water, sediment, and surface soil samples collected during 1991 Phase I and 1997 Phase II sampling activities were assessed in this investigation. However, calcium, magnesium, potassium, and sodium were excluded in the screening process since they are essential nutrients that are toxic only in extremely high concentrations. Due to the scarcity of data for these essential nutrients, it was not possible to develop ranges of toxicity even at high concentrations. The limited toxicity data available indicate that high dietary intake of these nutrients is well tolerated.

Assessment and Measurement Endpoints

One of the major tasks in problem formulation is the selection of assessment and measurement endpoints. An assessment endpoint is "an explicit expression of actual environmental values that are to be protected" and measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (USEPA, 1997). For this ERA, the assessment endpoint was the maintenance of aquatic and terrestrial receptor populations. Therefore, the specific objectives of this assessment were to determine if exposure to contaminants present in the surface water, sediment, and soil on and near the sites are likely to result in declines in ecological receptor populations. Declines in populations could result in a shift in community structure and possible elimination of resident species from aquatic, semi-aquatic, and terrestrial environments.

Measurement endpoints serve as surrogates for assessment endpoints, since they are more easily quantified or observed than assessment endpoints. Measurement endpoints consisted of contaminant concentrati ns associated with adverse effects on growth, survival, and reproduction of aquatic organisms (surface water screening levels), benthic organisms (sediment screening levels), and terrestrial vegetation and soil invertebrates (surface soil screening levels).

Conceptual Site Model

The conceptual model is designed to diagrammatically identify potentially exposed receptor populations and applicable exposure pathways, based on the physical nature of the site and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with the sites were determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has

three components: a source of contaminants that can be released to the environm nt; a route of contaminant transport through an environmental medium; and an exposure or contact point for an ecological receptor. The conceptual model for each site is presented in site-specific sections of this report.

3.2.1.2 Preliminary Ecological Effects Evaluation

For this ERA, exposure-point concentrations of detected analytes in surface water, sediment, and surface soil were compared to ecologically based guidelines to determine if the analytes should be selected as COPCs. Although groundwater-to-surface-water migration of groundwater contaminants is possible at NASJRB Willow Grove, ecological receptors are not directly exposed to groundwater. Additionally, no groundwater thresholds have been developed based on ecological concerns. Potential ecological risks associated with groundwater contaminants are reflected in the evaluation of the potential risks associated with surface water and sediment, since the sources of contamination at the sites under investigation have been in place long enough for groundwater plumes to discharge into nearby surface water and sediment. Thus, groundwater contaminants were not screened against surface water contaminants in the ecological risk assessment. It is noted that an artesian flowing well formerly existed downstream from the pond near Site 3. However, this well has been capped so that flow from this monitoring well is nonexistent. There are no other flowing artesian wells near any other site investigated in this report. The Navy corrected the problem of flowing artesian monitoring wells during RI field investigations in the spring of 1997 by repairing the leaking sample assemblies. Long-term annual inspection and maintenance of these artesian monitoring wells will ensure no flow of groundwater to surface water.

Methods used for the selection of medium-specific benchmarks used in this ERA are provided below.

Surface Water Screening Levels

Actual exposures of aquatic receptors to surface water contaminants at NASJRB Willow Grove were assumed to be primarily chronic (long-term) exposures, usually at sublethal concentrations. Initial screening levels for this ERA were chronic screening values obtained from USEPA Region III BTAG (EPA, 1995), EPA chronic ambient water quality criteria (AWQC), EPA final chronic values (FCVs), and Tier II values (EPA, 1996b).

Sediment Screening Levels

Initial contaminant screening levels for benthic organisms were preferentially EPA Region III BTAG screening levels (EPA, 1995). These values are primarily Effects Range-Low (ER-L) values from Long and Morgan (1990) and Long et al. (1995), and Apparent Effects Thresholds (AETs).

Surface Soil Screening Levels

Initial screening levels for soil organisms consisted primarily of USEPA Region III BTAG screening levels (EPA, 1995), Oak Ridge National Laboratory (ORNL) surface soil screening levels, and Dutch "B" levels that repres nt ecological toxicity endpoints (Netherlands, 1994).

3.2.2 Preliminary Exposure Estimate and Risk Calculation

Section 3.2.2.1 describes the components of preliminary exposure estimate and Section 3.2.2.2 describes the components of preliminary risk calculation.

3.2.2.1 Preliminary Exposure Estimate

The maximum detected concentrations of analytes in surface water, sediment, and surface soil w re used as exposure point contaminant concentrations for comparison to ecological scre ning levels in the risk calculation step. Detailed descriptions of sampling locations, data validation, data treatment, and data selection were presented in previous sections.

3.2.2.2 Preliminary Risk Calculation

The preliminary risk calculation step in the ERA process compares exposure-point contaminant concentrations with screening levels protective of ecological receptors (EPA, 1997). The ratio of the exposure-point contaminant concentration to the screening level is called the hazard quotient (HQ) and is defin d as follows:

$$HQ_i = EPC_i/ESL_i$$

where: HQ_i = Hazard Quotient for analyte "i" (unitless)

EPC_i = Exposure Point Concentration for analyte "i" (µg/L or mg/kg)

ESL_i = Ecological Screening Level for analyte "i" (µg/L or mg/kg)

When the ratio of the exposure point concentration to its respective screening level equaled or exceeded 1.0, adverse impacts were considered possible, and the contaminant was retained as a COPC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration exceeds or is less than a screening level. HQ values equal or greater than 1.0 indicate that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk.

The use of HQs is probably the most common method used for risk characterization in ERAs. Advantages of this method, according to Barnthouse et al. (1986), include the following:

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.
- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. That is, it uses single values for exposure concentrations and screening levels. The HQ method does not account for the variability in both these parameters or for incremental or cumulative toxicity.

The comparisons of maximum contaminant concentrations in each medium to screening levels are presented in screening tables. The screening tables include the frequency of detection for each analyte, the range of detected values, and contaminant-specific screening levels.

3.2.3 Step 3a: Refinement of Contaminants of Potential Concern

The ERA methods described above constitute the first two steps of the 8-step ERA process. Thus, the ERA, up to this point, can be considered to be a "screening-level" assessment, or "Tier 1" assessment, since it is based primarily on a conservative initial screening of contaminant concentrations against contaminant-specific screening levels. As will be seen in site-specific ERAs, maximum concentrations of several analytes exceed ecological screening levels. Because of this, and since the locations and number of samples appears to be adequate to determine the nature and extent of site related contamination, a more thorough assessment is warranted. Therefore, in accordance with EPA (1997) and Navy policy (DON, 1999), and as

per discussions with Region III BTAG, a portion of St p 3 of the 8-step ERA process was included in this assessment.

Step 3 of the 8-step ERA process is BERA problem formulation (EPA, 1997). This step consists of several sub-steps designed to develop the goals, breadth, and focus of the BERA. The initial sub-step within Step 3 is refinement of contaminants of potential concern, and is referred to as "Step 3a - Refinement of Conservative Exposure Assumptions" in the Navy's ERA guidance (DON, 1999).

The use of conservative guidelines and maximum detected concentrations in the screening-level assessment is necessary to ensure that potential risks are not underestimated. However, if the hazard quotients derived from comparisons of maximum concentrations to conservative screening levels are used as the single factor for including a COPC in a baseline ERA without consideration of other relevant information, additional ecological studies such as toxicity testing or tissue analyses could be undertaken for COPCs that do not actually pose significant risks. For this reason, refinement of COPCs, the first sub-step within Step 3, was incorporated into the ERA. Step 3a involves the consideration of factors such as background data (mainly for inorganics), toxicological evaluation of COPCs, frequency of detection, and comparisons of COPCs to alternate guidelines (EPA, 1997; DON, 1999).

3.2.3.1 Alternate Guidelines

Less conservative guidelines are presented in Step 3a of this ERA to provide balance to the conservativ screening-level assessment. For example, some sediment screening values in Steps 1 and 2 consisted of ER-L values obtained from Long et al. (1995) However, an ER-L is defined as the concentration below which adverse ecological effects "would rarely be observed", and the effects range-medium (ER-M) is the concentration below which adverse effects "would occasionally occur" (Long et al., 1995). Therefore, ascribing risk to a sediment contaminant detected in a concentration that exceeds the ER-L but is below the ER-M can be misleading. Recent studies have indicated that ER-Ms are much better indicators of potential adverse effects than ER-Ls (Long et al., 1998), and thus, ER-Ms are included in Step 3a.

Less conservative sediment guidelines also include Probable Effects Levels (PELs) developed by the Florida Department of Environmental Protection (FDEP, 1994). The PELs are loosely analogous to ER-Ms. The data set used by Long et al. (1995) to develop ER-Ls and ER-Ms was used also by FDEP. However, unlike the ER-Ls and ER-Ms, PELs also incorporate chemical concentrations observed or predicted to be associated with no adverse biological effects (no effects data). The PEL is the geometric mean of the 50th percentile in the effects data set and 85th percentile in the no effects data set. The PEL represents the lower limit of the range of contaminant concentrations that are usually, or always, associated with adverse biological effects (FDEP, 1994).

Other less conservative sediment guidelines such as Severe Effects Levels (SELs) developed by the Ontario Ministry of the Environment (MOE) are also presented in Step 3a. MOE guidelines are based exclusively on observ d effects in the field (absence of certain species). The SEL represents the contaminant level that could potentially eliminate most of the benthic organisms. Unlike National Oceanic and Atmospheric Administration (NOAA) and FDEP guidelines, MOE guidelines are based on freshwater sediments. Probable Effects Concentrations (PECs) developed as part of EPA's Assessment and Remediation of Contaminated Sediments Program (EPA, 1996c), and other guidelines are also presented in Step 3a.

Alternate guidelines for surface water are not as plentiful as for sediments. Therefore, a broad range of alternate guidelines for surface water could not be developed. However, alternate guidelines are presented, when available, for surface water COPCs in Step 3a for each site investigated herein.

Alternate surface soil guidelines for some COPCs were available from ORNL (Efroymson et al., 1997a; 1997b) and are presented in Step 3a. These data were derived to be used as screening values for investigating the potential effects of contaminants on soil litter inv rtebrates (i.e. earthworms), soil microbes,

and plants. Oth r alternate cological soil guidelin s include Dutch "B" soil valv s indicative of "moderate soil contamination that requires further study" (Beyer, 1990), and Canadian Council of Ministers of the Environment Soil Quality Guidelines (CCME, 1997).

3.2.3.2 Toxicological Evaluation of COPCs

Toxicity data and information from various sources in the literature are discussed as they relate to the interpretation of potential risks from each COPC. These sources include the USFWS Chemical Hazard Revi ws, commonly referred to as the "Eisler" publications, ATSDR Toxicity Profiles on CD-ROM, and ecotoxicological journals.

3.2.3.3 Other Considerations

The establishment of background concentrations was discussed in Section 2.3. Background data were obtained from the sampling and analysis of surface water, sediment, and surface soil during Phase II activities. As a result, background data are available for use in assessing the extent to which chemical concentrations at Sites 1, 2, 3, and 5 are due to site-related activities, since concentrations of inorganic contaminants can be naturally elevated and exceed screening values.

The frequency of detection and spatial analysis of elevated contaminant concentrations were evaluated to determin whether potential risks are widespread or limited to a small area. The magnitude of the HQs was also considered. As described earlier, the relationship between the magnitude of an HQ and toxicity is n t n cessarily linear. However, the magnitude of an HQ can be used as a rough approximation of the extent f potential risks, especially if there is sufficient confidence in the guideline used.

3.2.4 Ecological Risk Assessment Approach Summary

Due to past contaminant releases at Sites 1, 2, 3, and 5, a screening-level ERA was conducted for each of th se sites. Maximum contaminant concentrations in surface water, sediment, and surface soil were compared to screening level toxicity values that are protective of ecological receptors. Potential risks to ecological receptors were investigated in the form of HQ values, which is the ratio of the representative contaminant concentration to the screening level toxicity value. Risks were considered possible when an HQ value was equal to or greater than 1.0. Subsequently, other quantitative and qualitative factors were investigated in Step 3a to more fully assess potential risks. A "weight-of-evidence" approach (EPA, 1997) was used as part of Step 3a to determine the extent of potential risks when HQ values exceeded 1.0. Information in Step 3a was used to determine final ecological contaminants of concern (COCs).

3.2.5 Screening Level and Step 3a Uncertainty Analysis

Uncertainty is associated with all aspects of the ERA process. This section provides a summary of the general uncertainties involved in this ERA, and discusses how the uncertainties may affect the final risk values and conclusions. Discussions of site-specific uncertainties are contained in site-specific sections of this report.

Once an ERA is complete, the results must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. If numerous conservative assumptions are combined in the ERA process, the resulting calculations will propagate the uncertainties associated with each of those assumptions. The resulting bias is toward over-predicting risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

Generally, risk assessments carry two types of uncertainty: measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. Informational uncertainty stems from the limited availability of necessary information. There is often a significant gap between what is needed and what is available. Information regarding the effects of certain contaminants on ecological receptors, the biological mechanism of a contaminant, the impact of physiological differences on exposure pathways, or the behavior of a contaminant in various environmental media is often absent.

Uncertainty is associated with each of the steps of the risk assessment process:

- Uncertainty in problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes.
- Uncertainty in the ecological effects evaluation arises from the quality of the existing screening values and toxicity data to support a determination of potential adverse impacts to ecological receptors.
- Uncertainty associated with the exposure estimate includes the methods used and the assumptions made to determine exposure point concentrations.
- Uncertainty in risk calculation includes that associated with the potential effects of exposure to multipl contaminants and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

3.2.5.1 Uncertainty in the Preliminary Problem Formulation

The sites investigated in this ERA receive contaminant inputs from more than one source, although initially, contaminants are conservatively assumed to stem directly from site-related activities. Since contaminant concentrations may reflect inputs from many sources, uncertainties exist regarding whether risk characterized at a discrete site stems from site-related contaminants.

3.2.5.2 Uncertainty in the Ecological Effects Evaluation

Uncertainty in this risk assessment results from the nature and quality of the available toxicity data used to derive toxicity screening values. This uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose related; and when postulated mechanisms of toxicity are similar for laboratory and wildlife species. Most screening values are based on the most conservative assumptions possible. Thus, although an inherent level of conservatism is needed in an ecological risk assessment to ensure that the most sensitive receptors are protected, conservative screening values may heavily overestimate potential risks and the resulting HQ values may be misleading. AWQC and some sediment screening values used in this assessment are based on laboratory studies that do not take into account mitigating or ameliorating physical and chemical conditions in the environment. For example, the most bioavailable (i.e., toxic) form of the contaminant is usually applied to the exposure medium. In reality, bioavailability is rarely, if ever, 100 percent. Several of these uncertainties were addressed as part of Step 3A, but uncertainties still remain.

In addition, ERAs, unlike human health risk assessments, must consider risks to many different species. However, calculation of risk values for each potential receptor species is not possible. For this ERA, conservative screening values protective of a wide range of ecological receptors were sought. The underlying assumption associated with the use of these screening values is that contaminant concentrations in excess of these values are indicative of potential impacts to actual receptors inhabiting the area. How ver, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a contaminant are seldom known. Also, contaminants were present in some media for which no suitable benchmarks were available,

and as a result, they could not be quantitatively assessed. Risks may be biased low in thes instances. For these reasons, th use of toxicity screening values will introduce error into the results of an assessment.

Potential risks may be under- or over-estimated due to the interactive effects of contaminants. Contaminants with similar modes of action may have additive effects (e.g., organochlorine pesticides) or synergistic effects. In this case, potential risks could be underestimated. Contaminants can also have ameliorating effects on certain receptors. In this case, potential risks could be overestimated.

3.2.5.3 Uncertainty in the Exposure Estimate

Uncertainty in the exposure estimate arises mainly in the methods used to obtain exposure point concentrations. The maximum detected contaminant concentrations were used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the samples evaluated in this ERA are representative of contaminant concentrations associated with each site, then this approach is cons rvative and should overestimate potential risks to ecological receptors. The maximum concentration of a contaminant in a given medium may have been collected in a "hot spot" of contamination, and may be much higher than the remaining values in the data set. In such a case, the use of maximum values may overestimate potential risks. Additionally, contaminants that appear to pose significant potential risk may be mitigated by several factors, including a low frequency of detection or elevated concentrations in areas with no significant habitat. These factors would reduce actual exposure.

D rmal and inhalation exposures were not evaluated in this ERA. Dermal exposure is usually limited by the outer coverings of most receptors. Nevertheless, certain portions of some receptors, such as footpads, eyes, and nose do not contain fur or feathers, and may have a higher chance of exposure. However, these areas generally constitute a small portion of the total surface area of most receptors. Inhalation of contaminants is assumed to be miniscule. Airborne aerosols, particulates, and vapors are assumed to be inapplicable for aquatic media, and there is little bare soil at the sites under investigation. As a result, airborne particles would be expected to be minimal. Burrowing wildlife such as woodchucks could be exposed to some contaminants via inhalation. However, data regarding inhalation exposure and toxicity for wildlife were not available. In summary, the dermal and inhalation exposure routes are considered to be minor, but since they cannot be quantitatively assessed, the associated potential risks are inherently underestimated.

3.2.5.4 Uncertainty in the Risk Calculation

Uncertainty in the risk calculation is affected by all aspects of the ERA process described in the above sections. Uncertainty in risk calculation also results from the combination of different components of th ERA in this step. Each of those components already contains different types of uncertainty, as discussed above. Thus, uncertainties may be propagated when these components are combined. To try to reduce the overall uncertainty in the risk assessment, the weight-of-evidence approach is used to make risk decisions. This approach considers all aspects of the assessment, including the uncertainties, to make determinations of potential risks.

7.8 ECOLOGICAL RISK ASSESSMENT

This section presents the results of the ecological risk assessment performed at Site 5, the Fire Training Area.

7.8.1 Preliminary Problem Formulation

This section includes a discussion of available habitats, ecological receptors, contaminant sources, release mechanisms, migration pathways, exposure routes, selection of analytes to be investigated, assessment and measurement endpoints, and the conceptual site model.

7.8.1.1 Habitat Types and Ecological Receptors

Site 5 consists of disturbed areas of grass, weeds, and shrubs (Figure 7-10). The northern portion of the site is a regularly mowed grassy area adjacent to aircraft taxiway Juliet. A shrub thicket is located west of the paved access road into the site. An area of weeds and shrubs exists east of the access road in the vicinity of the former burn area. Sumac (*Rhus* spp.) and box-elder (*Acer negundo*) are abundant in that area. A shallow drainage ditch east of the access road separates the weedy area from the grassy ar a near the taxiway. The area surrounding the ditch is thickly vegetated with common reed (*Phragmites australis*) and cattail (*Typha* spp.). Two small, shallow excavated ponds (approximately 80 ft by 20 ft) are located approximately 100 feet south of the site. These ponds are not shown on the National Wetlands Inventory Map of the area (U.S. Department of the Interior, undated), but marsh vegetation has become established in the area surrounding the two ponds. The western pond was completely covered with a dense layer of cattail during a site visit in March 1999.

The site is adjacent to an open taxiway to the north, the Marine Corps Compound to the south and southeast, and a paved access road to the west. Thus, to a large extent, wildlife species at the site consist of those that have become accustomed to human disturbance. These include rabbits, raccoons, smaller mammals such as mice, reptiles and amphibians, and various birds. A woodchuck burrow was observed near the former burn area during the March 1999 site visit. During periods of relative human inactivity, deer and red foxes are known to occasionally utilize the site. Avian raptors are expected to forage in the grassy area adjacent to the taxiway. The two small ponds are inhabited by minnows, aquatic invertebrates, reptiles and amphibians, and are occasionally utilized by various receptors that forage on aquatic organisms (e.g., wading birds, waterfowl, raccoons, etc.). There are no known animals or plants state- or federally-listed as threatened, endangered, or candidates for listing, at the site.

7.8.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways

The contaminant source at Site 5 consists of the former Fire Training Area. Petroleum and related wastes were burned at the site for fire training exercises. Potential contaminant release pathways at the site include volatilization, wind erosion, overland runoff, and infiltration of contaminants. Combustion was probably a major transport mechanism during the period when the fire training area was in use. Howev r, combustion is not a current transport mechanism at Site 5 since open burning activities have ceased.

Constituents in soil could volatilize from surficial material or become airborne via wind erosion. Contaminated fugitive dust can be generated during ground-disturbing activities, such as construction or excavation. The contaminants could then be dispersed in the surrounding environment and transported to downwind locations where they could repartition to surface soil, surface water, or sediment through gravitational settling, precipitation, and deposition. However, most of the site is heavily vegetated,

minimizing the airborne contaminant transport pathway. Th absence of vegetation in the immediate area of the burn ring could contribute to fugitive emissions of fine-grained soil particl s, but since this area is small, fugitive emissions are probably insignificant.

The flat topography in the vicinity of the site decreases the degree of precipitation runoff. However, two small ponds are approximately 100 feet from the site in a slight downslope direction. In addition, some runoff could eventually drain into ditches that exit the base approximately 2,000 ft south of the site. This drainage eventually flows into Pennypack Creek approximately 3,000 south of the air station.

Infiltrating precipitation can cause the contamination of subsurface soil and groundwater. After reaching the water table, contaminants can be carried with the flow of groundwater to downgradient locations. Contaminants transported in groundwater to surface water can be deposited subsequently in sediment or surface water, and can potentially accumulate in the tissues of aquatic organisms downstream. Groundwater beneath Site 5 flows southeast or southwest, depending on location and depth. The nearest surface water (other than the two nearby ponds) into which site groundwater could discharge is Pennypack Creek, approximately 4,500 feet south of the site. There is no evidence from the RI indicating that groundwater discharges into Pennypack Creek.

7.8.1.3 Exposure Routes

T rr strial animals at Site 5 can be exposed to soil contaminants through the ingestion of contaminated food it ms. In addition, animals can incidentally ingest soil while grooming fur, preening feathers, digging, grazing close to the soil, or feeding on items that are covered with soil (such as roots and tubers). Terrestrial vegetation can be exposed to contaminants through direct aerial deposition and root translocation. Aerial deposition could have been a significant exposure route during historical landfill activities. However, aerial deposition is presently minimal since most of the site is vegetated. Terrestrial receptors can also come into contact with contaminants in surface water by using it for drinking, although this exposure route generally represents a negligible portion of total exposure for most receptors.

Aquatic and semi-aquatic organisms in the ponds near Site 5 can be exposed to contaminants through direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Exposure to contaminants in the soil via dermal contact can occur but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons minimize the transfer of contaminants across dermal tissue.

Volatile constituents could be present in some site soils and soil-bound contaminant airborne suspension could occur at Site 5. However, inhalation does not represent a significant exposure pathway because this investigation assumes that air contaminant concentrations are quite low, even for burrowing wildlife. Since inhalation ecotoxicity data for chronic exposure are lacking, the air pathway was not considered for ecological receptors.

7.8.1.4 Selection of Analytes to be Investigated

As discussed in Section 3.2.1.1, calcium, magnesium, potassium, and sodium were excluded as COPCs in all media because they are essential nutrients that are toxic only in extremely high concentrations. Otherwise, analytes selected for evaluation consisted of all analytes detected during current and pr vious sampling of surface water, sediment, and surface soil at Site 5.

7.8.1.5 Assessment and Measurement Endpoints

A description of assessment and measurement endpoints for this investigation is presented in Section 3.2.1.1.

7.8.1.6 Conceptual Site Model

Figure 7-11 shows the conceptual model for Site 5. The figure shows a complete exposure route for the wind erosion pathway. However, since most of the site is heavily vegetated, the wind erosion pathway is assumed to be minimal. In addition, the dermal (direct contact) exposure route is included in the conceptual model since it is theoretically possible, but as mentioned earlier, it represents a minor exposure route and was not investigated.

7.8.2 Preliminary Ecological Effects Evaluation

Ecologically-based screening values (ESVs), concentrations of contaminants in various media considered protective of ecological receptors, were compared to exposure point concentrations of detected analytes in surface water, sediment, and surface soil to determine if the analytes qualify as ecological COPCs at Site 5. The selection of ESVs was discussed in section 3.2.1.2.

7.8.3 Preliminary Exposure Estimate

The maximum detected contaminant concentrations in surface water, sediment, and surface soil were used as exposure point concentrations for comparison to ecological screening levels. Mean contaminant concentrations and 95% UCL of the mean contaminant concentrations (when available) were also compar d to alternate guidelines in Step 3a of the assessment.

7.8.4 Preliminary Risk Calculation

The maximum detected concentrations of aluminum, barium, iron, lead, and dieldrin in surface water exceeded screening levels and thus, they were retained as COPCs (Table 7-27).

No inorganic sediment analytes exceeded screening levels (Table 7-28). Aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium were retained as sediment COPCs since no screening levels were available. Several organics in sediments were retained as COPCs since their maximum concentrations exceeded screening levels; these consisted of anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, phenanthrene, and pyrene. Aldrin, dieldrin, benzo(k)fluoranthene, 2-butanone, and toluene were retained as sediment COPCs since no screening levels were available.

Aluminum, antimony, arsenic, cadmium, chromium, iron, lead, manganese, thallium, vanadium, and zinc were retained as inorganic COPCs in surface soil since their maximum concentrations exceeded screening levels (Table 7-29). Several SVOCs (primarily PAHs) were retained as organic COPCs in surface soils because their maximum concentrations exceeded screening levels. Acetone and a few SVOCs were retained as COPCs because no screening levels were available.

7.8.5 Step 3a: Discussion

Step 3a considerations are discussed below on a COPC-specific basis.

7.8.5.1 Metals

Aluminum

Aluminum was a COPC in sediment because no initial screening level was available, and was a COPC in surface water and soil because its HQ exceeded 1.0. Its concentration in surface water was twice the ORNL lowest chronic value (Table 7-30). Aluminum concentrations in sediment were well below the only available alternate guideline (Table 7-31), which was a probable effects concentration (PEC) from the USEPA Assessment and Remediation of Contaminated Sediments Program (ARCS). The maximum concentration of aluminum in sediments was less than twice the average background concentration. Conc ntrations of aluminum in all surface soil samples were within the range of background concentrations.

Aluminum is not readily absorbed through the skin and gastrointestinal absorption of ingested aluminum is poor due to the transformation of aluminum salts into insoluble aluminum phosphate (Venugopal and Luck y, 1978). Another factor in the lack of accumulation of aluminum in animals with age or the absence of any increase in tissue levels of aluminum following fairly high dietary intake may be that certain organisms possess a homeostatic mechanism for this element. Aluminum compounds are generally not harmful to most terrestrial organisms and are considered to be toxicologically inert, except in cases of high experimental doses or prolonged inhalation (Venugopal and Luckey, 1978). Data on the toxicity of aluminum to aquatic organisms is somewhat limited. Freshwater organisms usually are not adversely affected when pH is between 6.5 and 9.0 (EPA, 1988). The pH in the surface water sample collected from the western small pond south of the site was within this range (pH=6.77, Appendix C). The pH in the surface water sample collected from the eastern small pond south of the site was slightly lower, at pH=6.35. Overall, however, the aluminum concentrations in Site 5 media are similar to background values. For these reasons, aluminum should be dropped from further consideration at Site 5.

Antimony

Antimony was a COPC in surface soil, but was not detected in surface water and was not a COPC in sediment. Antimony was not detected in background surface soil samples but its HQ was relatively low (HQ=1.8). Few alternate ESVs are available for antimony in surface soil (Table 7-32). Because of its absence in surface water and low concentrations in sediment, and its and relatively low concentrations in surface soil, antimony should be dropped from further consideration at Site 5.

Arsenic

Arsenic was not a COPC in surface water or sediment. Arsenic concentrations in surface soil exceeded the initial screening level in only one sample, and its HQ was low (HQ=1.1). The concentration in this sample was less than the BTAG screening level, less than all alternate ESVs, and was within the rang of background values (Table 7-32). For these reasons, arsenic should be dropped from further consideration at Site 5.

Barium

Barium was a COPC in surface water and sediment, but an initial sediment ESV was not available. Th maximum surface water concentration was much less than the BTAG ESV (Table 7-30). Barium was detected in both surface water and sediment samples from each of the two ponds, but all values were l ss than the average background concentrations (Tables 7-30 and 7-31). Barium is a common element in sediments and it is not generally associated with significant toxicity (ATSDR, 1997). For these reasons, barium should be dropped from further consideration at Site 5.

Beryllium

Beryllium was a COPC in sediment since an ESV was not available. B ryllium was not det ct d in surface water and was not a COPC in surface soil. Although no sediment ESVs wer availabl for beryllium, its concentrations in sediment samples from both ponds were less than the average background concentration (Table 7-31). Therefore, beryllium should be dropped from further consideration at Site 5.

Cadmium

Cadmium was a COPC in surface soil, but was not detected in surface water or sediment. It was detected in 3 of 15 surface soil samples, and it exceeded the initial ESV in only one sample (Appendix A, Table A-18), with an HQ of 1.6. Its concentration in this single sample (4.7 mg/kg) was less than, or only slightly greater than the alternate ESVs shown in Table 7-32. Because of its absence in surface water and sediment, and its relatively low concentrations in surface soil, cadmium should be dropped from further consideration at Site 5.

Chromium

Chromium was a COPC in surface soil, but was not detected in surface water and was not a COPC in sediment. Chromium concentrations in surface soil exceeded the maximum background concentration in three samples (Appendix A, Table A-18), but were greater than twice the average background concentration in only one sample (05SS27), with a value of 56.5 mg/kg.

There is a wide range among available surface soil ESVs for chromium (Table 7-32). The ORNL values in table 7-32 are for hexavalent chromium, the most toxic form of this metal (Efroymson et al, 1997a; 1997b). All chromium concentrations at Site 5 are total chromium. The CCME value of 64 mg/kg is for total chromium (CCME, 1997). The Dutch B value of 250 mg/kg is also for total chromium (Beyer, 1990). Although not shown in Table 7-32, the Dutch "A" value representative of background values (Beyer, 1990), as well as the Dutch "Target Value" that represents the "soil quality required for the full restoration of the soil's functionality for human, animal and plant life" is 100 mg/kg (NMHSP&E, 1994). Since chromium concentrations exceeded twice the average background concentration in only one of 15 samples, and the concentration in this sample was less than most ESVs for total chromium, potential ecological risks (if any) appear to be limited to a small area. Therefore, chromium should be dropped from further consideration at Site 5.

Cobalt

Cobalt was a COPC in sediment because no initial ESV was available. It was not detected in surface water and was not a COPC in surface soil. Cobalt was detected at the same concentration (7.1 mg/kg) in both sediment samples. This value was less than the average concentration in background sediments, and was considerably less than the only available ESV of 50 mg/kg (Table 7-31). Cobalt is present in all natural media, and is a component of certain B vitamins, which are essential for birds and mammals. (ATSDR, 1997). For these reasons, cobalt should be dropped from further consideration at Site 5.

Iron

Iron was a COPC in surface water and surface soil because it exceeded the initial ESVs for these media, and was a COPC in sediment since an initial ESV was not available. The maximum concentration of iron in surface water only slightly exceeded the ESV (HQ = 1.2). The maximum sediment concentration was less than the average background sediment concentration, and was considerably less than the lowest available ESV, which is a "lowest effect level" established by the Ontario Ministry of the Environment (Table 7-31). Surface soil concentrations of iron exceeded the maximum background concentration in only three samples (Appendix A, Table A18), but concentrations in all samples were considerably less than twice the average background concentration (Table 7-32). Because its concentration in surface

water only slightly exceeded the ESV, and since its presence in surface soil and s diment was similar to background concentrations, iron should be dropped from further consideration at Site 5.

Lead

Lead was a COPC in surface water and surface soil but not in sediment. The surface water HQ was low (HQ=1.2), and the maximum concentration in surface water (3.0 µg/L) was less than the BTAG ESV and the ORNL lowest chronic value (Table 7-30). In addition, the concentrations in each of the two surface water samples were flagged with a "K" qualifier (Appendix A, Table A-20), indicating that the values are "biased high due to exceedance of technical quality control criteria". Lead concentrations in five of 15 surface soil samples exceeded twice the average background concentration and the maximum background value of 64.7 mg/kg (Figure 7-9C). Lead concentrations in all five of these samples exce ded the CCME guideline, and the Dutch "B" value was exceeded in two samples (Table 7-32). All soil lead concentrations were less than the ORNL ESV of 500 mg/kg. The maximum concentration of 412 mg/kg was in sample 05SS22 at the southern portion of the former burn area. Lead in this sample might pose potential risks to ecological receptors.

Manganese

Manganese was a COPC in sediment because an initial ESV was not available, and was a COPC in surfac soil with an HQ of 2.65. Its maximum concentration in sediment was less than one half of the average background sediment concentration, and was considerably less than all available screening levels (Table 7-31). Most surface soil concentrations exceeded the few available ESVs (Table 7-32), but the HQ was relatively low. All surface soil concentrations were less than the maximum background soil concentration, and most were less than the average background value. Manganese is a common element in the earth's crust and an essential nutrient. Because of its relatively low HQ and its presence at concentrations within the range of background concentrations, manganese should be dropped from further consideration at Site 5.

Thallium

Thallium was a COPC in surface soil but was not detected in surface water or sediment. Thallium was detected in 7 of 15 surface soil samples and its concentration slightly exceeded the maximum background value in only two samples (Appendix A, Table A-18). All surface soil concentrations were less than twice the average background value (Table 7-32). Only two ESVs were available for thallium in surface soil, and these differed by a factor of 1,000 (Table 7-32), so its potential toxicity is difficult to assess. How v r, all soil concentrations were less than the ORNL screening level of 1.0 mg/kg, a value established for soil phytotoxicity (Efroymson et al , 1997b). Because of this, and since thallium in surface soil was similar to background soil concentrations, thallium should be dropped from further consideration at Site 5.

Vanadium

Vanadium was a COPC in sediment because an initial ESV was not available, and was a COPC in surface soil with an HQ of 1.8. Vanadium was not detected in surface water. No sediment ESVs were available for vanadium, but all sediment concentrations at Site 5 were less than the average background sediment concentration (Table 7-31). Surface soil concentrations were generally within the range of background soil values, and all surface soil concentrations were less than twice the average background soil concentration (Table 7-32). Available ESVs cover a wide range of values (Table 7-32), so the potential toxicity is difficult to assess, but vanadium is not generally considered to be toxic in the environment (Mailman, 1980). Because of this, and since concentrations at Site 5 were similar to background concentrations, vanadium should be dropped from further consideration at Site 5.

Zinc

Zinc was a COPC in surface soil with an HQ of 2.7, and was not a COPC in surface water or sediment. Surface soil concentrations were generally less than the average background soil concentration, and the maximum soil concentration was less than one-fourth of the maximum background soil concentration (Table 7-32). Soil concentrations were greater than the lowest available ESV of 10 mg/kg, but less than the Dutch "B" value. Because zinc was not a COPC in surface water or sediment, and its concentrations in Sit 5 soil samples were well within the range of background soil concentrations, zinc should be dropped from further consideration at Site 5.

7.8.5.2 Pesticides

Aldrin

Aldrin was a sediment COPC since an initial ESV was not available. It was not detected in surface water or surface soil. The single detected value of aldrin in sediment was considerably less than the Ontario severe effects level (SEL) for aldrin (Table 7-31). The SEL values are based on actual observed field effects. Although aldrin was not detected in background sediments, it was probably used base-wide in the past for pest control and is unrelated to Site 5. For these reasons, aldrin should be dropped from further consideration at Site 5.

Dieldrin

Dieldrin was a sediment COPC since an initial ESV was not available, and was a COPC in surface water (HQ=31.6). It was not detected in surface soil. The single detected value of dieldrin in surface water was less than the alternate guideline for dieldrin. Sediment concentrations were considerably less than the SEL value (Table 7-31). As with aldrin, it is probable that dieldrin was used base-wide in the past for pest control and is unrelated to Site 5. For these reasons, dieldrin should be dropped from further consideration at Site 5.

7.8.5.3 Semivolatile Organic Compounds

Several SVOCs were retained as COPCs in sediment and surface soil; none were detected in surface water. Carbazole and dibenzofuran were detected in most surface soil samples but in no sediment samples. There were no soil ESVs for carbazole or dibenzofuran, but their concentrations were elevated only in a single sample (05SS30, Appendix A, Table A-18). Because ESVs were not available for these two compounds, and since they were elevated in only one sample, carbazole and dibenzofuran should be dropped from further consideration at Site 5.

PAH Compounds

All other SVOCs at Site 5 consisted of PAH compounds. Eight PAHs, as well as total PAHs, were retained as sediment COPCs sediment since their maximum concentrations exceeded ESVs. The HQ values for these compounds were relatively low, and none of the maximum concentrations of those compounds exceeded ER-M values or SEL values (Table 7-31). In addition, although not naturally-occurring, the concentrations of most of those compounds in Site 5 sediments were not markedly greater than the concentrations in background sediments. PAHs are common in media from industrialized areas, especially areas that experience vehicular traffic. One PAH compound (benzo(k)fluoranthene) was retained as a sediment COPC since no ESV was available, but its maximum concentration was comparable to the maximum concentrations of similar PAHs which did not exceed th ir alternate guidelines. Concentrations of total PAHs in all sediment samples were less than th ER-M, PEL, PEC,

and SEL valu s shown in table 7-31. For the reasons discuss d abov , no PAH compounds were retained as final sediment COCs, and PAH compounds in sediments should be dropped fr m further consideration at Site 5.

Several PAHs were retained as surface soil COPCs since their maximum concentrations exceeded ESVs or because ESVs were not available. Concentrations of most PAHs in surface soil samples located west of the access road and furthest from the burn area (samples 05SS26, 05SS27, and 05SS28; Figure 7-9C) were not significantly elevated. These samples were located in close proximity to the aircraft taxiway, and PAH concentrations in these samples may be the result of runoff.

Concentrations of several PAHs in samples collected closer to the burn pit were significantly elevated over initial ESVs and alternate guidelines. Specifically, concentrations of several PAHs in samples collected along the western edge of the burn area (05SS17, 05SS18, 05SS21, and 05SS22), the southern edge of the burn area (05SS23, 05SS24, and 05SS25), and the eastern edge of the burn area (05SS29 and 05SS30) were considerably elevated. Concentrations of all PAHs were highest in sample 05SS30, reaching a maximum of 200,000 µg/kg (for phenanthrene). Several individual PAHs and total PAHs ast of the access road near the burn area appear to pose potential risks to terrestrial receptors at Site 5, and therefore, are selected as surface soil COCs (Table 7-32).

7.8.5.4 Volatile Organic Compounds

Acetone

Acetone was a COPC in surface soil since an ESV was not available. Acetone was not detected in surface water or sediment. Because acetone is a common laboratory contaminant, and since it was detected in only one soil sample and in no surface water or sediment samples, it should be dropped from further consideration at Site 5.

2-Butanone

2-butanone was detected in one sediment sample and was a COPC since an ESV was not available. Acetone was not detected in surface water or surface soil. Because of its relatively low concentration in one sediment sample (22 µg/kg), and the absence of detections in other media at Site 5, 2-butanone should be dropped from further consideration at Site 5.

Toluene

Toluene was detected in one sediment sample and was a COPC since an ESV was not available. It was not a COPC in surface soil and was not detected in surface water. The only detection of toluene in sediment (4 µg/kg) was much less than its alternate guideline (670 µg/kg), an EPA sediment quality benchmark (Table 7-31). Because of its relatively low concentration in one sediment sample and its absence as a COPC in other media at Site 5, toluene should be dropped from further consideration at Sit 5.

7.8.6 Screening Level and Step 3a Uncertainty Analysis

Uncertainty is associated with all aspects of the ERA process. A detailed discussion of the general uncertainties involved in this ERA, and how the uncertainties may affect the final risk values and

conclusions, was presented in Section 3.2.5. This s ction discusses how sit -specific uncertainti s may affect the results and conclusions of th ERA for Site 5.

Site 5 has probably received contaminant inputs from sources other than former activities at the Fire Training Area. For example, at least some portions of Site 5 probably receive contaminant inputs from the adjacent aircraft taxiway north of the site. The extent that other sources are responsible for the presence of COCs at Site 5 is uncertain. However, the high concentrations of PAHs in the vicinity of the former burn area suggest that the former fire-fighting activities are responsible for the PAH "hot spot" in this area.

F w data are available for investigating risks to reptiles and amphibians. As a result, direct conclusions about the potential risks to reptiles and amphibians cannot be made. However, contaminants do not appear to have migrated to the two nearby ponds from the Fire Training Area. Thus, potential risks to amphibians and aquatic reptiles in the vicinity of the ponds appear to be low.

The maximum detected chemical concentrations were initially used to represent the chemical concentrations to which ecological receptors might be exposed. If the maximum concentration of a chemical in a given medium was collected in a "hot spot" of contamination and was much higher than the remaining values in the data set, potential risks may be grossly over-estimated. However, the uncertainties related to the location of samples were reduced in this ERA by the large number of surface soil samples collected. Fifteen soil samples were collected at a relatively small site. Thus, the soil concentrations probably present a relatively accurate estimate of soil contamination at the site.

7.8.7 Ecological Risk Summary

Several inorganic and organic contaminants were present in Site 5 surface water, sediment, and surface soil samples in concentrations in exceedance of ecological screening levels and were, therefore, retain d as COPCs. Several other contaminants in all media assessed in this ERA were retained as COPCs since screening levels were not available. Most of these contaminants were eliminated as COCs in Step 3a of th risk assessment process for one or more reasons, such as low frequency of detection, concentrations comparable to background values (primarily inorganics) or alternative screening levels, and spatial analysis of detections.

Contaminants do not appear to have migrated to the two nearby ponds from the Fire Training Area. Potential risks to aquatic receptors that inhabit the ponds appear to be low. Therefore, no COCs were selected for surface water and sediment.

The number and location of surface soil samples appear to be sufficient to delineate the nature and extent of surface soil contamination at Site 5. Organic compounds that could pose potential risks to terrestrial receptors on and near Site 5 are limited to PAH compounds. Concentrations of PAHs in surface soil samples collected west of the access road that borders the burn area were only slightly elevated, and that area may receive PAH inputs from the taxiway to the north. Conversely, concentrations of several PAHs in samples collected around the burn pit greatly exceeded screening levels for individual and total PAHs. Therefore, these PAHs are selected as COCs in Site 5 surface soils around the burn area. The high concentrations of PAHs in the vicinity of the former burn area suggest that the former fire-fighting activities are responsible for the PAH "hot spot" in this area. Lead was the only inorganic COC in Site 5 surface soil, and appears to pose potential ecological risks only in the area that is also the hot spot for PAH compounds. Although terrestrial habitat in this area is marginal, it is utilized by ecological receptors such as mammals and birds. Since the area of highest lead and PAH contamination is relatively discrete and does not contain mature trees, wetlands, or other aquatic habitats, remediation of contaminated soils appears to be possible with minimal damage to the existing cology of the site.

TABLE 7-30
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SURFACE WATER
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

COPC	Maximum Concentration	Mean Concentration	Initial Screening Level	BTAG Screening Level	Alternate Screening Level	Mean/Max Background	Retained as Final COC?
Metals (ug/L)							
Aluminum	926.0	926	25	25	87[a]/460[b]	561[e]	No
Barium	44.8	34.1	3.9	10,000	4.0[c]	101/112	No
Iron	1170.0	716	1,000	320	158[b]	321/635	No
Lead	3.0	2.2	2.5	3.2	1.32[a]/12.3[b]	0.538/0.8	No
Pesticides (ug/L)							
Dieldrin	0.06	0.055	0.0019	0.0019	0.062[d]	ND	No

a AWQC (USEPA, 1995)
b ORNL Lowest Chronic Value (Suter and Tsao, 1996)
c Secondary Chronic Value (Suter and Tsao, 1996)
d Final Chronic Value (USEPA, 1996b)
e Aluminum was analyzed in only one background surface water sample.
ND = not detected.

TABLE 7-31
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SEDIMENT
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

COPC	Maximum Concentration	Mean Concentration	Initial Screening Level	BTAG Screening Level	ER-M[a]	PEL[b]	ARCS PEC[c]	Ontario MOE[d]	Other Screening Level	Mean/Max. Background	Retained as Final COC?
M tals (mg/kg)											
Aluminum	12000.00	11600	NA	NA	NA	NA	58030	NA	NA	6620/8950	No
Barium	74.30	72.1	NA	NA	NA	NA	NA	NA	20-60[g]	98.2/160.5	No
Beryllium	0.77	0.675	NA	NA	NA	NA	NA	NA	NA	0.878/1.2	No
Cobalt	7.10	7.1	NA	NA	NA	NA	NA	NA	50[h]	7.21/12.4	No
Iron	11900.00	11500	NA	NA	NA	NA	NA	20,000/40,000	NA	16500/35400	No
Manganes	222.00	165	NA	NA	NA	NA	1081	460/1110	300-500[g]	514/759	No
Vanadium	21.20	18.4	NA	NA	NA	NA	NA	NA	NA	22.6/52.6	No
Pesticides/PCBs (ug/kg)											
Aldrin	11.00	6.05	NA	NA	NA	NA	NA	2/80	NA	ND	No
Dieldrin	220.00	119	NA	NA	NA	4.3	NA	2/910	52[e]	2.26/3.1	No
SVOCS (ug/kg)											
Anthracen	160.00	160	85.3	85.3	1100	245	547.7	220/3700	NA	ND	No
Benz(a)anthracene	850.00	750	261	261	1600	693	4200	320/14800	NA	275/580	No
Benzo(a)pyrene	910.00	715	430	430	1600	763	393.7	370/14400	NA	268/530	No
Benzo(k)flu ranthene	700.00	565	NA	NA	NA	NA	NA	240/13400	NA	240/300	No
Chrysene	1200.00	960	384	384	2800	846	5200	340/4600	NA	238/640	No
Dibenz(a,h)anthracene	120.00	170	63.4	63.4	260	135	28.2	60/1300	NA	ND	No
Flu ranthen	1800.00	1550	600	600	5100	1494	834.27	750/10200	2900[e]	221/510	No
Ph nanthrene	880.00	750	240	240	1500	544	NA	560/9500	850[e]	235/260	No
Pyrene	1900.00	1700	660	665	2600	1398	3225	490/8500	NA	315/1300	No
Total PAHs	10,900	8480	4,000	NA	44792	16,770	13660	4000/100,000	NA	834/4790	No
VOCS (ug/kg)											
2-Butanone	22.00	14.3	NA	NA	NA	NA	NA	NA	NA	ND	No
Toluene	4.00	5.25	NA	NA	NA	NA	NA	NA	670[f]	ND	No

a. Effects Range - Median (Long et al., 1995).
b. Probable Effects Levels (FDEP, 1994).
c. Assessment and Remediation of Contaminated Sediments Program; Probable Effects Concentration (USEPA 1996c).
d. Ontari Ministry of the Environment: LEL = lowest effect level / SEL = severe effect level (Jones et al, 1997).
. EPA Sediment Quality Criteria (USEPA, 1996b)
f. EPA Sediment Quality Benchmark (USEPA, 1996b)
g. EPA Region 5 guideline indicating moderate pollution (Giesy & Hoeke, 1990).
h. Open water disposal guid line, Ontario Ministry of the Environment (Jones et al, 1997)
NA = not available or not applicable.
ND = not detected.

TABLE 7-32
STEP 3A: REFINEMENT OF CONTAMINANTS OF POTENTIAL CONCERN – SURFACE SOIL
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW GROVE

Contaminant	Maximum Concentration	95% UCL	Mean Concentration	Initial Screening Level	BTAG Screening Level	ORNL[a,b]	Dutch B[c]	CCME[d]	Mean/Max. Background	Retained as Final COC?
Metals (mg/kg)										
Aluminum	12400.00	10600	9840	1.0	1.0	600[a]	NA	NA	11300/15000	No
Antimony	9.20	9.89	4.82	5	0.48	5[b]	NA	NA	ND	No
Arsenic	10.5	6.04	4.87	10	328	60[a]/10[b]	30	19	6.6/10.8	No
Cadmium	4.70	1.73	1.17	3	2.5	20[a]/4[b]	5.0	3.8	ND	No
Chromium	56.50	23.8	18.6	10	0.0075	0.4[a]/1.0[b]	250	64	15.3/20.8	No
Iron	21600.00	16700	14400	12	12	200[a]	NA	NA	14800/17600	No
Lead	412.00	217	90	50	0.01	500[a]	150	70	30.6/64.7	Yes
Manganese	873.00	582	494	330	330	100[a]/500[b]	NA	NA	642/1190	No
Thallium	0.39	0.26	0.202	0.001	0.001	1.0[b]	NA	NA	0.226/0.34	No
Vanadium	36.3	27.7	24.3	20	0.5	20[a]/2[b]	NA	130	24.9/28.2	No
Zinc	137.00	87.6	59.6	50	10	100[a]/50[b]	200	NA	90.1/597	No
SVOCs (ug/kg)										
2-methylnaphthalene	16000.0	1270	1170	NA	NA	NA	NA	NA	ND	Yes
Acenaphthene	36000.0	4370	2560	100	100	20,000[b]	NA	NA	178/64	Yes
Acenaphthylene	2300.0	643	356	NA	NA	NA	NA	NA	177/62	No
Anthracene	54000.0	11800	4290	2050	100	NA	10,000	NA	154/160	Yes
Benzo(a)anthracene	48000.0	45400	711	2050	100	NA	NA	NA	306/940	Yes
Benzo(a)pyrene	36000.0	26700	5760	2050	100	NA	1,000	750	394/1100	Yes
Benzo(b)fluoranthene	35000.0	39100	7260	2050	100	NA	NA	NA	507/1500	Yes
Benzo(g,h,i)perylene	13000.0	5910	2290	2050	100	NA	NA	NA	225/490	Yes
Benzo(k)fluoranthene	29000.0	22800	4630	2050	100	NA	NA	NA	370/920	Yes
Carbazole	19000.0	3200	1780	NA	NA	NA	NA	NA	213/310	No
Chrysene	45000.0	37500	7290	2050	100	NA	NA	NA	420/1200	Yes
Dibenz(a,h)anthracene	4800.0	1710	843	2050	100	NA	NA	NA	161/160	Yes
Dibenzofuran	34000.0	3120	2380	NA	NA	NA	NA	NA	172/120	No
Fluoranthene	140000.0	151000	17600	2050	100	NA	10,000	NA	902/2600	Yes
Fluorene	56000.0	5560	3890	2050	100	30,000[a]	400,000	NA	184/160	Yes

Contaminant	Maximum Concentration	95% UCL	Mean Concentration	Initial Screening Level	BTAG Screening Level	ORNL[a,b]	Dutch B[c]	CCME[d]	Mean/Max. Background	Retained as Final COC?
Ind n (1,2,3-cd)pyrene	18000.0	9700	3180	2050	100	NA	NA	NA	251/640	Yes
Naphthalene	22000.0	1610	1540	2050	100	NA	5,000	600	ND	Yes
Phenanthrene	200000.0	106000	18100	2050	100	NA	5,000	NA	667/1700	Yes
Pyrene	120000.0	135000	15800	2050	100	NA	10,000	NA	723/2100	Yes
Total PAHs	928,000	5,410,000	107,000	4,000	NA	NA	20,000	NA	4,450/14,100	Yes
VOCs (ug/kg)										
Acetone	17.0	16.8	7.7	NA	NA	NA	NA	NA	ND	No

a. Oak Ridge National Laboratory (ORNL) screening levels; a = lowest valve for earthworms and soil micro-organisms (Efroymson et al, 1997a).
b. ORNL screening levels; b = soil phytotoxicity (Efroymson et al, 1997b).
c. Dutch "B" soil valve: moderate soil contamination that requires further study (Beyer, 1990).
d. Canadian Council of Ministers of the Environment Soil Quality Guidelines (CCME, 1997).
NA = not available or not applicable.
ND = not detected.

APPENDIX O

Interpretation of Borehole Geophysical Logs, Aquifer-Isolation Tests, and Water Quality, Supply wells 1 and 2, Willow grove Naval Air Station/Joint Reserve Base, Horsham Township Montgomery Township, Pennsylvania

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Interpretation of Borehole Geophysical Logs, Aquifer-Isolation Tests, and Water Quality, Supply Wells 1 and 2, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania

Water-Resources Investigations Report 01-4264

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U.S. Geological Survey

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by Ronald A. Sloto, Daniel J. Goode, and Steven M. Frasch

Water-Resources Investigations Report 01-4264

U.S. Department of the Interior
U.S. Geological Survey

New Cumberland, Pennsylvania
2002

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
	Length	
inch (in)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	0.4047	hectare
	Volume	
gallon (gal)	3.785	liter
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second
	Specific capacity	
gallon per minute per foot [(gal/min)/ft)]	0.2070	liter per second per meter
	Temperature	
degree Fahrenheit (°F)	°C=5/9 (°F-32)	degree Celsius

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units used in report:

mg/L, milligrams per liter
µg/L, micrograms per liter
µS/cm, microsiemens per centimeter at 25 degrees Celsius

Int rpretation of Borehole G ophysical Logs, Aquifer-Isolation Tests, and Water Quality, Supply Wells 1 and 2, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania

by Ronald A. Sloto, Daniel J. Goode, and Steven M. Frasch

ABSTRACT

Ground water pumped from supply wells 1 and 2 on the Willow Grove Naval Air Station/Joint Reserve Base (NAS/JRB) provides water for use at the base, including potable water for drinking. The supply wells have been contaminated by volatile organic compounds (VOC's), particularly trichloroethylene (TCE) and tetrachloroethylene (PCE), and the water is treated to remove the VOC's. The Willow Grove NAS/JRB and surrounding area are underlain by sedimentary rocks of the Triassic-age Stockton Formation, which form a complex, heterogeneous aquifer.

The ground-water-flow system for the supply wells was characterized by use of borehole geophysical logs and heatpulse-flowmeter measurements. The heatpulse-flowmeter measurements showed upward and downward borehole flow under nonpumping conditions in both wells. The hydraulic and chemical properties of discrete water-bearing fractures in the supply wells were characterized by isolating each water-bearing fracture with straddle packers. Eight fractures in supply well 1 and five fractures in supply well 2 were selected for testing on the basis of the borehole geophysical logs and borehole television surveys. Water samples were collected from each isolated fracture and analyzed for VOC's and inorganic constituents.

Fractures at 50–59, 79–80, 196, 124–152, 182, 241, 256, and 350–354 ft btoc (feet below top of casing) were isolated in supply well 1. Specific capacities ranged from 0.26 to 5.7 (gal/min)/ft (gallons per minute per foot) of drawdown. The highest specific capacity was for the fracture isolated at 179.8–188 ft btoc. Specific capacity and depth of fracture were not related in either supply well. The highest concentrations of PCE were in water samples collected from fractures isolated at 236.8–245 and 249.8–258 ft btoc, which are hydraulically connected. The concentration of PCE generally increased with depth to a maximum of 39 µg/L (micrograms per liter) at a depth of 249.8–258 ft btoc and then decreased to 21 µg/L at a depth of 345.3–389 ft btoc.

Fractures at 68–74, 115, 162, 182, 205, and 314 ft btoc were isolated in supply well 2. Specific capacities ranged from 0.08 to less than 2.9 (gal/ min)/ft. The highest specific capacity was for the fracture isolated at 157–165.2 ft btoc. Concentrations of detected VOC's in water samples were 3.6 µg/L or less.

Lithologic units penetrated by both supply wells were determined by correlating natural-gamma and single-point-resistance borehole geophysical logs. All lithologic units are not continuous water-bearing units because water-bearing fractures are not necessarily present in the same lithologic units in each well. Although the wells penetrate the same lithologic units, the lithologic location of only three water-bearing fractures are common to both wells. The same lithologic unit may have different hydraulic properties in each well.

A regional ground-water divide is southeast of the supply wells. From this divide, ground water flows northwest toward Park Creek, a tributary to Little Neshaminy Creek. Potentiometric-surface maps were prepared from water levels measured in shallow and deep wells. For both depth intervals, the direction of ground-water flow is toward the northwest. For most well clusters, the vertical head gradient is downward from the shallow to the deeper part of the aquifer. Pumping of the supply wells at times can cause the vertical flow direction to reverse.

INTRODUCTION

The Willow Grove Naval Air Station/Joint Reserve Base (NAS/JRB) is in Horsham Township, Montgomery County, Pa. (fig. 1). In addition to its primary use as a reserve naval air station, this 1,000-acre facility also supports U.S. Marine and U.S. Army activities. The U.S. Air Force has property holdings within the base boundary and shares

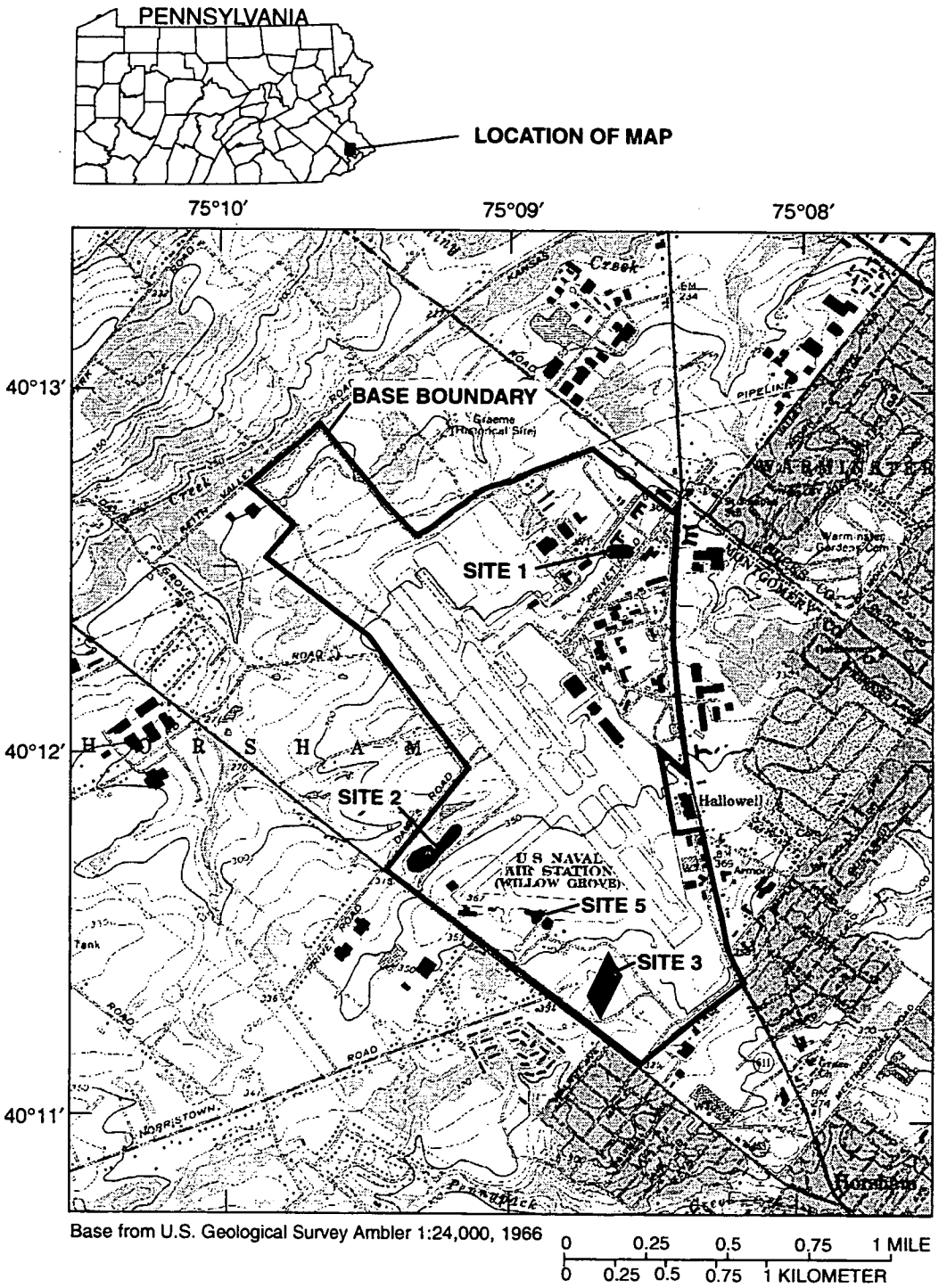


Figure 1. Location of the Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

common facilities with the U.S. Navy. Contaminated sites within the base (fig. 1) were identified by the U.S. Navy as part of a preliminary assessment program (Halliburton NUS Environmental Corporation, 1993). A hydrogeological investigation is being conducted as part of the U.S. Navy's Installation Restoration Program to address ground-water contamination at these sites.

Ground water pumped from supply well 1 (MG–209) and supply well 2 (MG–210) at the Willow Grove NAS/JRB provides water for use at the base, including potable water for drinking. The wells are at Site 1 (figs. 1 and 2). The supply wells have been contaminated by volatile organic compounds (VOC's), particularly trichloroethylene (TCE) and tetrachloroethylene (PCE), and the water is treated to remove the VOC's. Replacement of the pumps in these wells provided an opportunity for investigation of the geophysical and hydraulic properties of the wells and measurement of contaminant concentrations at different depths. This information can be used to further identify the contamination sources and to evaluate alternative management strategies for improving well efficiency and water quality.

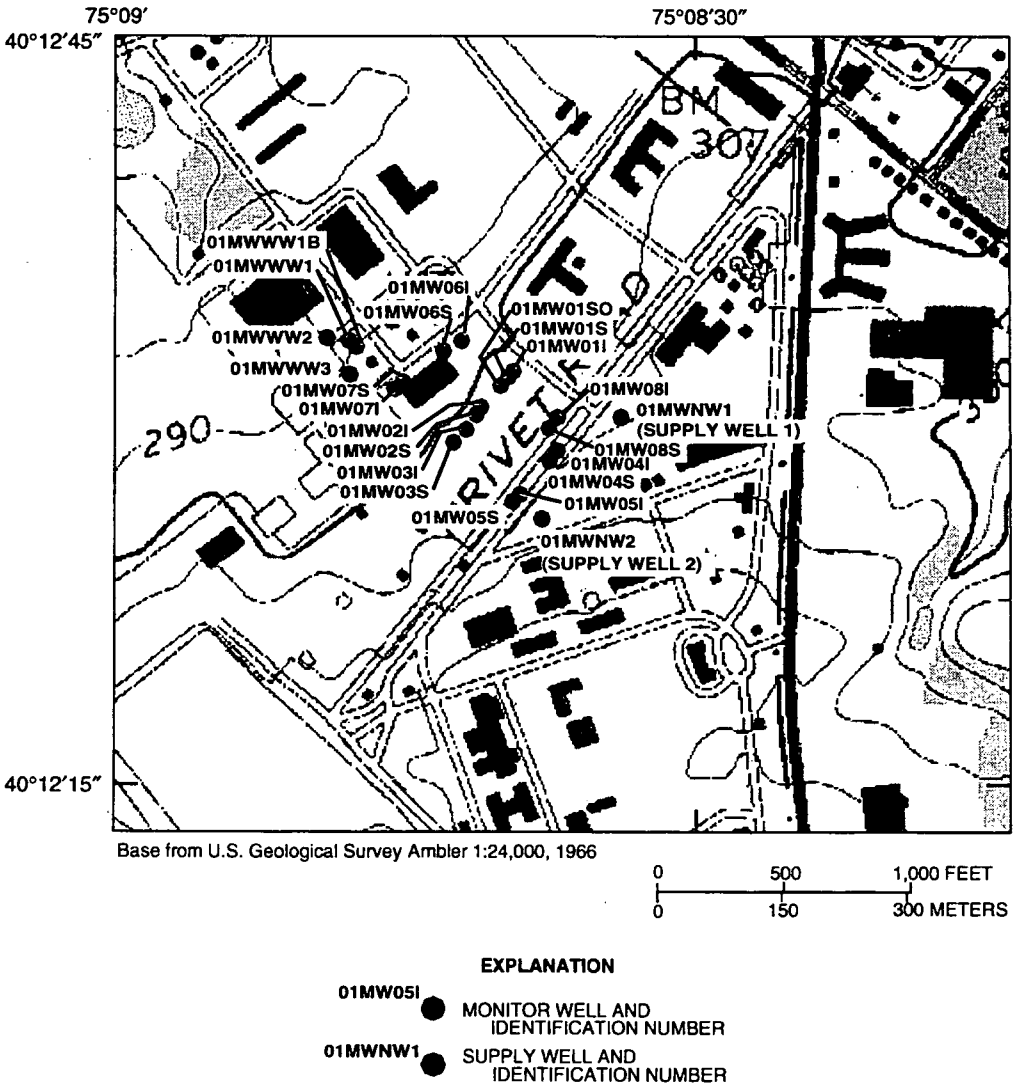


Figure 2. Locations of selected wells, Willow Grove Naval Air Station/ Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

The U.S. Navy requested the U.S. Geological Survey (USGS) provide technical assistance to their hydrogeological investigation. Specifically, the USGS was asked to conduct borehole geophysical logging and aquifer-isolation (packer) tests in supply wells 1 and 2 to characterize the geophysical and hydraulic properties, characterize the water quality of water-producing fractures, and collect and analyze water-level data. This work is a continuation of the Phase I and II borehole geophysical logging by the USGS (Conger, 1997; 1999). The USGS prepared this report as part of the environmental hydrogeological investigation at the Willow Grove NAS/JRB in cooperation with the U.S. Navy. Some data used for this study and presented in this report were provided by TetraTech NUS, Inc., an environmental contractor for the U.S. Navy.

Purpose and Scope

This report provides an interpretation and correlation of borehole geophysical logs and heat-pulse-flowmeter measurements collected in supply wells 1 and 2 by the USGS at the Willow Grove NAS/JRB and aquifer-isolation (packer) tests conducted by the USGS in those wells. This report describes drawdowns, water-level distributions, and specific capacities of isolated fractures. It describes the distribution of VOC's and inorganic constituents with depth. It also provides an interpretation of water-level data collected in the vicinity of the supply wells.

Hydrogeologic Setting

The Willow Grove NAS/JRB is in the Gettysburg-Newark Lowlands Section of the Piedmont Physiographic Province. The site and surrounding area are underlain by the Stockton Formation, which consists of sedimentary rocks of Triassic age. The Stockton Formation is subdivided into three units known as the lower arkose, middle arkose, and upper shale members (Rima and others, 1962). The middle arkose member crops out at the Willow Grove NAS/JRB, where it consists of fine- to medium-grained arkosic sandstone interbedded with red siltstone and mudstone. Quartz and feldspar are the dominant minerals. The Stockton Formation is about 6,000 ft thick at the Bucks-Montgomery County border (Rima and others, 1962). Bedding in the Stockton Formation at the base strikes N. 76° E. and dips about 7° NW (Brown and Root Environmental, Inc., 1998). Vertical fractures are common.

The rocks of the Stockton Formation form a complex, heterogeneous aquifer with partially connected zones of high permeability. The aquifer is composed of a series of gently dipping lithologic units with different hydraulic properties, and permeability commonly differs from one lithologic unit to another.

Ground water in the unweathered part of the Stockton Formation primarily flows through a network of interconnecting secondary openings: fractures, bedding planes, and joints. Primary porosity, that originally may have been present has been almost eliminated by compaction and cementation. Ground water in the weathered zone moves through intergranular openings formed as a result of weathering. In some places, permeability of the weathered zone may be poor because of a high percentage of clay derived from weathering of mudstone and siltstone.

Deep wells (greater than 100 ft) may penetrate several major water-bearing zones with different hydraulic properties. Each water-bearing zone usually has a different hydraulic head (water level). The head in a deep, open-hole well is the composite of the heads in the water-bearing zones penetrated. This can cause heads in some wells to be different than heads in adjacent wells of different depths. Where differences in head exist between water-bearing zones, water in the well bore flows in the direction of decreasing head. Wells that connect several water-bearing zones may act as conduits for the transport of contaminants (Sloto and others, 1996).

Ground water at the base originates from local infiltration of precipitation and inflow of ground water from upgradient areas. Ground-water levels fluctuate with seasonal variations in recharge and also are affected by pumping of wells. Water in the shallow part of the aquifer generally is under unconfined (water-table) conditions; ground water in the deeper part of the aquifer may be confined or partially confined. Local artesian (confined) conditions are common.

W ll-Identification Syst m

Two well-identification numbering systems are used in this report to maintain consistency with previous studies. U.S. Navy well-identification numbers are used for wells at the Willow Grove NAS/JRB. U.S. Navy well-identification numbers consist of a site-designation number, the letters MW, a sequentially assigned well-cluster number, and a depth-interval letter (S for shallow, I for intermediate). Well 01MW01S would indicate a shallow well in cluster 1 at Site 1. The USGS well-identification number consists of a county-abbreviation prefix followed by a sequentially assigned number. The prefix MG denotes a well in Montgomery County. A cross-reference between U.S. Navy and USGS well-identification numbers is given in table 1. Locations of the wells are shown on figure 2.

Table 1. *Record of selected wells, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

[Depths are given in feet below land surface. Water levels were measured on October 7, 1999; --, no data]

Site well-identification number	U.S. Geological Survey well-identification number	Well depth (feet)	Casing diameter (inches)	Open interval (feet)	Water level elevati n (feet ab ve sea level)
01MWNW1 (supply well 1)	MG–209	389	10	50–389	--
01MWNW2 (supply well 2)	MG–210	340	10	43–340	--
01MW01S	MG–1879	18	2	8–18	291.32
01MW01SO	MG–1880	33	2	23–33	291.31
01MW01I	MG–1632	85	2	75–85	291.49
01MW02S	MG–1881	27	4	7–27	291.50
01MW02I	MG–1882	88	4	78–88	291.58
01MW03S	MG–1883	26.5	4	6.5–26.5	291.53
01MW03I	MG–1631	79	2	69–79	291.59
01MW04S	MG–1884	35	4	15–35	291.82
01MW04I	MG–1885	90	4	80–90	294.39
01MW05S	MG–1886	38.5	4	18.5–38.5	291.73
01MW05I	MG–1887	85	4	75–85	295.76
01MW06S	MG–1888	26	4	6–26	290.54
01MW06I	MG–1889	85.5	4	74.5–84.5	290.53
01MW07S	MG–1890	26	4	2–26	290.39
01MW07I	MG–1891	84	4	74–84	291.45
01MW08S	MG–1892	34	2	23–34	291.76
01MW08I	MG–1633	86	2	76–86	291.72
01MWWW1	MG–1893	29	4	9–29	286.18
01MWWW1B	MG–1894	100	4	80–100	288.23
01MWWW2	MG–1895	21.7	4	--	284.07
01MWWW3	MG–1896	21.95	4	--	286.47

Pr vi us Inv stigati ns

The geology and hydrology of the Stockton Formation in southeastern Pennsylvania were described by Rima and others (1962). Sloto and others (1996) described the use of borehole geophysical methods to determine the extent of aquifer cross-contamination by VOC's through open boreholes in the Stockton Formation in adjacent Hatboro Borough and Warminster Township.

Previous studies at the Willow Grove NAS/JRB were conducted by Halliburton NUS Environmental Corporation (1993), and Brown and Root Environmental, Inc. (1997; 1998). USGS reports by Conger (1997; 1999) described the interpretation of borehole geophysical logs collected at the base. Sloto and others (2001) presented a potentiometric-surface map of the Willow Grove NAS/JRB and vicinity. Sloto (2002) described USGS hydrogeological investigations conducted at Site 5 and vicinity.

Acknowledgments

Borehole geophysical logging was conducted by Randall Conger, and borehole television surveys were conducted by Philip Bird of the USGS Pennsylvania District. Kevin Grazul, Abdul Mohammad, and Leif Olson of the USGS Pennsylvania District and Robert Rosman, Nicholas Smith, and Timothy Oden of the USGS New Jersey District assisted with the aquifer-isolation tests. Their assistance is appreciated greatly.

METHODS OF INVESTIGATION

Borehole Geophysical Logs

Caliper, natural-gamma, single-point-resistance, fluid-resistivity, and fluid-temperature borehole geophysical logs were collected in supply wells 1 and 2. The logs were used to locate water-bearing fractures, determine the rate and direction of vertical movement of water in the borehole, and determine intervals to be isolated by straddle packers for the aquifer-isolation tests.

Caliper logs provide a continuous record of average borehole diameter, which is related to fractures, lithology, and drilling technique. Caliper logs were used to identify fractures and possible water-bearing openings. Correlation of caliper logs with fluid-resistivity and fluid-temperature logs was used to identify water-producing and water-receiving fractures or zones. The term fracture used in association with the caliper-log interpretations might identify a change in borehole diameter that may not necessarily indicate a bedding-plane separation, lithologic contact, or water-producing or water-receiving zone but may simply indicate an enlargement of the borehole.

Natural-gamma logs, also called gamma-ray logs, record the natural-gamma radiation emitted from rocks penetrated by the borehole. Uranium-238, thorium-232, and the progeny of their decay series and potassium-40 are the most common emitters of natural-gamma radiation. These radioactive elements are concentrated in clays by adsorption, precipitation, and ion exchange. Fine-grained sediments, such as mudstone or siltstone, usually emit more gamma radiation than sandstone. Geophysical logging with a gamma probe can be conducted in the water-filled, dry, cased, or uncased parts of the borehole. However, well casing reduces the gamma response. The gamma log also is used to correlate geologic units between wells (Keys, 1990).

Single-point-resistance logs record the electrical resistance between the borehole and an electrical ground at land surface. In general, resistance increases with grain size and decreases with borehole diameter, density of water-bearing fractures, and increasing dissolved-solids concentration of borehole water (Keys, 1990). A water-filled borehole is required for single-point-resistance logs, and they are run only for the saturated part of the formation below the casing. A single-point-resistance log is used to correlate lithology between wells and may help identify water-bearing fractures or zones.

Fluid-temperature logs provide a continuous record of the vertical water-temperature variation in the borehole. Fluid-temperature logs were used to identify water-producing and water-receiving zones and to determine intervals of vertical borehole flow. Water-producing and water-receiving zones usually are identified by sharp changes in temperature, and intervals of vertical borehole flow are identified by little or no temperature gradient.

Fluid-resistivity logs measure the electrical resistance of the water in the borehole. Resistivity is the reciprocal of fluid conductivity, and fluid-resistivity logs reflect changes in the dissolved-solids concentration of the borehole water. Fluid-resistivity logs are used to identify water-producing and water-receiving zones and to determine intervals of

vertical borehole flow. Water-producing and water-receiving zones usually are identified by sharp changes in resistivity. Intervals of vertical borehole flow usually are identified by a low-resistivity gradient between a water-producing and a water-receiving zone.

Measurement of Vertical Borehole Flow

The direction and rate of borehole-fluid movement were measured with a high-resolution heat-pulse flowmeter. The heatpulse flowmeter operates by diverting nearly all flow to the center of the tool where a heating grid slightly heats a thin zone of water. If vertical borehole flow is occurring, the water moves up or down the borehole to one of two sensitive thermistors (heat sensors). When a peak temperature is recorded by one of the thermistors, a measurement of direction and rate is calculated by the computer collecting the logging data. The range of flow measurement is about 0.01 to 1.5 gal/min in a 2- to 10-in. diameter borehole. Heatpulse-flowmeter measurements may be affected by poor seal integrity between the borehole and the flowmeter. If the seal between the borehole and the heatpulse flowmeter is not complete, some water can bypass the flowmeter, resulting in flow measurements that are less than the actual rate. The quantity of water bypassing the tool is a function of borehole size and shape and degree of fracturing. Although the heatpulse flowmeter is a calibrated tool, the data primarily are used as a relative indicator of water-producing zones.

Borehole Television Surveys

Borehole television surveys were conducted in supply wells 1 and 2 by lowering a waterproof video camera down the borehole and recording the image on video tape. The depth indicated on the video image may not correspond exactly to the geophysical logs because of slippage of the video cable. The borehole television surveys were used to characterize water-bearing fractures and to locate smooth sections of borehole to set packers.

Aquifer-Isolation Tests

Because most ground-water flow and contaminant movement at the Willow Grove NAS/JRB occurs in distinct water-bearing fractures rather than through primary openings in the bedrock, it is important to define the hydraulic and chemical characteristics of important, discrete water-bearing fractures. This characterization only can be performed by isolating each water-bearing fracture with straddle packers so that its properties can be separated from the other water-bearing fractures in the borehole. These tests are called aquifer-isolation tests and commonly are referred to as packer tests.

The straddle packer assembly consisted of two inflatable rubber bladders (packers) about 4 ft long set on 2-in.-diameter lift pipe with a pump set between the packers. The distance from the center of the upper packer to the center of the lower packer varied. Packer settings given in this report are from the bottom of the top packer to the top of the bottom packer. Isolated intervals are numbered in order from the top to the bottom of the well.

Several aquifer-isolation tests were conducted in each supply well. Intervals selected for aquifer-isolation tests were based on the borehole geophysical logs and borehole television surveys. The packer assembly was lowered to the selected depth in the borehole, and the packers were inflated against the borehole wall, isolating the selected interval. Exact depths to set packers were based on the location of smooth sections of borehole wall determined from the caliper logs and borehole television surveys. For the test of most intervals, both packers were inflated (fig. 3A). For the test of the lowermost isolated interval in supply well 1, only the upper packer was inflated (fig. 3B). Inflation of both packers created three intervals—an upper interval above the upper packer, the isolated interval between the packers, and a lower interval below the lower packer. Pressure in the packers was monitored continuously so that the packers always remained at maximum inflation. After the packers were inflated, water levels in each interval were allowed to stabilize before pumping began. Because of interference caused by the pumping of the supply well not being tested, water levels may not have stabilized completely before the start of the test. Water levels were recorded above, below, and in the isolated interval.

During aquifer-isolation tests, measurements of water levels were made in each interval by calibrated pressure transducers and recorded by a digital datalogger. Water levels initially were determined by electric measuring tapes; these water levels were used to calibrate the transducers. The transducers were set in measurement tubes open to the monitored intervals. The accuracy of the transducer in the isolated interval was ±0.06 ft. The

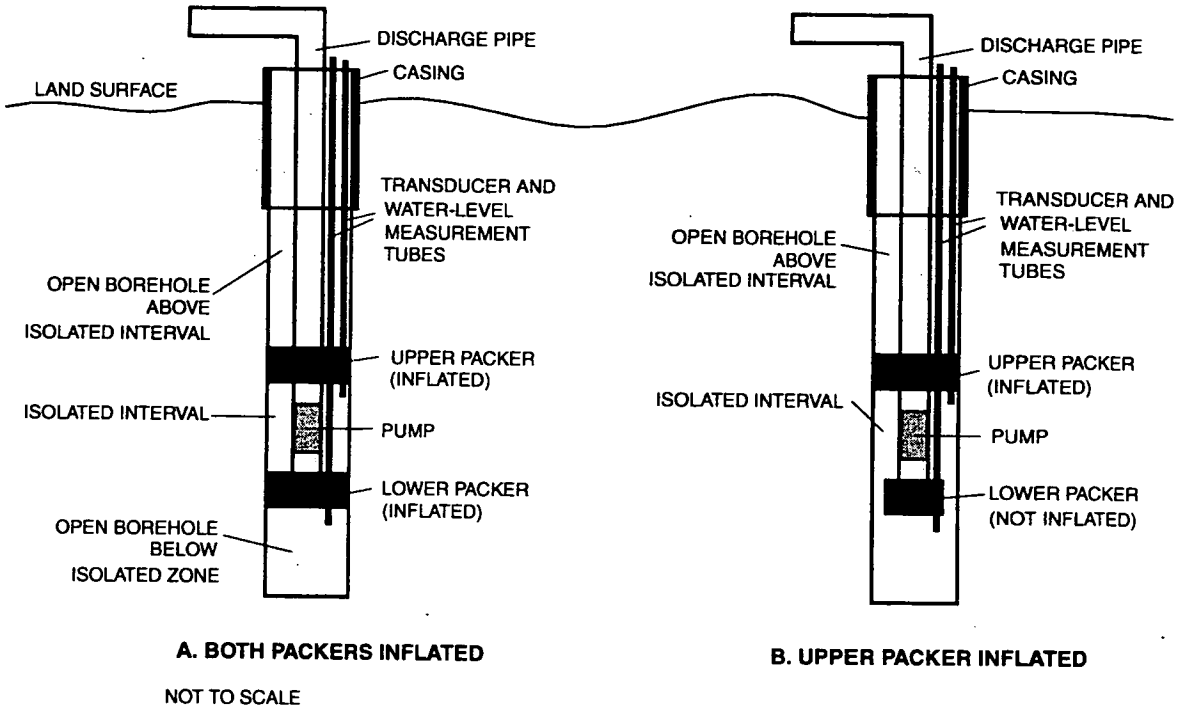


Figure 3. Generalized sketch of straddle-packer assembly and pump in borehole.

accuracy of the transducers used in the intervals above and below the isolated interval was ± 0.03 ft. Top of casing is used as a reference for all water-level measurements in this report. Calibrated, in-line flowmeters were used to measure discharge.

The specific capacity of each isolated interval was determined by dividing the pumping rate by the drawdown. Specific capacity is affected by the pumping rate and the length of pumping. In general, a higher pumping rate and/or a longer pumping duration will result in a lower specific capacity.

Water Quality

Water samples were collected for field determinations (dissolved oxygen, pH, specific conductance, and temperature) and laboratory analysis for inorganic constituents by the USGS and for laboratory analysis for VOC's by TetraTech NUS, Inc. Samples were collected near the end of each aquifer-isolation test from a sampling port placed in the discharge line before the flowmeter. Samples for field determinations and inorganic constituents were collected and measured according to established procedures (Wood, 1981). Samples for VOC analysis were collected in 40-milliliter septum bottles, placed on ice, and shipped overnight to the laboratory.

SUPPLY WELL 1

Supply well 1 (MG–209) is one of two wells supplying the U.S. Navy part of the Willow Grove NAS/JRB with potable water. USGS records from 1947 indicate the well was drilled in 1942 to a depth of 397 ft and cased with 26 ft of 16-in.-diameter outer casing and 52 ft of 10-in.-diameter inner casing.

Interpretation of Borehole Geophysical Logs

A suite of borehole geophysical logs (fig. 4) was collected in supply well 1 by the USGS on April 14, 2000. At the time of geophysical logging, supply well 2 was pumping, and the water-level decline in the aquifer was nearing stabilization; this stabilization was determined from the water level in well 01MW05I, which is affected by the pumping of supply well 2 (fig. 5). The fluid-temperature and fluid-resistivity logs and heat-pulse-flowmeter measurements are affected by the pumping of supply well 2 and reflect borehole conditions in supply well 1 during the pumping of supply well 2. The caliper log shows the well is 389 ft deep and is cased to 50 ft below top of casing (btoc). The well was drilled as a 10-in.-diameter borehole to 208 ft btoc and as an 8-in.-diameter borehole below 208 ft btoc. The caliper log shows major fractures at 50–59, 80, 85, 124–152, 165, 182, 199, 256, 296–300, 320, 350–355, 360–365, and 374–380 ft btoc. The fluid-temperature and fluid-resistivity logs indicate possible water-bearing zones at about 106, 144, 181, 257, and 353 ft btoc.

Heatpulse-flowmeter measurements were made under nonpumping conditions at 74, 120, 155, 175, 192, 220, 264, and 358 ft btoc (table 2). Flow measurements were attempted at 98, 309, and 340 ft btoc, but the rate and direction of flow could not be determined. On the basis of the geophysical logs, heatpulse-flowmeter measurements, and borehole television survey, water enters the upper part of the borehole through a vertical fracture just below casing at 50–59 ft btoc (1.2 gal/min) and flows downward. Water also enters the borehole through a horizontal fracture at 106 ft btoc (>0.3 gal/min) and flows downward. The fluid-resistivity and fluid-temperature logs indicate water may enter or exit the borehole through fractures between 140 and 150 ft btoc; however, this movement could not be confirmed because flow in this part of the borehole exceeded the upper resolution limit (1.5 gal/min) of the heatpulse flowmeter. Water flowing downward exits the borehole through a horizontal fracture at 182 ft btoc (2.1 gal/min) (fig. 6). Water also enters the borehole through horizontal fractures at 241–244 (determined from the head-distribution data for the aquifer-isolation test of interval 6), 256, and 350–355 ft btoc (>1.5 gal/min) and flows upward. Water flowing upward exits the borehole through fractures at 182 and 199 ft btoc (>0.8 gal/min). The principal water-bearing zones in supply well 1 are at 50–59, 106, 182, 199, 256, and 350–354 ft btoc. The fractures at 50–60, 106, 256, and 350–355 ft btoc are water-producing fractures. The fractures at 182 and 199 ft btoc are water-receiving fractures.

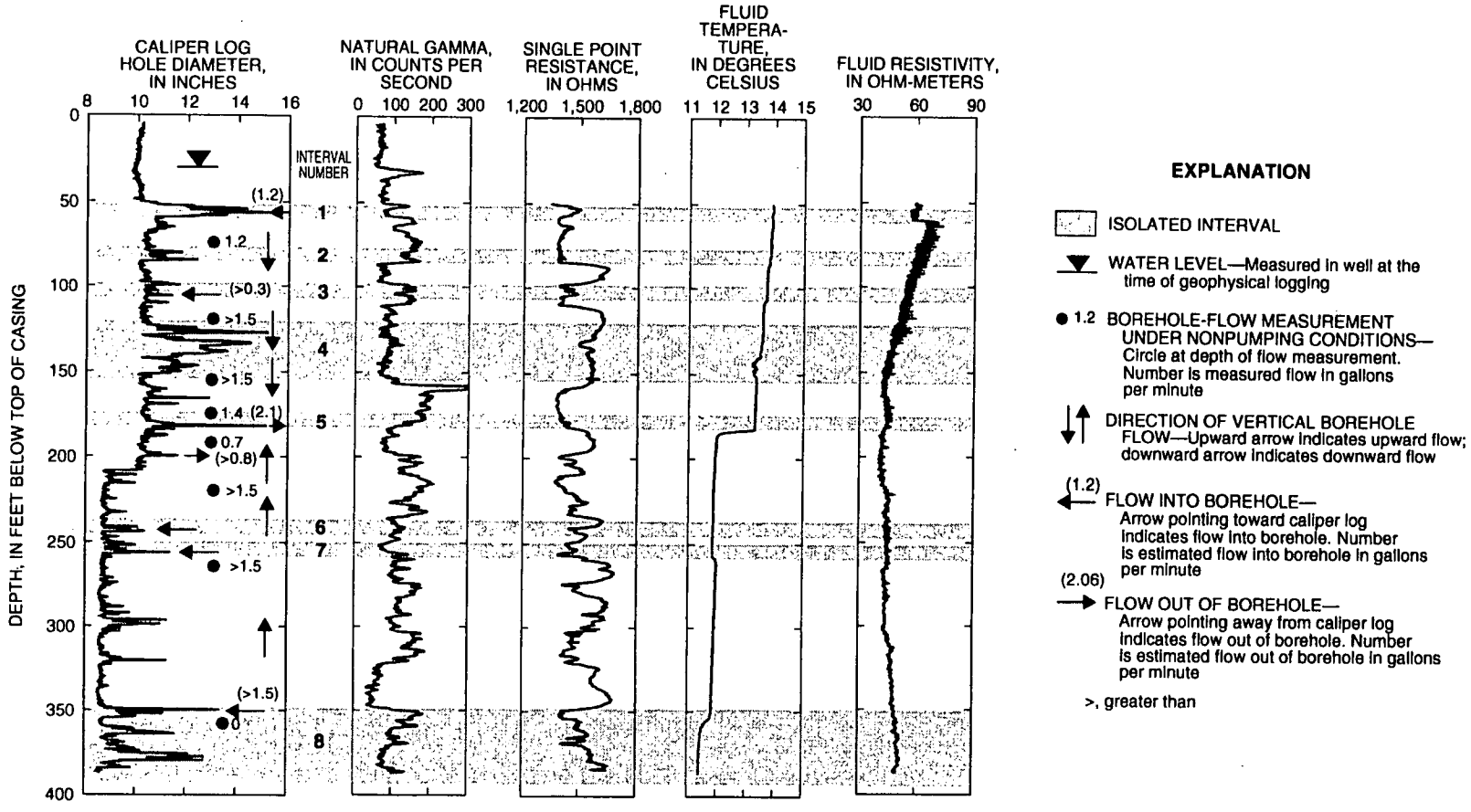


Figure 4. Borehole geophysical logs for supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

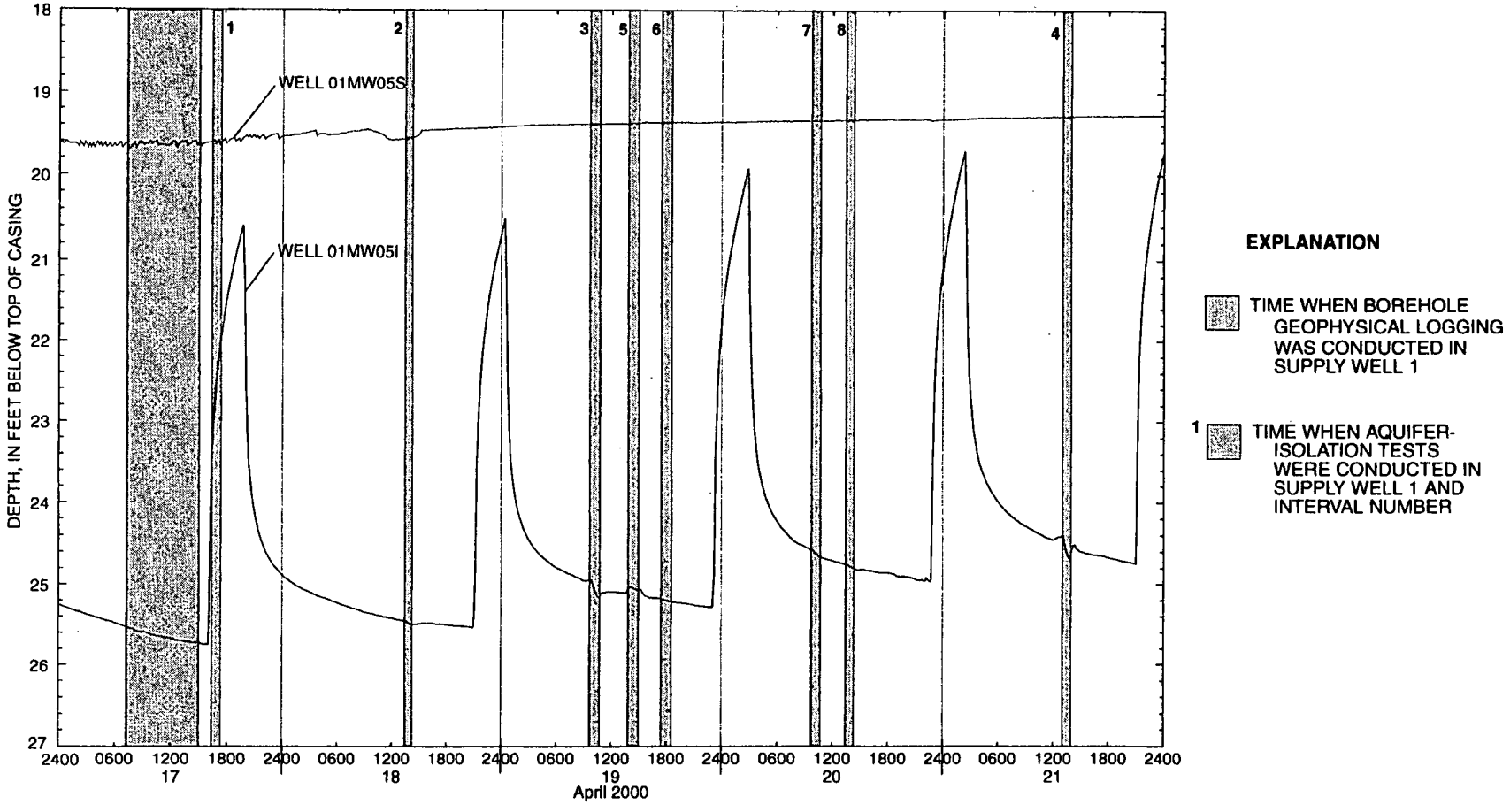


Figure 5. Hydrographs from wells 01MW05S and 01MW05I showing effect of pumping supply well 2, April 17–21, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Table 2. Heatpulse-flowmeter measurements made in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania

[>, greater than; --, flow occurring but rate and direction could not be determined]

Depth (feet below top of casing)	Flow (gallons per minute)	Flow direction
74	1.2	Down
98	--	--
120	>1.5	Down
155	>1.5	Down
175	1.4	Down
192	.7	Up
220	>1.5	Up
264	>1.5	Up
309	--	--
340	--	--
358	0	No flow

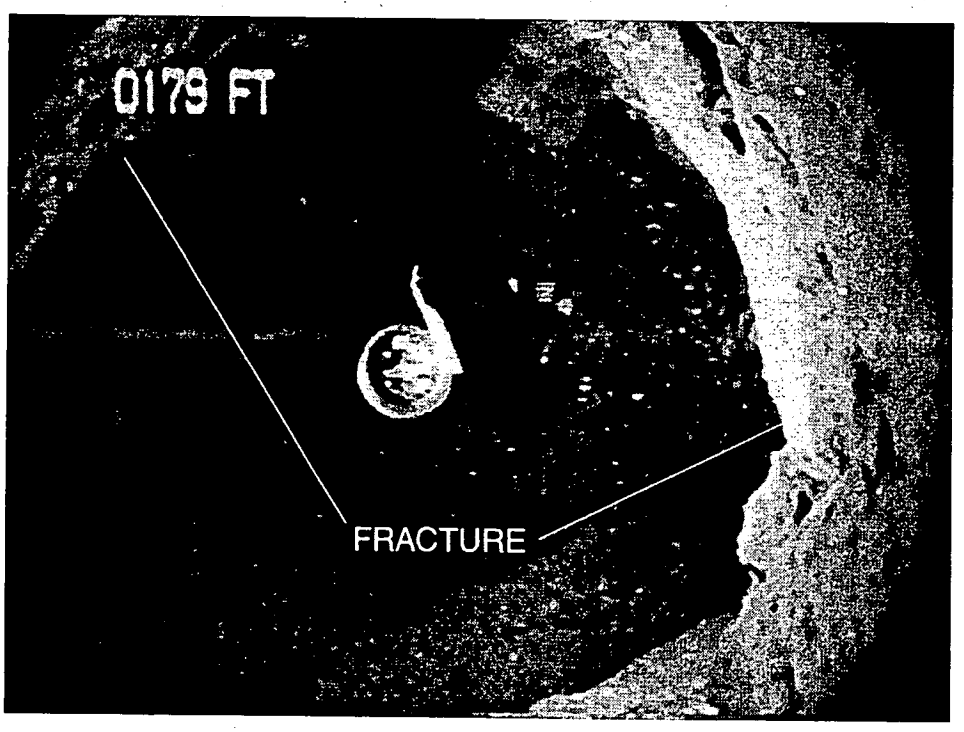


Figure 6. Borehole television survey showing horizontal fracture at 182 feet below top of casing in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Aquif r-Is lation Tests

On the basis of the borehole geophysical measurements, eight intervals were selected for aquifer-isolation tests in supply well 1 (table 3). A straddle-packer assembly was used to isolate discrete fractures to determine depth-discrete specific-capacity values and to obtain depth-discrete water samples. For the test of all intervals except interval 4, the distance between the bottom of the upper packer and the top of the lower packer was 8.2 ft, and both packers were inflated. For the test of interval 4, packer spacing was increased to 32.4 ft. For the test of interval 8, only the upper packer was inflated. Except for the test of interval 1, supply well 2 was pumping, and drawdown in the aquifer was nearing stabilization (fig. 5); this stabilization was determined from the water level in well 01MW05I, which is affected by the pumping of supply well 2.

Interval 1 (51.8–60 Feet Below Top of Casing)

For the aquifer-isolation test of interval 1, the bottom of the upper packer and the top of the lower packer were set at 51.8 and 60 ft btoc, respectively, to isolate the fracture zone at 50–59 ft btoc. Most of the upper packer was in the casing. Before packer inflation, the depth to water in the open borehole was 32.27 ft btoc. Fifty minutes after packer inflation, the depth to water in the isolated interval was 32.27 ft btoc (no change), and the depth to water in the interval below the packers was 32.18 ft btoc, an increase of 0.09 ft. The small change in water level probably was the result of a poor seal between the lower packer and the borehole wall.

At approximately 16:00 on April 17, the pump in supply well 2 shut down, and the water levels in both intervals began to rise. Pumping supply well 1 began at 16:12 at an initial rate of 5 gal/min, and the water levels continued to rise at approximately the same rate. The pumping rate then was increased to 23 gal/min. The water levels in both intervals continued to rise but at a lesser rate. After 65 minutes of pumping, the depth to water in the isolated interval rose 5.41 ft, and the depth to water in the interval below the packers rose 4.20 ft. The specific capacity of interval 1 could not be calculated because the water level in the isolated interval rose throughout the test.

Table 3. *Intervals isolated during aquifer-isolation tests conducted in supply well 1 (MG–209), April 17–21, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

[ft, feet; ft btoc, feet below top of casing; gal/min, gallons per minute; (gal/min)/ft, gallons per minute per foot of drawdown; --, no data]

Interval	Depth of isolated fracture (ft btoc)	Bottom of top packer (ft btoc)	Top of bottom packer (ft btoc)	Final pumping rate (gal/min)	Drawdown (ft)	Specific capacity [(gal/min)/ft]
1	50–59	51.8	60	23	--	--
2	79–85	77.8	86	5.8	20.90	0.28
3	106	98.8	107	21	50.01	.42
4	124–152	121	153.4	16	48.63	.33
5	182	179.8	188	22	3.87	5.7
6	241–244	236.8	245	12.7	49.57	.26
7	256	249.8	258	20	35.55	.56
8	350–354	345.3	Not inflated	22	6.01	3.7
--	Open-hole test[1]	--	--	200	20	10

[1] From data provided by TetraTech NUS, Inc., from an 8-hour open-hole aquifer test conducted March 15–16, 2000.

Interval 2 (77.8–86 Feet B low Top of Casing)

For the aquifer-isolation test of interval 2, the bottom of the upper packer and the top of the lower packer were set at 77.8 and 86 ft btoc, respectively, to isolate the fracture zone at 79–85 ft btoc. Supply well 2 was pumping during this test and all subsequent tests. Before packer inflation, the depth to water in the open borehole was 31.92 ft btoc. Eighty-nine minutes after packer inflation, the depth to water in the isolated interval was 22.38 ft btoc, an increase of 9.54 ft; the depth to water in the interval below the packers was 27.21 ft btoc, an increase of 4.71 ft; and the depth to water in the interval above the packers was 20.42 ft, an increase of 11.50 ft. This is consistent with the heatpulse-flowmeter measurements, which showed downward flow.

Pumping began at 13:30 at a rate of 5.5 gal/min (table 4). Because of sediment partially clogging the filter, the rate was unstable throughout the first 15 minutes of pumping. After the first 15 minutes, the rate became more stable and averaged about 5.8 gal/min. Total drawdown was 20.90 ft in the isolated interval, 1.03 ft in the interval below the packers, and 2.37 ft in the interval above the packers. The specific capacity of interval 2 is 0.28 (gal/min)/ft. The hydrographs for the interval above the packers, isolated interval, and interval below the packers (fig. 7) indicate a weak hydraulic connection among the three intervals.

Table 4. *Schedule for the aquifer-isolation test of interval 2 (77.8–86 feet below top of casing) in supply well 1 (MG–209), April 18, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
10:51	Start datalogger
12:03	Begin upper packer inflation
12:36	Begin lower packer inflation
13:30	Pump on
14:15	Pump off
14:26	Begin upper packer deflation
14:32	Begin lower packer deflation
14:45	Stop datalogger

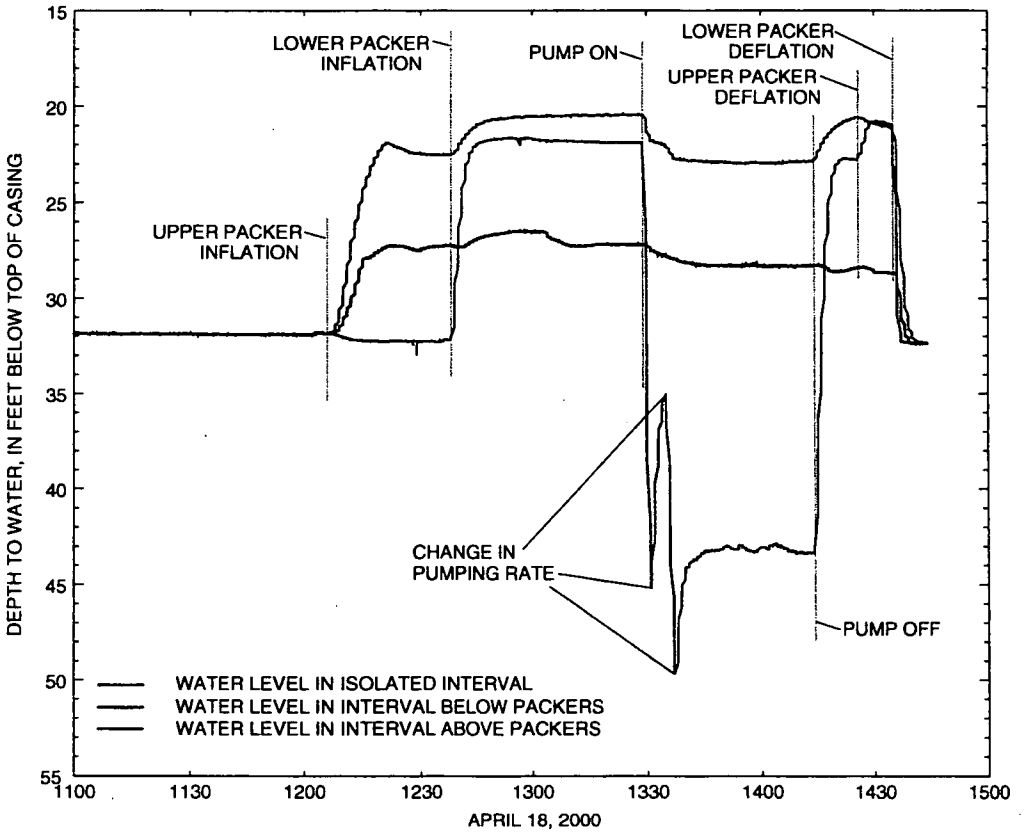


Figure 7. Hydrographs from aquifer-isolation test of interval 2 (77.8–86 feet below top of casing) in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Interval 3 (98.8–107 Feet B l w Top of Casing)

For the aquifer-isolation test of interval 3, the bottom of the upper packer and the top of the lower packer were set at 98.8 and 107 ft btoc, respectively, to isolate the fracture at 106 ft btoc. Before packer inflation, the depth to water in the open borehole was 31.30 ft btoc. Twenty-seven minutes after packer inflation, the depth to water in the isolated interval was 21.4 ft btoc, an increase of 9.9 ft; the depth to water in the interval below the packers was 30.44 ft btoc, an increase of 0.86 ft; and the depth to water in the interval above the packers was 21.05 ft btoc, an increase of 10.25 ft. This is consistent with the heatpulse-flowmeter measurements, which showed downward flow.

Pumping began at 9:47 at an initial rate of 7 gal/min (table 5). After 6 minutes, the pumping rate was increased to 21 gal/min. Total drawdown was 50.01 ft in the isolated interval, 1.74 ft in the interval below the packers, and 19.94 ft in the interval above the packers. The specific capacity of interval 3 is 0.42 (gal/min)/ft. The hydrographs for the interval above the packers, isolated interval, and interval below the packers (fig. 8) indicate a weak hydraulic connection between the isolated interval and the interval below the packers and a strong hydraulic connection between the isolated interval and the interval above the packers.

Table 5. *Schedule and pumping rates for the aquifer-isolation test of interval 3 (98.8-107 feet below top of casing) in supply well 1 (MG–209), April 19, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
8:45	Start datalogger
9:05	Begin lower packer inflation
9:20	Begin upper packer inflation
9:47	Pump on at 7 gallons per minute
9:53	Increase pumping rate to 21 gallons per minute
10:40	Pump off
10:52	Begin lower packer deflation
11:05	Begin upper packer deflation
11:15	Stop datalogger

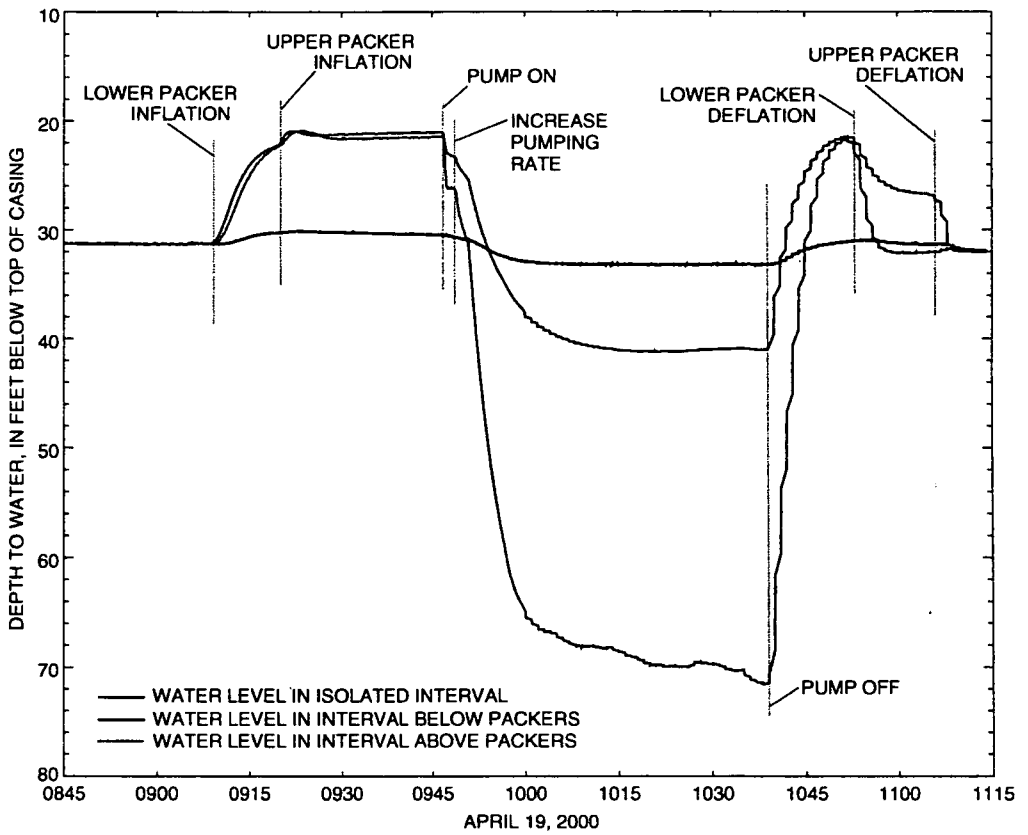


Figure 8. Hydrographs from aquifer-isolation test of interval 3 (96.8–107 feet below top of casing) in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Int rval 4 (121–153.4 Feet Below Top of Casing)

For the aquifer-isolation test of interval 4, the bottom of the upper packer and the top of the lower packer were set at 121 and 153.4 ft btoc, respectively, to isolate the fracture zone from 124–152 ft btoc. Before packer inflation, the depth to water in the open borehole was 30.86 ft btoc. Sixty-seven minutes after packer inflation, the depth to water in the isolated interval was 21.02 ft btoc, an increase of 9.84 ft; the depth to water in the interval below the packers was 31.53 ft btoc, a decrease of 0.67 ft; and the depth to water in the interval above the packers was 20.21 ft btoc, an increase of 10.65 ft. This is consistent with the heatpulse-flowmeter measurements, which showed downward flow.

Pumping began at 13:02 at a rate of 6.5 gal/min (table 6). After 5 minutes, the pumping rate was increased to 21 gal/min. After 8 minutes at this rate, the pumping rate was decreased to 16 gal/min. Total drawdown was 48.63 ft in the isolated interval, 0.68 ft in the interval below the packers, and 0.97 ft in the interval above the packers. The specific capacity of interval 4 is 0.33 (gal/min)/ft. The hydrographs for the interval above the packers, isolated interval, and interval below the packers (fig. 9) indicate a weak hydraulic connection among the three intervals.

Table 6. *Schedule and pumping rates for the aquifer-isolation test of interval 4 (121–153.4 feet below top of casing) in supply well 1 (MG–209), April 21, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
11:48	Start datalogger
11:55	Begin upper packer inflation
12:13	Begin lower packer inflation
13:02	Pump on at 6.5 gallons per minute
13:07	Increase pumping rate to 21 gallons per minute
13:15	Decrease pumping rate to 16 gallons per minute
13:50	Pump off
14:01	Begin upper packer deflation
14:17	Begin lower packer deflation
14:31	Stop datalogger

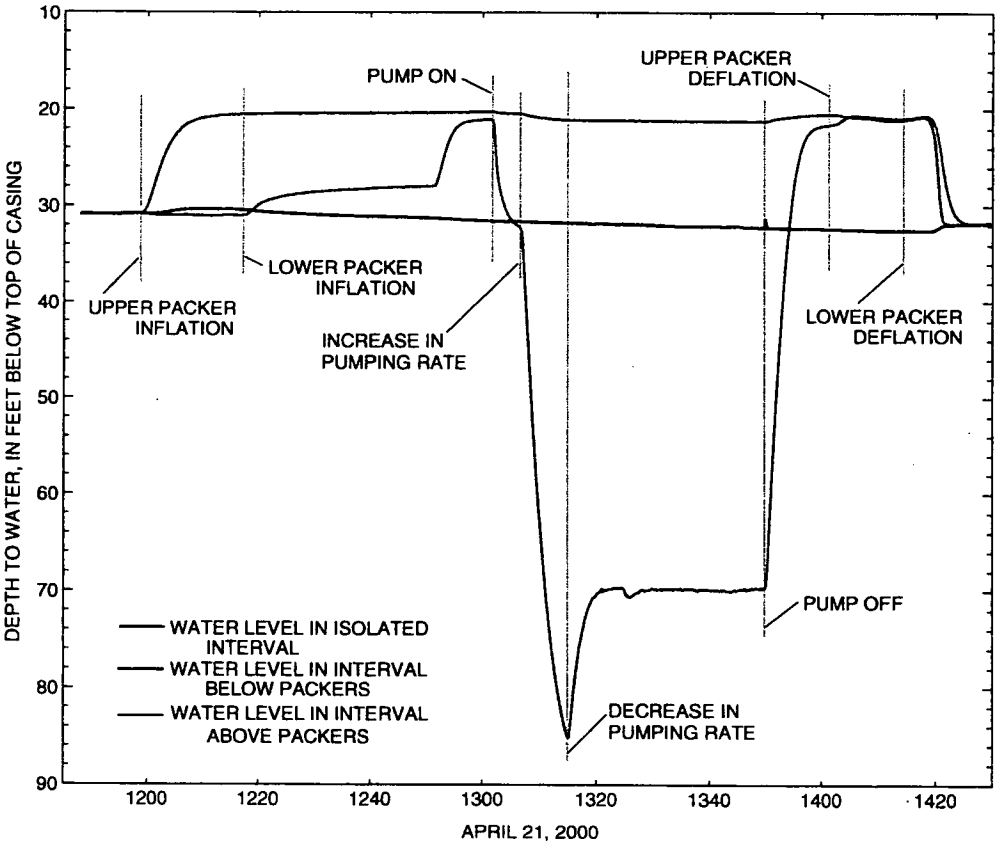


Figure 9. Hydrographs from aquifer-isolation test of interval 4 (121–153.4 feet below top of casing) in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Int rval 5 (179.8–188 Feet B l w Top of Casing)

For the aquifer-isolation test of interval 5, the bottom of the upper packer and the top of the lower packer were set at 179.8 and 188 ft btoc, respectively, to isolate the fracture at 182 ft btoc. Before packer inflation, the depth to water in the open borehole was 31.77 ft btoc. Twenty-three minutes after packer inflation, the depth to water in the isolated interval was 33.60 ft btoc, a decrease of 1.83 ft; the depth to water in the interval below the packers was 29.11 ft btoc, an increase of 2.66 ft; and the depth to water in the interval above the packers was 21.40 ft btoc, an increase of 10.37 ft. This is consistent with the heatpulse-flowmeter measurements, which showed downward flow from above the isolated interval and upward flow from below the isolated interval.

Pumping began at 13:55 at a rate of 7 gal/min (table 7). After 2 minutes, the pumping rate was increased to 22 gal/min. Total drawdown was 3.87 ft in the isolated interval and 0.73 ft in the interval below the packers. The water level rose 0.31 ft in the interval above the packers. The specific capacity of interval 5 is 5.7 (gal/min)/ft. The hydrographs for the interval above the packers, isolated interval, and interval below the packers (fig. 10) indicate a weak hydraulic connection between the isolated interval and the interval below the packers, and no hydraulic connection between the isolated interval and the interval above the packers.

The fracture at 182 ft btoc, which was isolated in the test of interval 5, has the greatest specific capacity of the isolated intervals tested in supply well 1. It is a water-receiving fracture, through which water flowing up and down the well bore exits the well. This fracture is the most hydraulically important fracture in supply well 1.

Table 7. *Schedule and pumping rates for the aquifer-isolation test of interval 5 (179.8–188 feet below top of casing) in supply well 1 (MG–209), April 19, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
12:54	Start datalogger
13:07	Begin lower packer inflation
13:32	Begin upper packer inflation
13:55	Pump on at 7 gallons per minute
13:57	Increase pumping rate to 22 gallons per minute
14:45	Pump off
14:53	Begin lower packer deflation
15:10	Begin upper packer deflation
15:20	Stop datalogger

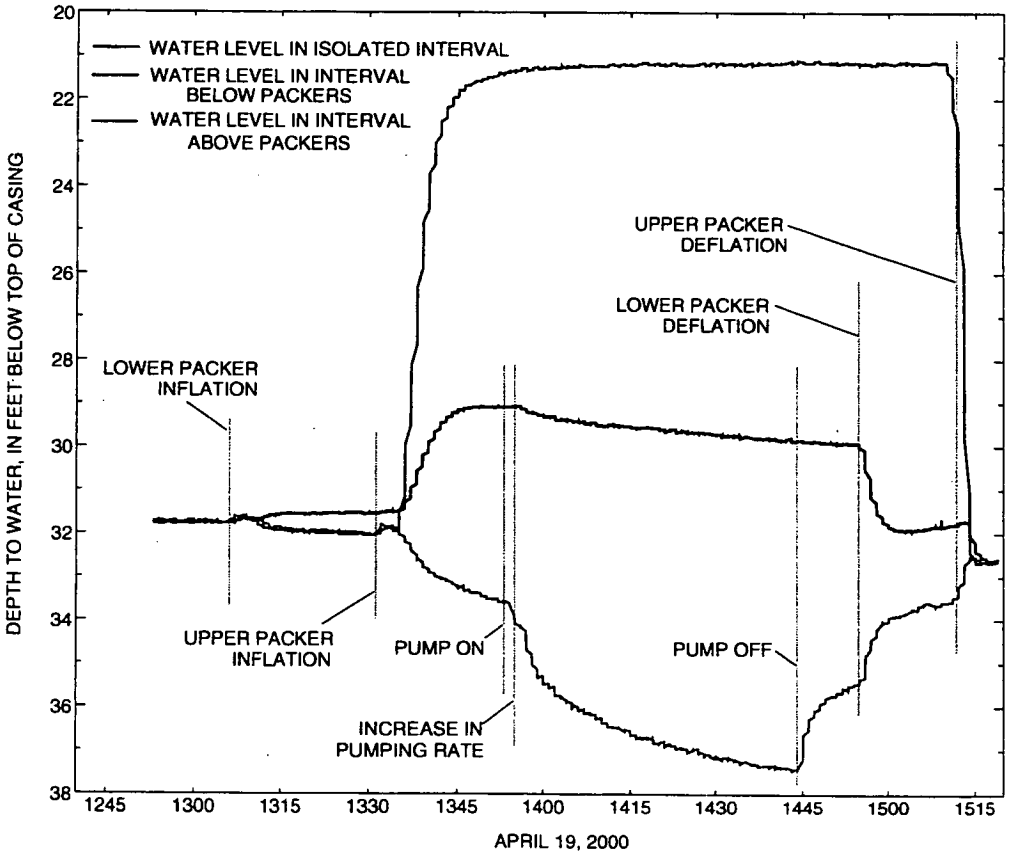


Figure 10. Hydrographs from aquifer-isolation test of interval 5 (179.8–188 feet below top of casing) in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Int rval 6 (236.8–245 Feet Bel w Top of Casing)

For the aquifer-isolation test of interval 6, the bottom of the upper packer and the top of the lower packer were set at 236.8 and 245 ft btoc, respectively, to isolate the fractures at 241–244 ft btoc. Before packer inflation, the depth to water in the open borehole was 32.10 ft btoc. Twenty-nine minutes after packer inflation, the depth to water in the isolated interval was 31.60 ft btoc, a decrease of 0.50 ft; the depth to water in the interval below the packers was 31.95 ft btoc, an increase of 0.15 ft; and the depth to water in the interval above the packers was 32.30 ft btoc, a decrease of 0.20 ft. This is consistent with the heatpulse-flowmeter measurements, which showed upward flow. The head distribution indicates the fracture isolated in this interval is a water-producing fracture that contributes water to borehole flow.

Pumping began at 17:35 at a rate of 12 gal/min (table 8). Total drawdown was 49.57 ft in the isolated interval, 1.59 ft in the interval below the packers, and 0.12 ft in the interval above the packers. The specific capacity of interval 6 is 0.26 (gal/min)/ft. The hydrographs for the interval above the packers, isolated interval, and interval below the packers (fig. 11) indicate a weak hydraulic connection between the isolated interval and the interval below the packers, and no hydraulic connection between the isolated interval and the interval above the packers.

Table 8. *Schedule for the aquifer-isolation test of interval 6 (236.8–245 feet below top of casing) in supply well 1 (MG–209), April 19–20, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Date	Time	Activity
April 19	17:00	Start datalogger
-	17:06	Begin lower packer inflation
-	17:17	Begin upper packer inflation
-	17:35	Pump on at 12 gallons per minute
-	18:16	Pump off
-	23:10	Supply well 2 off
April 20	3:00	Supply well 2 on
-	7:55	Begin lower packer deflation
-	8:11	Begin upper packer deflation
-	8:27	Stop datalogger

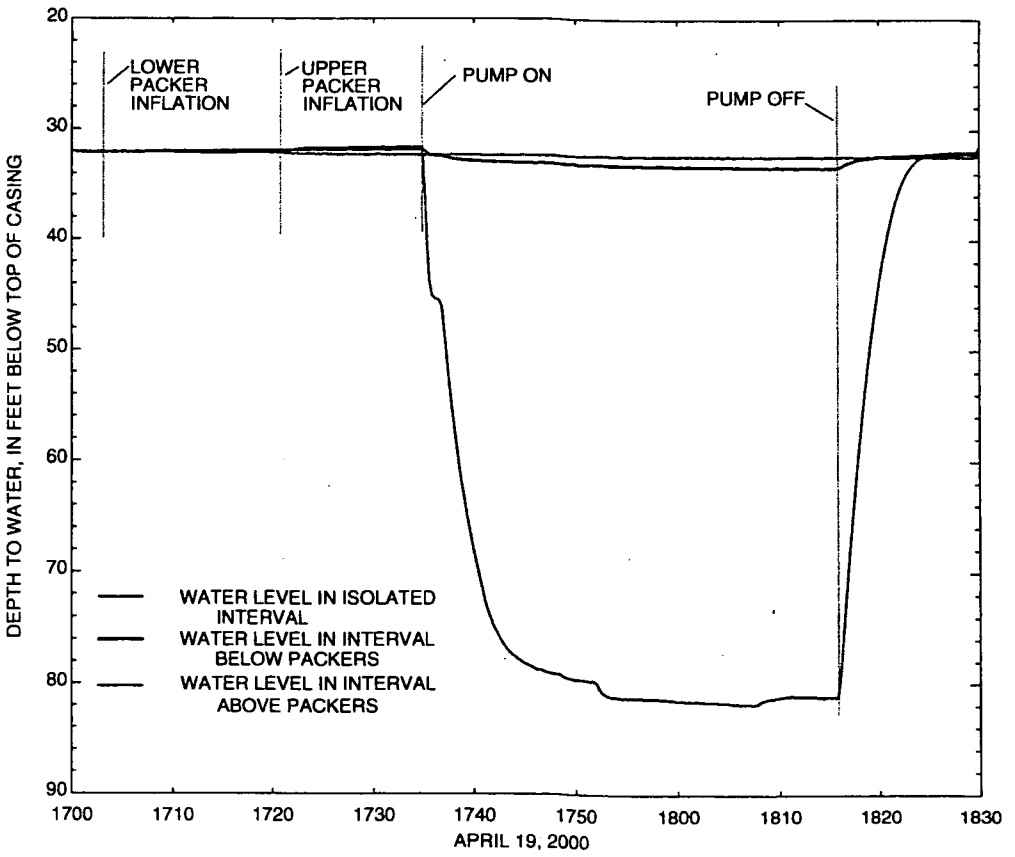


Figure 11. Hydrographs from aquifer-isolation test of interval 6 (236.8–245 feet below top of casing) in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

The packers were left inflated, and the datalogger was left running overnight. At approximately 23:10 on April 19, the pump in supply well 2 shut down. It restarted at approximately 3:00 on the morning of April 20. During this time period, the water levels in the three intervals of supply well 1 recovered. The depth to water in the isolated interval rose from 31.69 ft to 23.39 ft btoc, an increase of 8.30 ft. The depth to water in the interval below the packers rose from 31.96 ft to 23.10 ft btoc, an increase of 8.86 ft. The depth to water in the interval above the packers rose from 32.49 ft to 20.92 ft btoc, an increase of 11.57 ft (fig. 12).

While supply well 2 was pumping, the vertical flow direction was downward from the interval above the packers to the isolated interval and upward from the interval below the packers to the isolated interval. When supply well 2 stopped pumping, the vertical flow direction reversed, and flow was upward from the isolated interval to the interval above the packers and downward from the isolated interval to the interval below the packers.

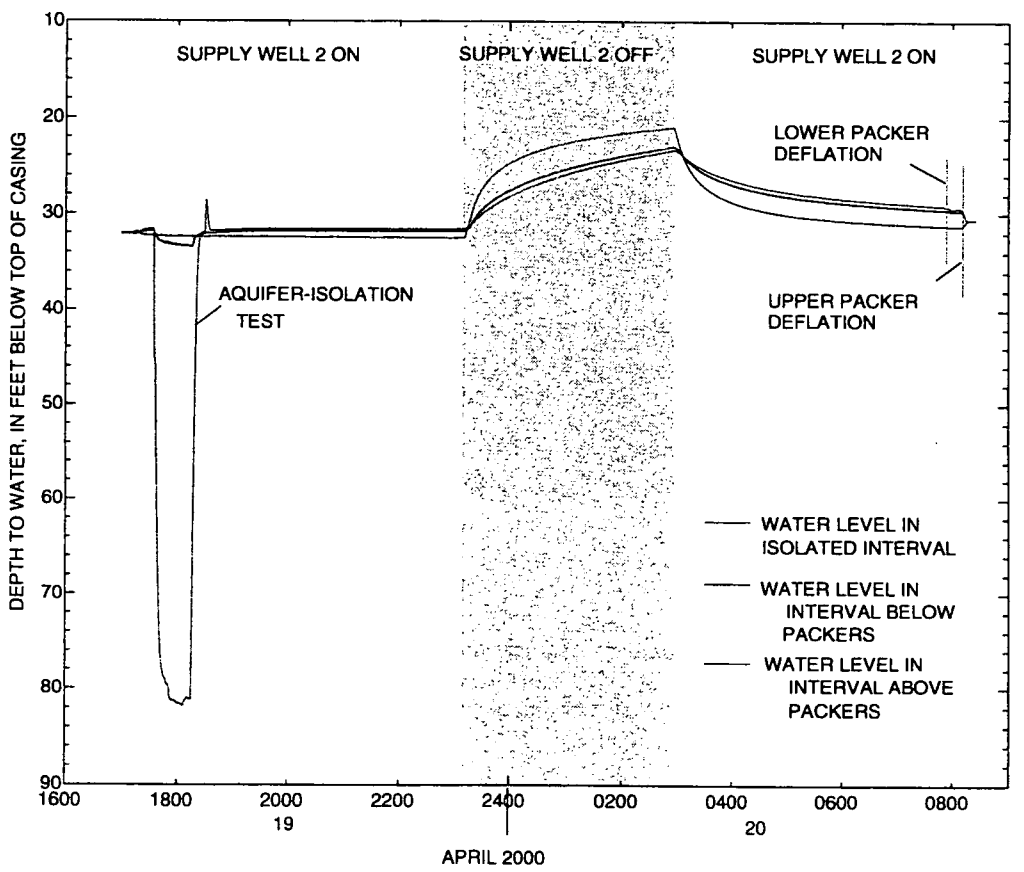


Figure 12. Hydrographs during and after aquifer-isolation test of interval 6 (236.8–245 feet below top of casing) in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Int rval 7 (249.8–258 Feet B low Top f Casing)

For the aquifer-isolation test of interval 7, the bottom of the upper packer and the top of the lower packer were set at 249.8 and 258 ft btoc, respectively, to isolate the fracture at 256 ft btoc. Before packer inflation, the depth to water in the open borehole was 30.69 ft btoc. Twenty-three minutes after packer inflation, the depth to water in the isolated interval was 28.97 ft btoc, an increase of 1.72 ft; the depth to water in the interval below the packers was 30.53 ft btoc, an increase of 0.16 ft; and the depth to water in the interval above the packers was 31.20 ft btoc, a decrease of 0.51 ft. This is consistent with the heatpulse-flowmeter measurements, which showed upward flow. The water-level distribution confirms the fracture isolated in this interval is a water-producing fracture that contributes water to borehole flow.

Pumping began at 9:45 at an initial rate of 5 gal/min (table 9). After 5 minutes, the pumping rate was increased to 20 gal/min. Total drawdown was 35.55 ft in the isolated interval, 0.53 ft in the interval below the packers, and 0.56 ft in the interval above the packers. The specific capacity of interval 7 is 0.56 (gal/min)/ft. The hydrographs for the interval above the packers, isolated interval, and interval below the packers (fig. 13) indicate a weak hydraulic connection among the three intervals.

Table 9. *Schedule and pumping rates for the aquifer-isolation test of interval 7 (249.8–258 feet below top of casing) in supply well 1 (MG–209), April 20, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
9:12	Start datalogger
9:17	Begin lower packer inflation
9:28	Begin upper packer inflation
9:45	Pump on at 5 gallons per minute
9:50	Increase pumping rate to 20 gallons per minute
10:25	Pump off
10:34	Begin lower packer deflation
10:42	Begin upper packer deflation
10:51	Stop datalogger

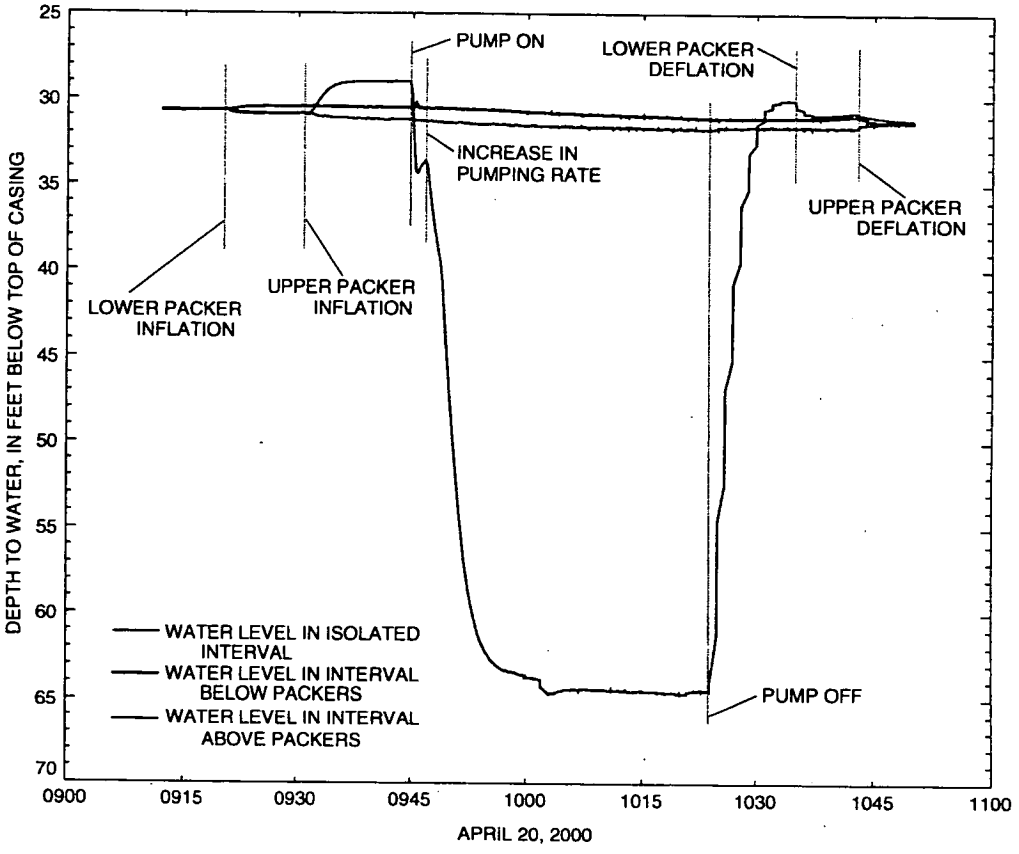


Figure 13. Hydrographs from aquifer-isolation test of interval 7 (249.8–258 feet below top of casing) in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Int rval 8 (345.3–389 Feet B low T p f Casing)

For the aquifer-isolation test of interval 8, the bottom of the upper packer was set at 345.3 ft btoc, and the lower packer was not inflated. Before packer inflation, the depth to water in the open borehole was 31.29 ft btoc. Twenty minutes after packer inflation, the depth to water in the isolated interval was 31.15 ft btoc, an increase of 0.14 ft, and the depth to water in the interval above the packers was 31.32 ft btoc, a decrease of 0.03 ft. This is consistent with the heatpulse-flowmeter data, which showed upward flow.

Pumping began at 13:20 at a rate of 4 gal/min (table 10). After 2 minutes, the pumping rate was increased to 22 gal/min. Total drawdown was 6.01 ft in the isolated interval and 0.49 ft in the interval above the packers. The specific capacity of interval 8 is 3.7 (gal/min)/ft. Isolated interval 8 has the second highest specific capacity of the isolated intervals tested in supply well 1. This may be, in part, because isolated interval 8 is longer (43.7 ft) than the other isolated intervals (8.3 ft for intervals 1–3 and 5–7 and 37.4 ft for interval 4). The hydrographs for the interval above the packers and the isolated interval (fig. 14) indicate a weak hydraulic connection between the two intervals.

Table 10. *Schedule and pumping rates for the aquifer-isolation test of interval 8 (345.3–389 feet below top of casing) in supply well 1 (MG–209), April 20, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
12:55	Start datalogger
13:00	Begin upper packer inflation
13:20	Pump on at 4 gallons per minute
13:22	Increase pumping rate to 22 gallons per minute
14:15	Pump off
14:25	Begin upper packer deflation
14:48	Stop datalogger

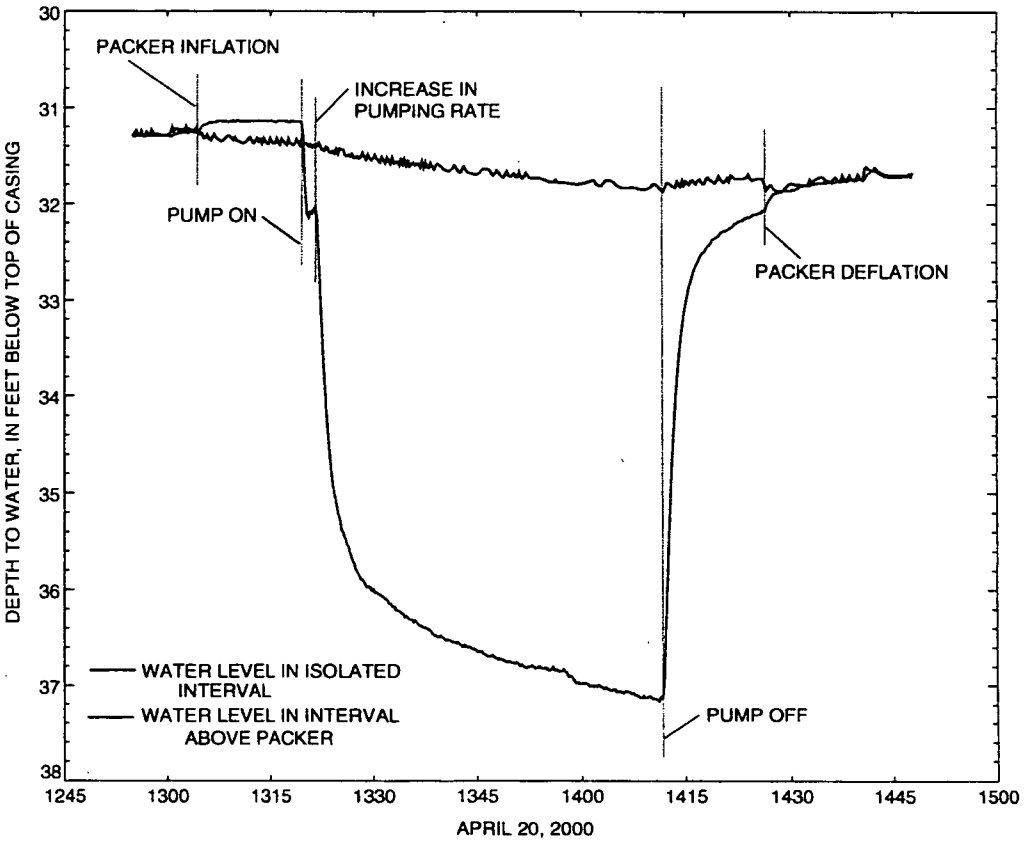


Figure 14. Hydrographs from aquifer-isolation test of interval 8 (345.3–389 feet below top of casing) in supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Vertical Distributi n of Wat r-Quality Constitu nts

During each aquifer-isolation test, water samples were collected by the USGS and analyzed for inorganic constituents and by TetraTech NUS, Inc. and analyzed for VOC's. Analytical results were used to determine change in concentration with depth. However, vertical mixing occurs in the aquifer and the well because of drawdown and recovery cycles in the supply wells, borehole flow when the supply wells are not pumping, and the pumping of one supply well affecting water levels (well interference) and borehole flow in the other supply well.

VOC's detected in water samples collected during aquifer-isolation tests and not attributable to laboratory contamination are listed in table 11. Cis-1,2-dichloroethylene (cis-1,2-DCE) is a degradation product of PCE and TCE and is present in samples where PCE is greater than 10 µg/L. Concentrations of cis-1,2-DCE, methylene chloride, TCE, toluene, and 1,1,1-trichloro-ethane (TCA) were less than 10 µg/L (table 11). The concentration of PCE generally increased with depth to a maximum of 39 µg/L at a depth of 249.8–258 ft btoc and then decreased to 21 µg/L at a depth of 345.3–389 ft btoc (fig. 15). The sample collected at 179.8–188 ft btoc was the only one in which toluene, TCE, PCE, and TCA all were detected.

The highest concentrations of PCE and TCE were in water samples collected from fractures isolated at 236.8–245 (interval 6) and 249.8–258 ft btoc (interval 7) (fig. 15). Concentrations of PCE and TCE were similar in those samples as were concentrations of dissolved oxygen and total dissolved solids (fig. 15), which indicates these fractures are hydraulically connected. The aquifer-isolation tests also indicated a hydraulic connection between the two intervals.

Inorganic constituents in water samples collected during aquifer-isolation tests are listed in table 12. The concentrations of total dissolved solids (fig. 15), calcium, magnesium (fig. 16), and strontium generally increase with depth. The concentrations of dissolved oxygen (fig. 15), chloride, and sulfate (fig. 16) generally decrease with depth.

Table 11. *Concentrations of selected volatile organic compounds in water samples collected during aquifer-isolation tests in supply well 1 (MG–209), April 17–21, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

[Laboratory results were provided by TetraTech NUS, Inc.; ft btoc, feet below top of casing; µg/L, micrograms per liter; ND, not detected, reporting limit is 10 µg/L; J, estimated result less than reporting limit of 10 µg/L]

Interval	Depth of sample (ft btoc)	Date sampled	cis-1,2-Dichloro-ethylene (µg/L)	Methylene chloride (µg/L)	Tetrachloro-ethylene (µg/L)	Trichloro-ethylene (µg/L)	Toluene (µg/L)	1,1,1-Trichloro-ethane (µg/L)
1	51.8–60	4/17/2000	ND	ND	4.0 J	ND	1.3 J	1.5 J
2	77.8–86	4/18/2000	ND	ND	1.7 J	ND	4.7 J	2.6 J
3	98.8–107	4/19/2000	ND	ND	2.0 J	ND	2.0 J	2.3 J
4	121–153.4	4/21/2000	ND	ND	6.2 J	ND	ND	ND
5	179.8–188	4/19/2000	1.0 J	ND	16	2.4 J	1.1 J	1.9 J
6	236.8–245	4/19/2000	3.9 J	ND	34	9.0 J	ND	ND
7	249.8–258	4/20/2000	4.7 J	2.2 J	39	8.3 J	ND	ND
8	345.3–389	4/20/2000	3.1 J	ND	21	8.3 J	ND	ND

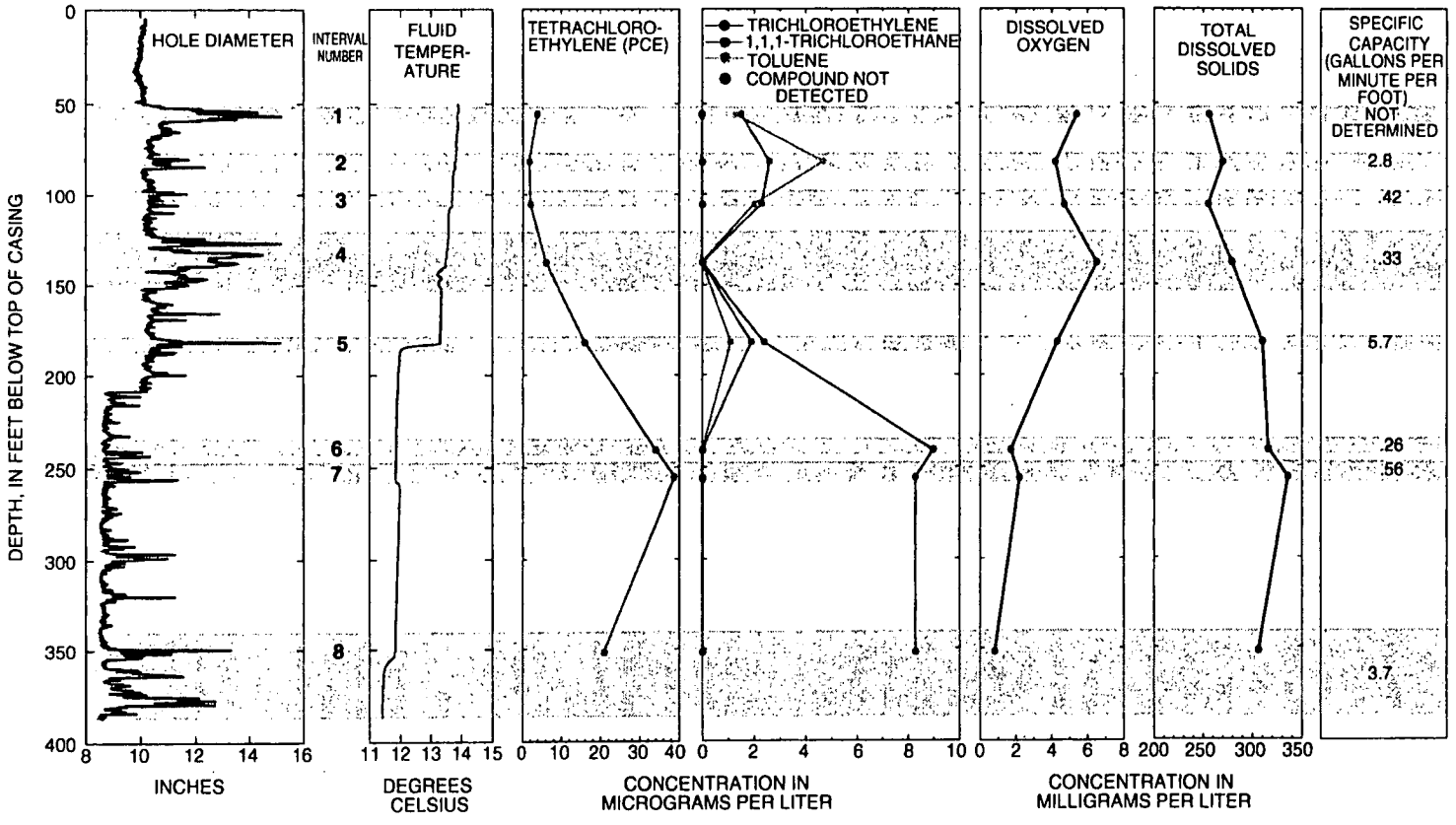


Figure 15. Concentration of tetrachloroethylene, trichloroethylene, 1,1,1-trichloroethane, toluene, dissolved oxygen, and total dissolved solids with depth in water samples from supply well 1 (MG–209), Willow Grove Naval Air Station/Joint R serve Base, Horsham Township, Montgomery County, Pennsylvania.

Table 12. Selected field determinations and concentrations of inorganic constituents in water samples collected during aquifer-isolation tests in supply well 1 (MG–209), April 17–21, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania

[ft btoc, feet below top of casing; mg/L, milligrams per liter; µS/cm at 25°C, microsiemens per centimeter at 25 degrees Celsius; C, Celsius; µg/L, micrograms per liter; <, less than; J, estimated result less than reporting limit of 2.2 µg/L]

Interval	Depth of sample (ft btoc)	Date sampled	Dissolved oxygen (mg/L)	pH (standard units)	Specific conductance (µS/cm at 25°C)	Temperature (degrees C)	Calcium (mg/L)
1	51.8–60	4/17/2000	5.4	6.2	460	14.4	44
2	77.8–86	4/18/2000	4.2	6.1	461	15.3	45
3	98.8–107	4/19/2000	4.7	6.1	443	15	43
4	121–153.4	4/21/2000	6.5	6.6	496	14.3	51
5	179.8–188	4/19/2000	4.3	6.6	519	15.2	53
6	236.8–245	4/19/2000	1.7	7.3	553	14.1	52
7	249.8–258	4/20/2000	2.2	7.5	588	14.1	57
8	345.3–389	4/20/2000	.8	7.4	534	14.1	48

Interval	Magnesium (mg/L)	Potassium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)	Sulfate, dissolved (mg/L)
1	16	1.3	19	52	< 0.1	32	37
2	15	1.2	21	49	<.1	33	57
3	14	1.2	20	52	<.1	33	42
4	18	1.2	19	60	<.1	32	20
5	24	1.4	20	52	<.1	31	29
6	33	1	16	37	<.1	26	17
7	33	1.1	16	40	<.1	30	12
8	34	1.2	16	35	<.1	23	23

Interval	Barium, dissolved (µg/L)	Iron, dissolve d (µg/L)	Manganese, dissolved (µg/L)	Strontium, dissolved (µg/L)	Total dissolved solids (mg/L)
1	125	12	<2.2	141	256
2	75	280	13	115	270
3	92	260	7.2	121	255
4	209	56	7.2	156	279
5	480	59	4.8	235	310
6	266	38	<2.2	335	316
7	354	35	<2.2	215	336
8	171	43	1.6 J	510	306

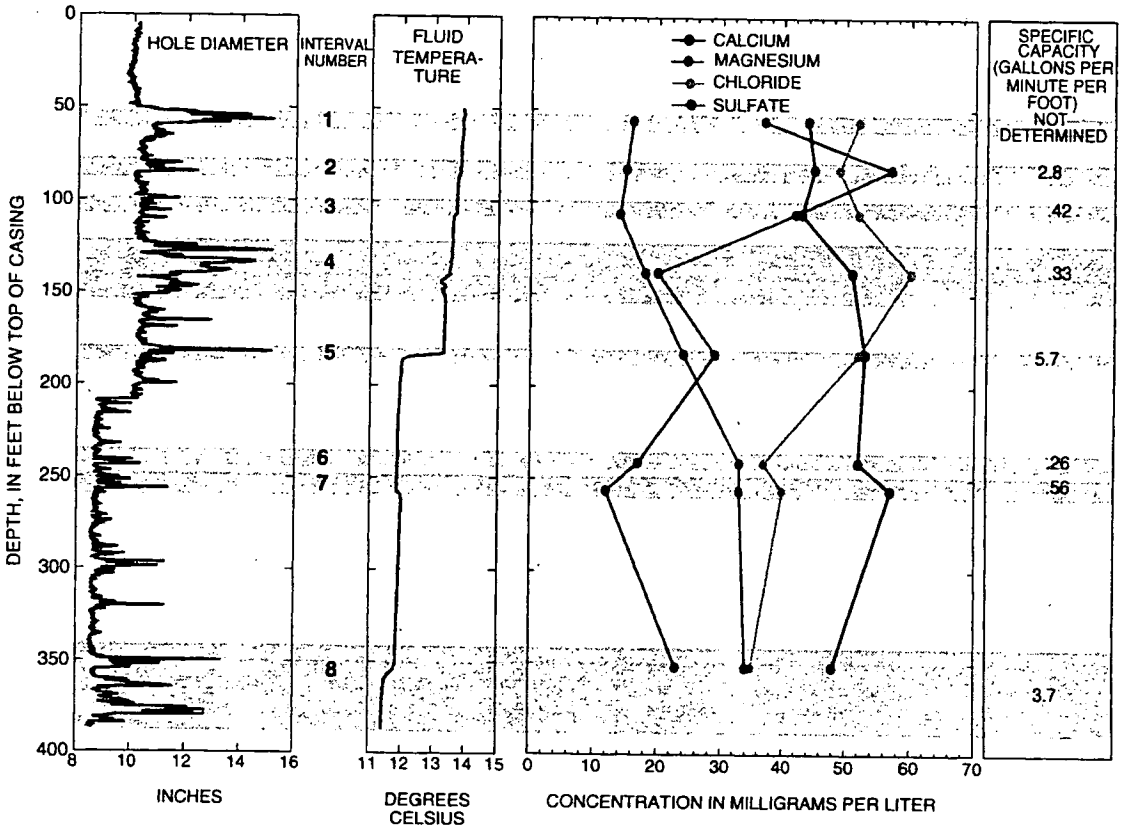


Figure 16. Concentration of calcium, chloride, magnesium, and sulfate with depth in water samples from supply well 1 (MG–209), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

SUPPLY WELL 2

Supply well 2 (MG–210) is one of two wells supplying the U.S. Navy part of the Willow Grove NAS/JRB with potable water. USGS records from 1947 indicate the well was drilled in 1942 to a depth of 351 ft and cased with 18 ft of 16-in.-diameter outer casing and 43 ft of 10-in.-diameter inner casing.

Interpretation of Borehole Geophysical Logs

A suite of borehole geophysical logs (fig. 17) was collected in supply well 2 by the USGS on March 17, 2000. At the time of geophysical logging, supply well 1 was pumping, and the water-level decline in the aquifer was nearing stabilization. The fluid-temperature and fluid-resistivity logs and heatpulse-flowmeter measurements are affected by the pumping of supply well 1 and reflect borehole conditions in supply well 2 during the pumping of supply well 1. The caliper log shows the well is 340 ft deep and is cased to 43 ft btoc. The well was drilled as a 10-in.-diameter borehole to 200 ft btoc and as an 8-in.-diameter borehole below 200 ft btoc. The caliper log shows major fractures and fracture zones at 43–53, 68–74, 93, 115, 162, 270, and 314 ft btoc. The fluid-temperature and fluid-resistivity logs indicate possible water-bearing zones at about 72, 113, 160, 205, 298, and 313 ft btoc.

Heatpulse-flowmeter measurements made under nonpumping conditions at 64, 85, 104, 132, 153, 184, 210, 238, 252, 282, 300, and 324 ft btoc (table 13) reveal a complicated pattern of borehole flow. On the basis of the geophysical logs and heatpulse-flowmeter measurements, water enters the upper part of the borehole through a vertical fracture at 68–74 ft btoc (1.2 gal/min) and flows downward. Water also enters the borehole through a horizontal fracture at 115 ft btoc (0.27 gal/min) (fig. 18) and flows downward. Water flowing downward exits the borehole through a large horizontal fracture at 162 ft btoc (1.53 gal/min total outflow). Water enters the borehole through a vertical fracture at 205 ft btoc (1.34 gal/min) and flows upward (0.1 gal/min) and downward (1.24 gal/min). The water flowing upward exits the borehole through the fracture at 162 ft btoc. Water flowing downward exits the borehole through a vertical fracture at 270 ft btoc (0.52 gal/min) (fig. 19) and a large horizontal fracture at 314 ft btoc (1.22 gal/min total outflow). A vertical fracture at 287 ft btoc (0.17 gal/min) contributes water to this downward flow. Water also enters the borehole through a vertical fracture at 331 ft btoc (0.1 gal/min) near the bottom of the borehole and flows upward. This water exits the borehole through the fracture at 314 ft btoc. The principal water-bearing fractures in supply well 2 are at 68–74, 115, 162, 205, 270, 287, 314, and 331 ft btoc. The fractures at 62–74, 115, 205, 287, and 331 ft btoc are water-producing fractures. The fractures at 162, 270, and 314 ft btoc are water-receiving fractures.

Table 13. *Heatpulse-flowmeter measurements made in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Depth (feet below top of casing)	Flow (gallons per minute)	Flow direction
64	0	No flow
85	1.20	Down
104	1.18	Down
132	1.45	Down
153	1.43	Down
184	.10	Up
210	1.24	Down
238	1.47	Down
252	1.47	Down
282	.95	Down
300	1.12	Down
324	.10	Up

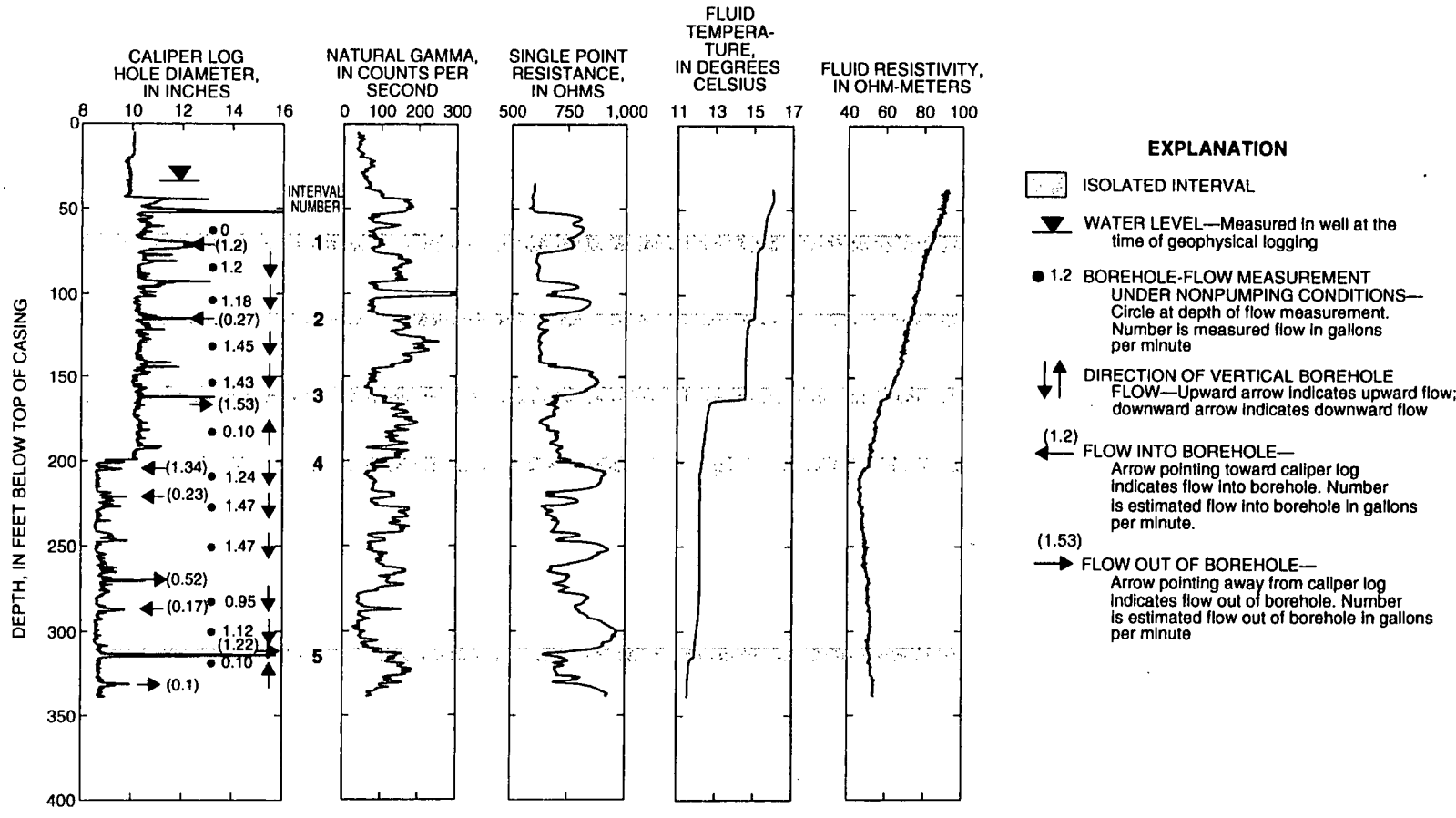


Figure 17. Borehole geophysical logs for supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

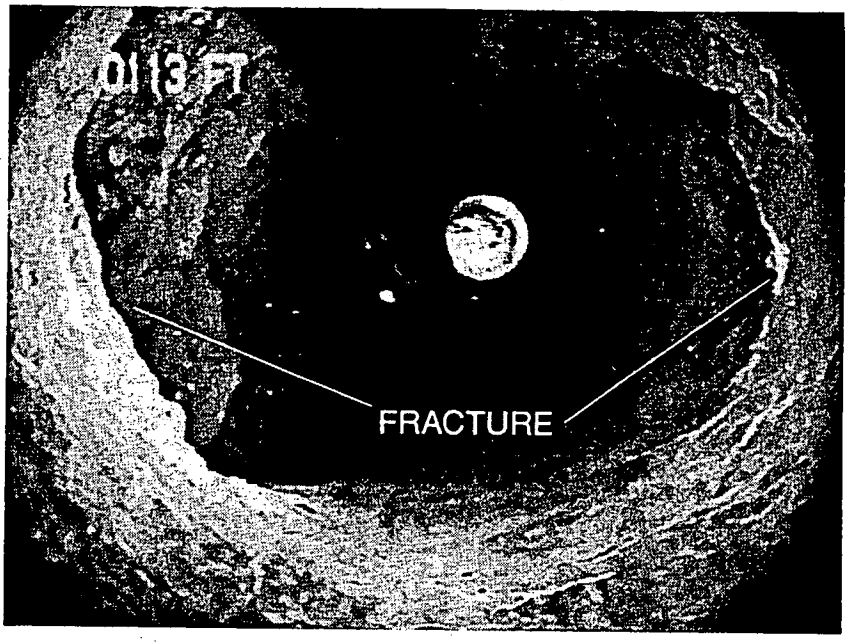


Figure 18. Borehole television survey showing horizontal fracture at 115 feet below top of casing in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

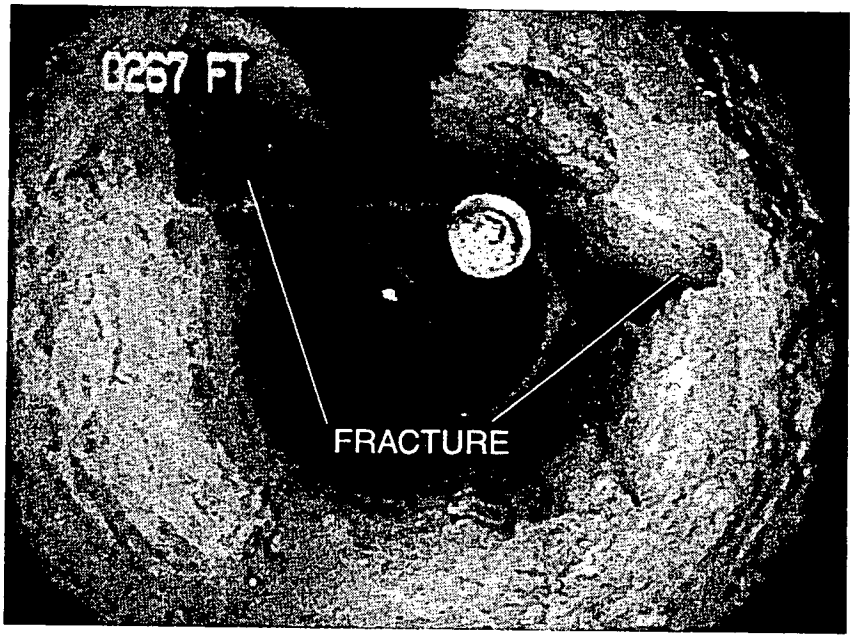


Figure 19. Borehole television survey showing vertical fracture at 270 feet below top of casing in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Aquif r-Is lati n Tests

On the basis of the borehole geophysical measurements and borehole television survey, five intervals were selected for aquifer-isolation tests in supply well 2 (table 14). A straddle-packer assembly was used to isolate discrete fractures to determine depth-discrete specific capacity and to obtain depth-discrete water samples. For the test of all five intervals, the distance between the bottom of the upper packer and the top of the lower packer was 8.2 ft, and both packers were inflated. For the test of intervals 1, 2, and 5, supply well 1 was pumping, and drawdown in the aquifer was nearing stabilization; this stabilization was determined from the water level in well 01MW05I, which is affected by the pumping of supply well 1 (fig. 20). For the test of intervals 3 and 4, supply well 1 was not pumping.

Int rval 1 (67–75.2 Feet B low Top of Casing)

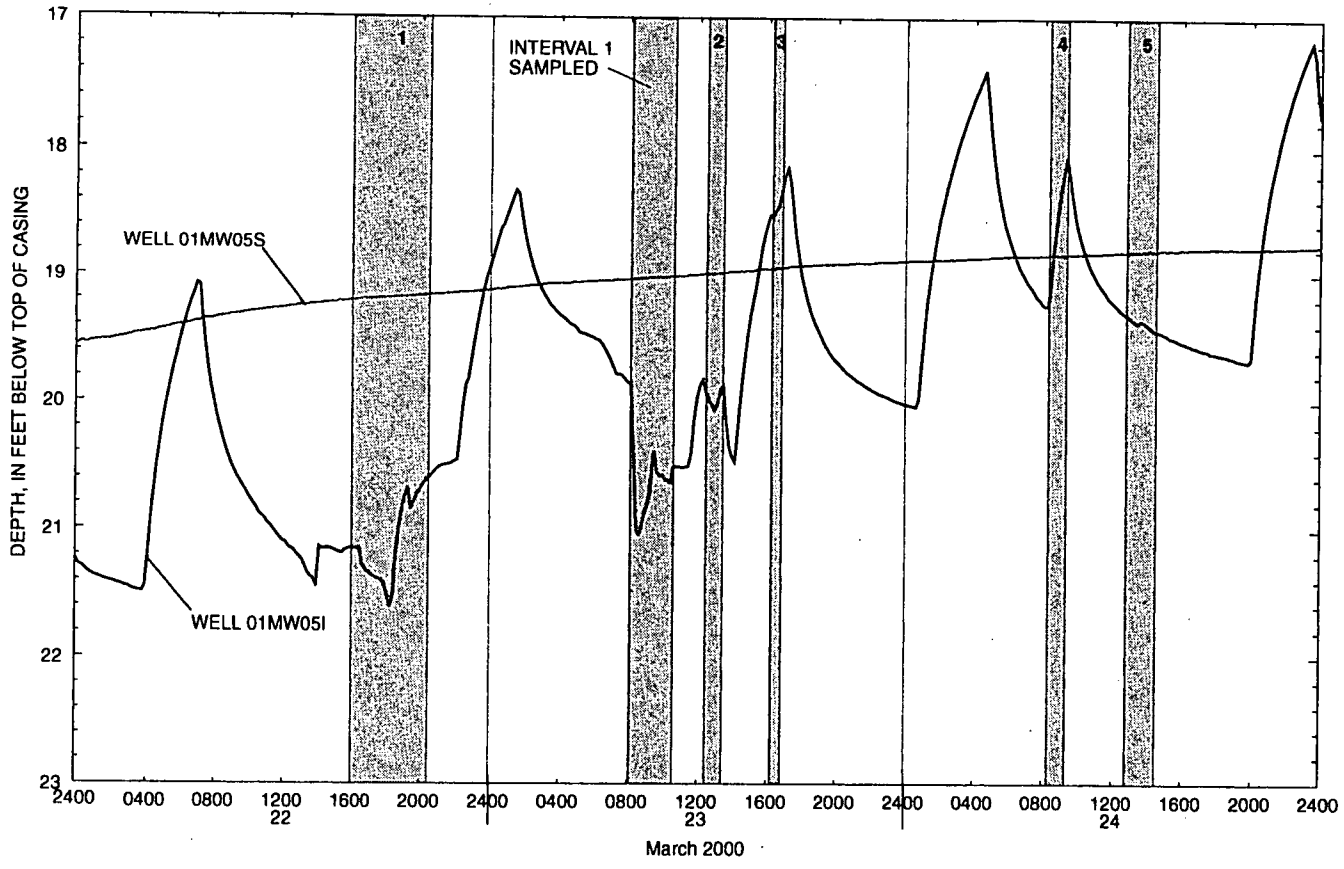
For the aquifer-isolation test of interval 1, the bottom of the upper packer and the top of the lower packer were set at 67 and 75.2 ft btoc, respectively, to isolate the fractures at 68–74 ft btoc. Before packer inflation, the depth to water in the open borehole was 33.11 ft btoc. Thirty-six minutes after packer inflation, the depth to water in the isolated interval was 33.41 ft btoc, a decrease of 0.30 ft; the depth to water in the interval below the packers was 33.39 ft btoc, a decrease of 0.28 ft; and the depth to water in the interval above the packers was 33.34 ft btoc, a decrease of 0.23 ft. The similar water levels probably resulted because the packers were not fully inflated.

Table 14. *Summary of intervals isolated during aquifer-isolation tests in supply well 2 (MG–210), March 22–24, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

[ft, feet; ft btoc, feet below top of casing; gal/min, gallons per minute; (gal/min)/ft, gallons per minute per foot of drawdown; <, less than; --, no data]

Interval	Depth of isolated fracture (ft btoc)	Bottom of top packer (ft btoc)	Top of bottom packer (ft btoc)	Final pumping rate (gal/min)	Drawdown (ft)	Specific capacity [(gal/min)/ft]
1	68–74	67	75.2	22	13.58	<1.6
2	115	111.5	119.7	10	11.17	.9
3	162	157	165.2	23	7.93	<2.9
4	205	197.7	205.9	6	54.43	--
5	314	310.5	318.7	4	47.14	.08
--	Open-hole test[1]	--	--	200	65	3

[1] From data provided by TetraTech NUS, Inc., from an 8-hour open-hole aquifer test conducted April 12, 2000.



EXPLANATION

1 TIME WHEN AQUIFER-ISOLATION TESTS WERE CONDUCTED IN SUPPLY WELL 2 AND INTERVAL NUMBER

Figure 20. Hydrographs from wells 01MW05S and 01MW05I showing the effect of pumping supply well 1, March 22–24, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Pumping began at 16:35 on March 22 at a rate of 22 gal/min (table 15). After 83 minutes, drawdown was similar in all three intervals. The pressure in the packers then was increased to achieve better separation of the intervals. After 32 additional minutes of pumping, total drawdown was 13.58 ft in the isolated interval, 3.50 ft in the interval below the packers, and 12.87 ft in the interval above the packers. The pump was shut down, but the packers were left inflated and the datalogger was left running overnight. The water level in the isolated interval still was declining rapidly when the test ended; therefore, the specific capacity of interval 1 is less than 1.6 (gal/min)/ft. The hydrographs for the interval above the packers, the isolated interval, and the interval below the packers (fig. 21) indicate either a poor seal between the upper packer and the borehole wall or a very strong hydraulic connection between the isolated interval and the interval above the packers and a strong hydraulic connection between the isolated interval and the interval below the packers.

Table 15. *Schedule for the aquifer-isolation test of interval 1 (67–75.2 feet below top of casing) in supply well 2 (MG–210), March 22–23, 2000, Willow Grove Naval Air Station/ Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Date	Time	Activity
March 22	15:39	Start datalogger
-	16:00	Begin packer inflation
-	16:35	Start pump at 22 gallons per minute
-	17:58	Increase packer pressure
-	18:30	Pump off
-	22:15	Supply well 1 off
March 23	1:35	Supply well 1 on
-	9:30	Begin packer deflation
-	9:43	Stop datalogger

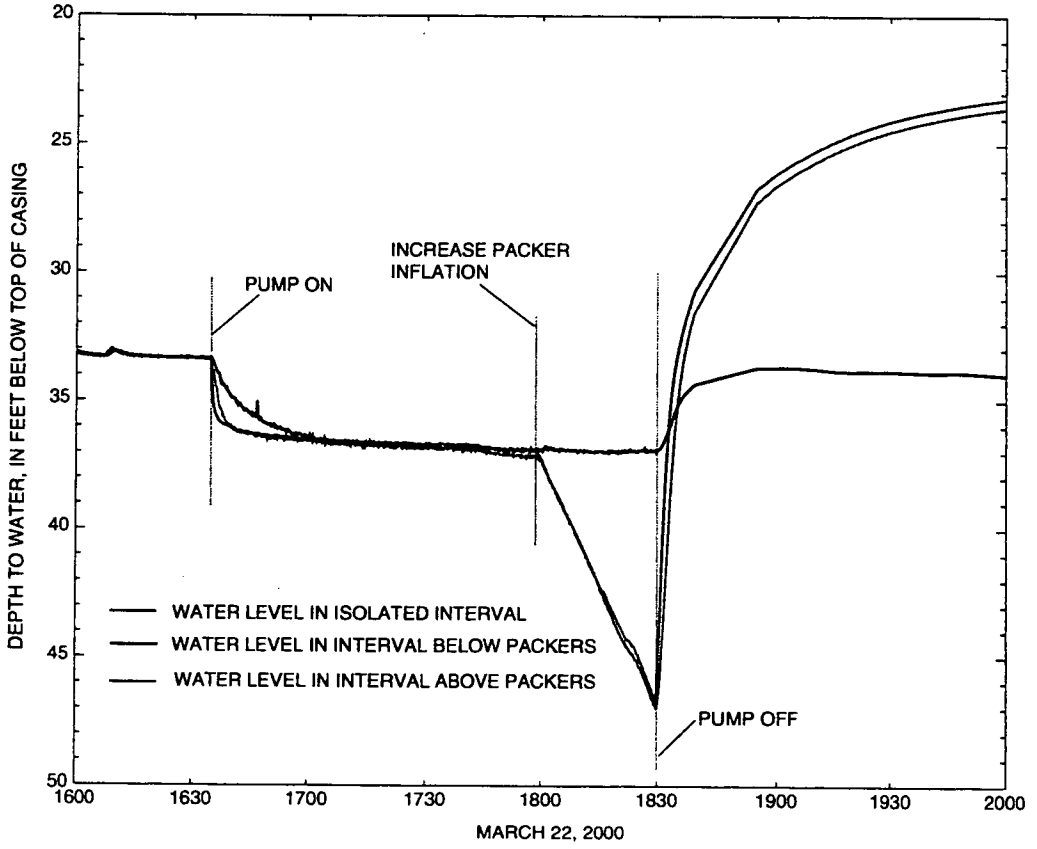


Figure 21. Hydrographs from aquifer-isolation test of interval 1 (67–75.2 feet below top of casing) in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

At approximately 22:15 on March 22, the pump in supply well 1 shut down. It restarted at approximately 1:35 on March 23. During this time, the water levels in the three intervals in supply well 2 recovered. The depth to water in the interval below the packers rose 10.13 ft, the depth to water in the isolated interval rose 2.51 ft, and the depth to water in the interval above the packers rose 2.49 ft (fig. 22). The pumping of supply well 1 caused more drawdown in the deeper (below 75.2 ft btoc) fractures than in the shallower (above 75.2 ft btoc) fractures.

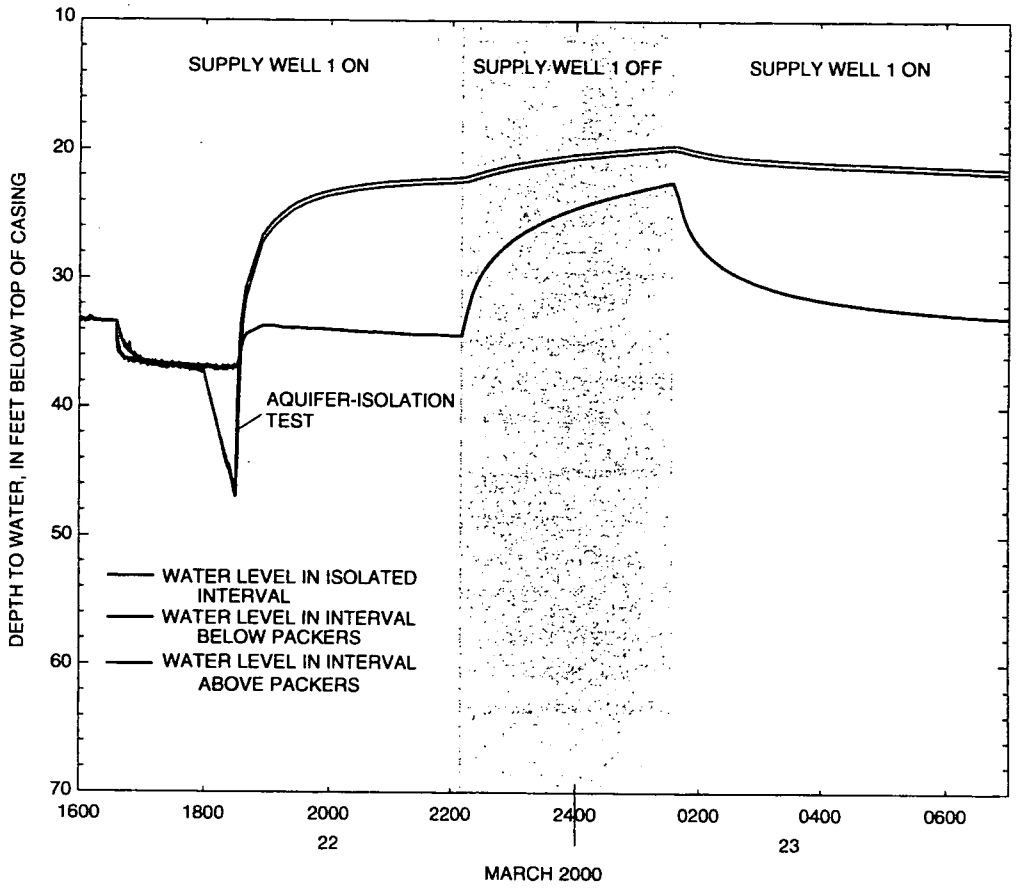


Figure 22. Hydrographs during and after the aquifer-isolation test of interval 1 (67–75.2 feet below top of casing) in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Interval 2
(111.5–119.7 Feet B l w T p f Casing)

For the aquifer-isolation test of interval 2, the bottom of the upper packer and the top of lower packer were set at 111.5 and 119.7 ft btoc, respectively, to isolate the water-producing fracture at 115 ft btoc. Before packer inflation, the depth to water in the open borehole was 33.17 ft btoc. At 67 minutes after packer inflation, the depth to water in the isolated interval was 28.66 ft btoc, an increase in water level of 4.51 ft; the depth to water in the interval below the packers was 30.39 ft btoc, an increase in water level of 2.78 ft; and the depth to water in the interval above the packers was 33.95 ft btoc, a decrease in water level of 0.78 ft.

Pumping began at 12:30 at an initial rate of 24 gal/min (table 16). After 2 minutes, the pumping rate was decreased to 5 gal/min. After another 4 minutes, the pumping rate was increased to 10 gal/min. After 41 minutes of pumping, the total drawdown was 11.17 ft in the isolated interval. The water level declined 0.44 ft in the interval below the packers and 0.26 ft in the interval above the packers. The specific capacity of interval 2 is 0.9 (gal/min)/ft. The hydrographs for the interval above the packers, the isolated interval, and the interval below the packers (fig. 23) indicate a weak hydraulic connection among the three intervals. Missing data for the interval above the packers from 11:40 to 11:48 were caused by the water level rising above the range of the transducer. After the transducer was moved to a higher location in the borehole, data collection continued.

Table 16. *Schedule and pumping rates for the aquifer-isolation test of interval 2 (111.5–119.7 feet below top of casing) in supply well 2 (MG–210), March 23, 2000, Willow Grove Naval Air Station/ Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
11:16	Start datalogger
11:24	Begin packer inflation
12:30	Start pump at 24 gallons per minute
12:32	Decrease pumping rate to 5 gallons per minute
12:36	Increase pumping rate to 10 gallons per minute
13:11	Pump off
13:32	Begin lower packer deflation
13:40	Begin upper packer deflation
13:53	Stop datalogger

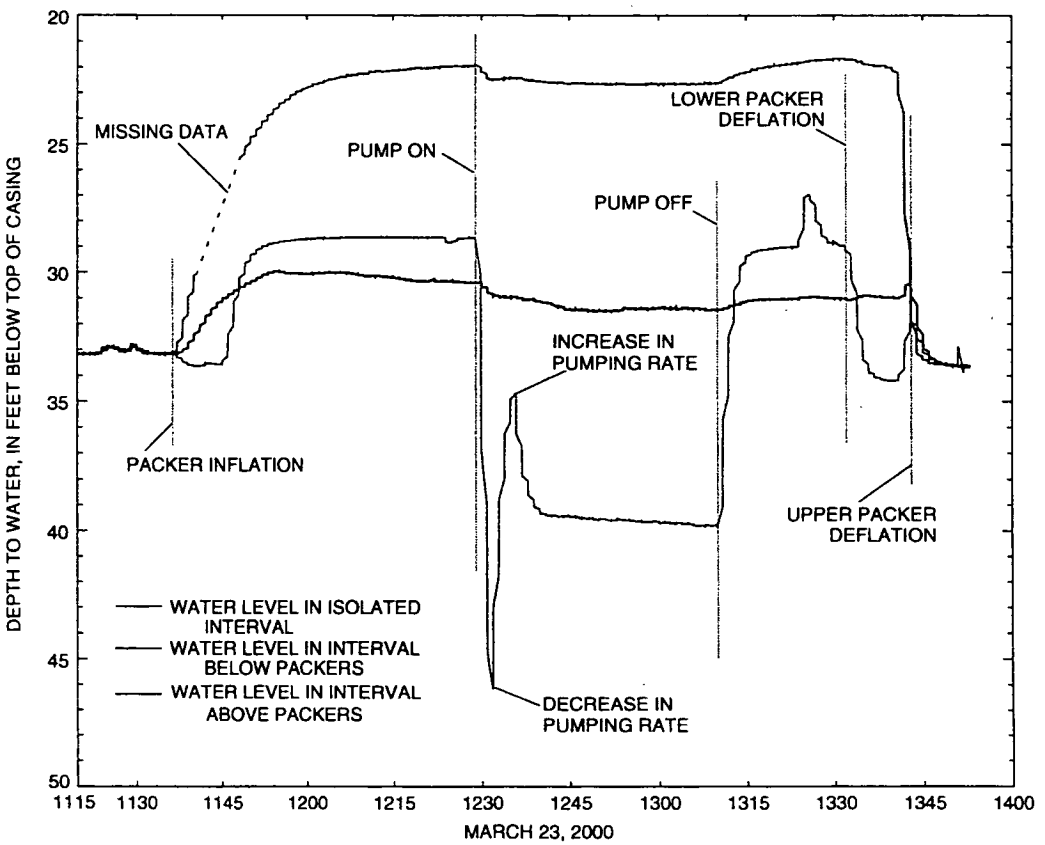


Figure 23. Hydrographs from aquifer-isolation test of interval 2 (111.5–119.7 feet below top of casing) in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Int rval 3 (157–165.2 Feet B low Top f Casing)

The aquifer-isolation test of interval 3 took place while supply well 1 was not pumping and recovery of water levels in the aquifer was taking place (fig. 20). The bottom of the upper packer and the top of the lower packer were set at 157 and 165.2 ft btoc, respectively, to isolate the water-receiving fracture at 162 ft btoc. No data were collected between 15:36 and 15:41. Before packer inflation, the depth to water in the open borehole was 25.14 ft btoc. Forty-eight minutes after packer inflation, the depth to water in the isolated interval was 25.82 ft btoc, a decrease in water level of 0.68 ft; the depth to water in the interval below the packers was 22.73 ft btoc, an increase in water level of 2.41 ft; and the depth to water in the interval above the packers was 22.36 ft btoc, an increase in water level of 2.78 ft. This is consistent with the heatpulse-flowmeter measurements that showed downward flow from above the isolated interval and upward flow from below the isolated interval.

Pumping began at 16:13 at 23 gal/min (table 17). After 37 minutes of pumping, drawdown in the isolated interval was 7.93 ft, drawdown in the interval below the packers was 0.42 ft, and drawdown in the interval above the packers was 0.57 ft. Because water levels in the aquifer were recovering during the test (fig. 20), drawdown was less than it would have been if water levels were stable; therefore, the specific capacity of interval 3 is less than 2.9 (gal/min)/ft. The hydrographs for the interval above the packers, the isolated interval, and the interval below the packers (fig. 24) indicate a weak hydraulic connection among the three intervals.

Table 17. *Schedule for the aquifer-isolation test of interval 3 (157–165.2 feet below top of casing) in supply well 2 (MG–210), March 23, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
14:10	Supply well 1 off
15:12	Start datalogger
15:25	Begin packer inflation
16:13	Start pump at 23 gallons per minute
16:50	Pump off
17:04	Begin packer deflation
17:10	Supply well 1 on
17:28	Stop datalogger

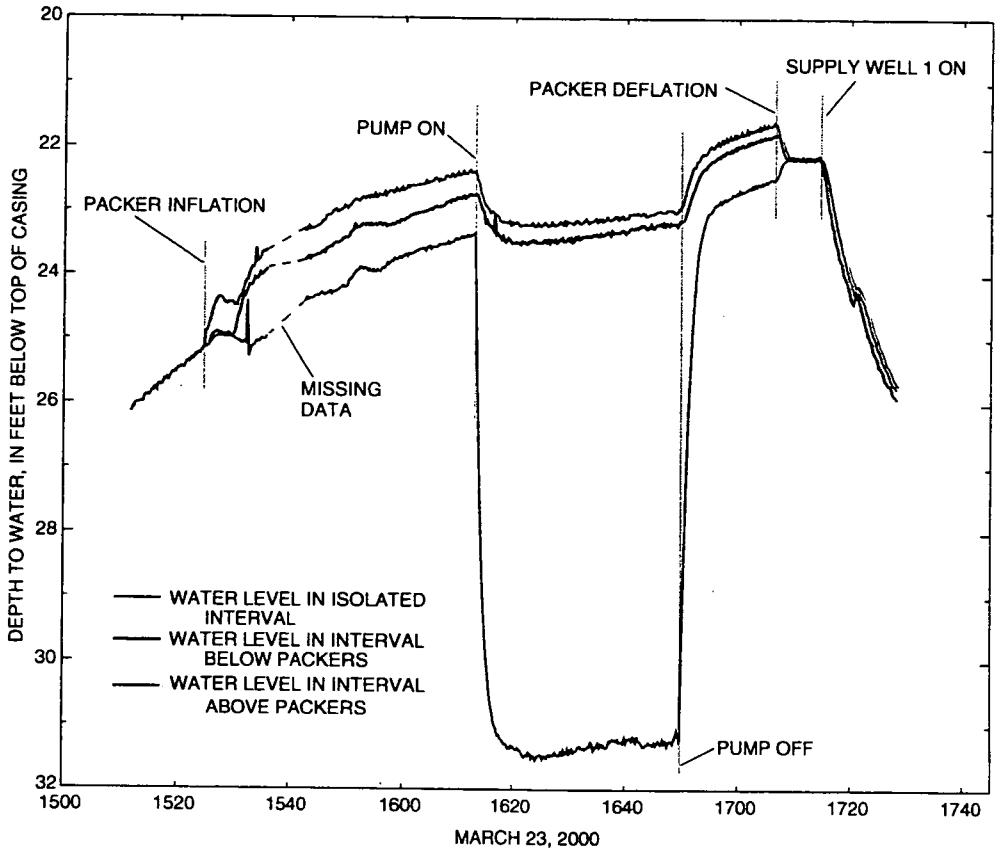


Figure 24. Hydrographs from aquifer-isolation test of interval 3 (157–165.2 feet below top of casing) in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Int rval 4
(197.7–205.9 Feet B l w Top f Casing)

For the aquifer-isolation test of interval 4, the bottom of the upper packer and the top of the lower packer were set at 197.7 and 205.9 ft btoc, respectively, to isolate the water-producing fracture at 205 ft btoc. On March 23 before packer inflation, the depth to water in the open borehole was 30.12 ft btoc. Fifteen minutes after packer inflation, the depth to water in the isolated interval was 26.38 ft btoc, an increase of 3.74 ft; the depth to water in the interval above the packers was 30.82 ft btoc, a decrease of 0.70 ft; and the depth to water in the interval below the packers was 30.95 ft btoc, a decrease of 0.83 ft. This is consistent with the heatpulse-flowmeter measurements that showed upward and downward flow from the isolated interval.

The packers were left inflated overnight, and the datalogger was left on. At approximately 0:40 on March 24, the pump in supply well 1 shut down; it restarted at approximately 4:45. During this time, the water levels in the three intervals of supply well 2 recovered. The water level in the isolated interval rose 8.61 ft, the water level in the interval below the packers rose 11.93 ft, and the water level in the interval above the packers rose 11.86 ft (fig. 25).

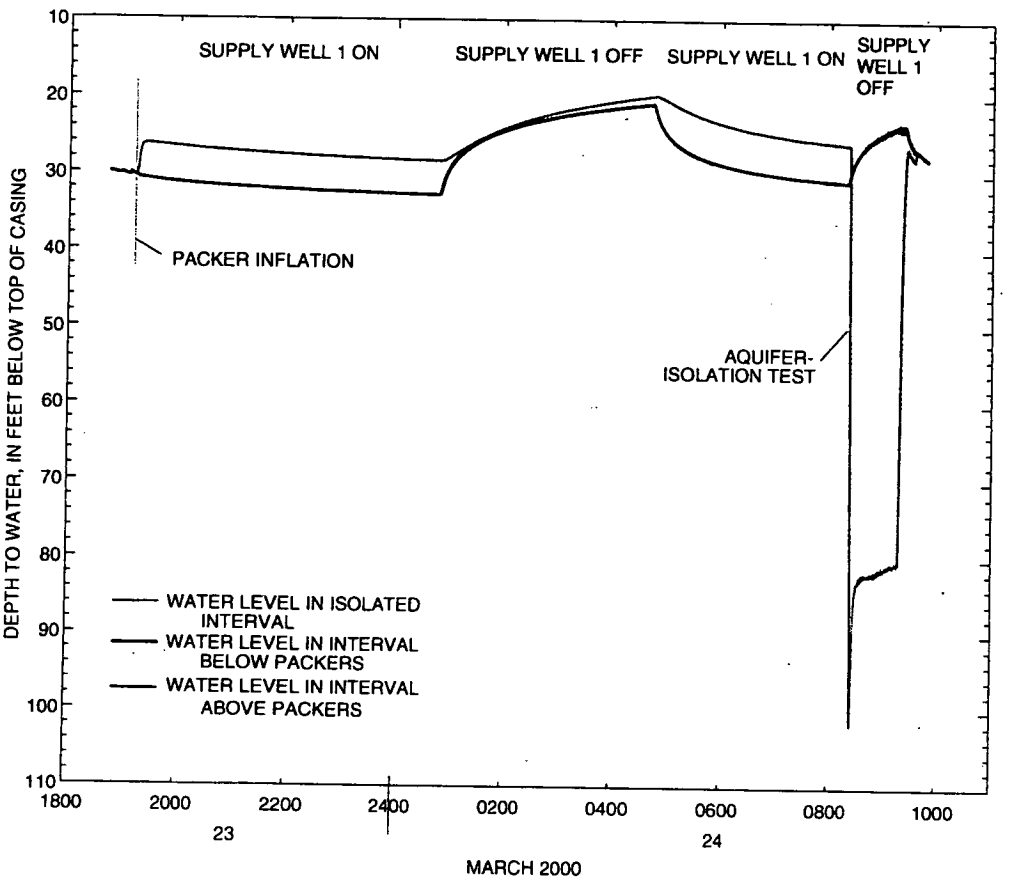


Figure 25. Hydrographs before and during the aquifer-isolation test of interval 4 (197.7–205.9 feet below top of casing) in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

On March 24 at 8:20, the water level in the interval below the packers was 30.99 ft btoc; the water level in the isolated interval was 25.95 ft btoc; and the water level in the interval above the packers was 30.83 ft btoc. At approximately 8:21, the pump in supply well 1 shut down. The pump in the isolated interval of well 2 was started at 8:22 at a rate of 20 gal/min (table 18). After 3 minutes, the water level in the isolated interval dropped to 101.86 ft btoc, and the pumping rate was decreased to 6 gal/min. After 51 additional minutes of pumping, drawdown in the isolated interval was 54.43 ft.

Because of water-level recovery from the shutdown of supply well 1, the water level in the intervals above and below the packers increased during the pumping of the isolated interval. The water level in the interval below the packers rose 6.86 ft, and the water level in the interval above the packers rose 6.77 ft. The specific capacity of interval 4 was not calculated because the water level was affected by recovery from the shutdown of supply well 1, and the water level in the isolated interval was rising during the latter part of the test because of the decrease in the pumping rate (fig. 25).

Table 18. *Schedule and pumping rates for the aquifer-isolation test of interval 4 (197.7–205.9 feet below top of casing) in supply well 2 (MG–210), March 23–24, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Date	Time	Activity
March 23	18:42	Start datalogger
-	18:55	Begin packer inflation
March 24	0:40	Supply well 1 off
-	4:45	Supply well 1 on
-	8:21	Supply well 1 off
-	8:22	Start pump at 20 gallons per minute
-	8:25	Decrease pumping rate to 6 gallons per minute
-	9:17	Pump off
-	9:38	Begin packer deflation
-	9:50	Stop datalogger

Interval 5
(310.5–318.7 Feet B low T p f Casing)

For the aquifer-isolation test of interval 5, the bottom of the upper packer and the top of the lower packer were set at 310.5 and 318.7 ft btoc, respectively, to isolate the water-receiving fracture at 314 ft btoc. Before packer inflation, the depth to water in the open borehole was 30.96 ft btoc. Twenty-six minutes after packer inflation, the depth to water in the isolated interval was 34.44 ft btoc, a decrease in water level of 3.48 ft; the depth to water in the interval below the packers was 31.14 ft btoc, a decrease in water level of 0.18 ft; and the depth to water in the interval above the packers was 31.67 ft btoc, a decrease in water level of 0.71 ft. This is consistent with the heat-pulse-flowmeter measurements that showed downward flow from above the isolated interval and upward flow from below the isolated interval.

Pumping began at 12:56 at an initial rate of 5.2 gal/min (table 19), and the water level in the isolated interval quickly dropped to 68.18 ft btoc. The pumping rate was decreased to 2.6 gal/min at 12:58 and then increased to 4.4 gal/min at 13:01. Because of sediment partially clogging the filter, the pumping rate was unstable throughout the first 40 minutes of pumping. After this period of unstable pumping, the rate became more stable and was about 4 gal/min. Total drawdown was 47.14 ft in the isolated interval, 0.45 ft in the interval above the packers, and 0.41 ft in the interval below the packers, The specific capacity of interval 5 is 0.08 (gal/min)/ft. The hydrographs for the interval above the packers, the isolated interval, and the interval below the packers (fig. 26) indicate a weak hydraulic connection among the three intervals.

Table 19. *Schedule and pumping rates for the aquifer-isolation test of interval 5 (310.5–318.7 feet below top of casing) in supply well 2 (MG–210), March 24, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

Time	Activity
11:54	Start datalogger
12:19	Begin upper packer inflation
12:31	Begin lower packer inflation
12:56	Start pump at 5.2 gallons per minute
12:58	Decrease pumping rate to 2.6 gallons per minute
13:01	Increase pumping rate to 4.4 gallons per minute
14:13	Pump off
14:25	Begin deflating packers
14:47	Stop datalogger

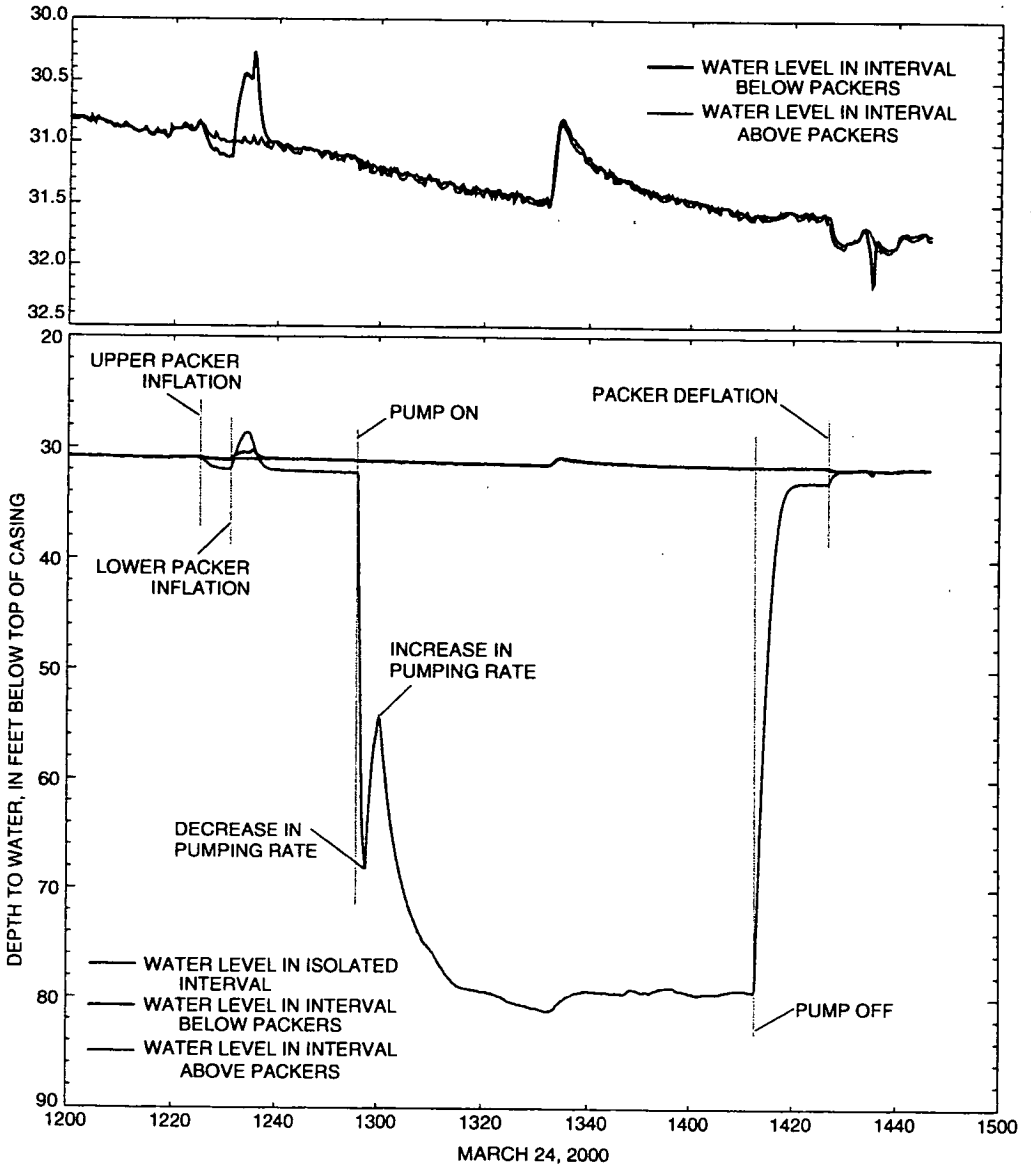


Figure 26. Hydrographs from aquifer-isolation test of interval 5 (310.5–318.7 feet below top of casing) in supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Vertical Distributi n f Wat r-Quality C nstituents

During each aquifer-isolation test, water samples were collected by the USGS and analyzed for inorganic constituents and by TetraTech NUS, Inc., and analyzed for VOC's. Analytical results were used to determine change in concentration with depth. However, vertical mixing occurs in the aquifer and the well because of drawdown and recovery cycles in the supply wells, borehole flow when the supply wells are not pumping, and the pumping of one supply well affecting water levels (well interference) and borehole flow in the other supply well.

VOC's detected in water samples collected during aquifer-isolation tests and not attributable to laboratory contamination are listed in table 20. Concentrations of detected VOC's were estimated at 3.6 µg/L or less. Toluene was detected in every sample (table 20). PCE was detected only in samples from 197.7–205.9 and 310.5–318.7 ft btoc, and TCE was detected only in samples from 157–165.2 and 197.7–205.9 ft btoc (fig. 27). TCA, which was detected in water samples from supply well 1, was not detected in water samples from supply well 2.

Inorganic constituents in water samples collected during aquifer-isolation tests are listed in table 21. The concentrations of magnesium (fig. 28), barium, and strontium and pH generally increase with depth. Concentrations of dissolved oxygen (fig. 27), chloride, and sulfate generally decrease with depth (fig. 28).

Table 20. *Concentrations of selected volatile organic compounds in water samples collected during aquifer-isolation tests in supply well 2 (MG–210), March 23–24, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania*

[Laboratory results were provided by TetraTech NUS, Inc.; ft btoc, feet below top of casing; µg/L, micrograms per liter; ND, not detected; J, estimated result less than reporting limit of 10 micrograms per liter]

Interval	Depth of sample (ft btoc)	Date sampled	Acetone (µg/L)	2-Butanone (µg/L)	Chloroform (µg/L)	Tetrachloro-ethylene (µg/L)	Trichloro-ethylene (µg/L)	Toluene (µg/L)
1	67–75.2	3/23/2000	ND	ND	ND	ND	ND	3.5 J
2	111.5–119.7	3/23/2000	ND	ND	ND	ND	ND	2.1 J
3	157–165.2	3/23/2000	2.1 J	ND	ND	ND	1.6 J	2.2 J
4	197.7–205.9	3/24/2000	2.2 J	ND	1.6 J	3.6 J	1.1 J	2.2 J
5	310.5–318.7	3/24/2000	1.7 J	1.6 J	ND	1.8 J	ND	1.4 J

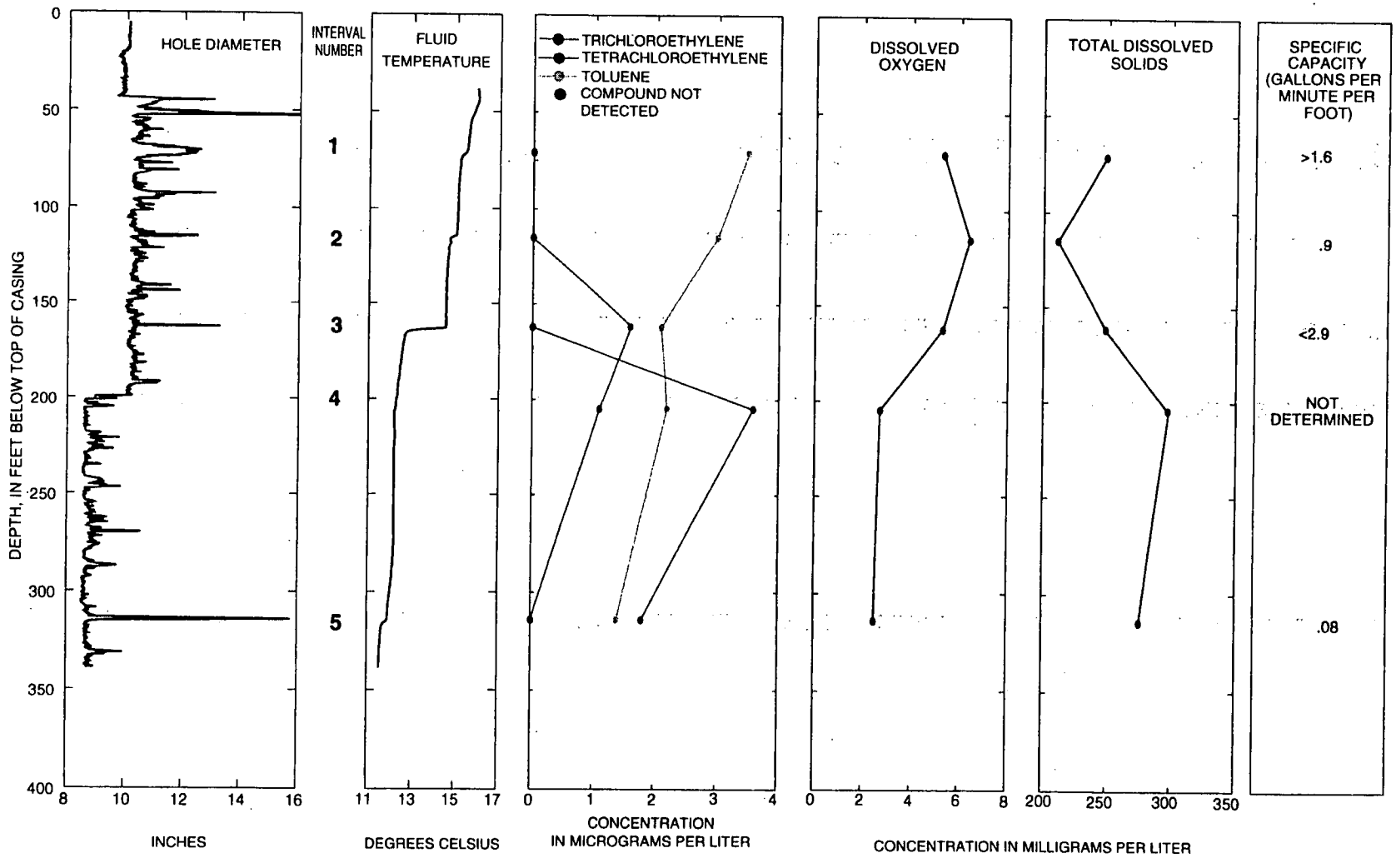


Figure 27. Concentration of tetrachloroethylene, trichloroethylene, toluene, dissolved oxygen, and total dissolved solids with depth in water samples from supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

Table 21. Selected field determinations and concentrations of inorganic constituents in water samples collected during aquifer-isolation tests in supply well 2 (MG–210), March 23–24, 2000, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania

[ft btoc, feet below top of casing; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm at 25°C, microsiemens per centimeter at 25 degrees Celsius; C, Celsius; <, less than; J, estimated concentration below reporting limit]

Interval	Depth sampled (ft btoc)	Date sampled	Dissolved oxygen (mg/L)	pH (standard units)	Specific conductance (µS/cm at 25°C)	Temperature (degrees C)	Calcium (mg/L)
1	67–75.2	3/23/2000	5.3	6.5	401	15.3	38
2	111.5–119.7	3/23/2000	6.4	6.2	359	16.9	35
3	67–75.2	3/23/2000	5.3	6.6	429	15.6	46
4	111.5–119.7	3/24/2000	2.7	7.4	514	15.4	60
5	157–165.2	3/24/2000	2.5	7.4	477	15.6	51

Interval	Magnesium (mg/L)	Potassium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L)	Sulfate, dissolved (mg/L)
1	9.6	1.4	19	39	< 0.1	32	38
2	9.6	1.3	19	40	<.1	36	25
3	14	1.4	17	39	<.1	34	24
4	21	.85	16	34	<.1	33	18
5	21	1.0	14	30	<.1	29	18

Interval	Barium, dissolved (µg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Strontium, dissolved (µg/L)	Total dissolved solids (mg/L)
1	146	96	4.0	87	249
2	202	110	2.4	100	211
3	251	44	1.6 J	118	249
4	333	47	1.6 J	135	298
5	412	30	8.8	371	276

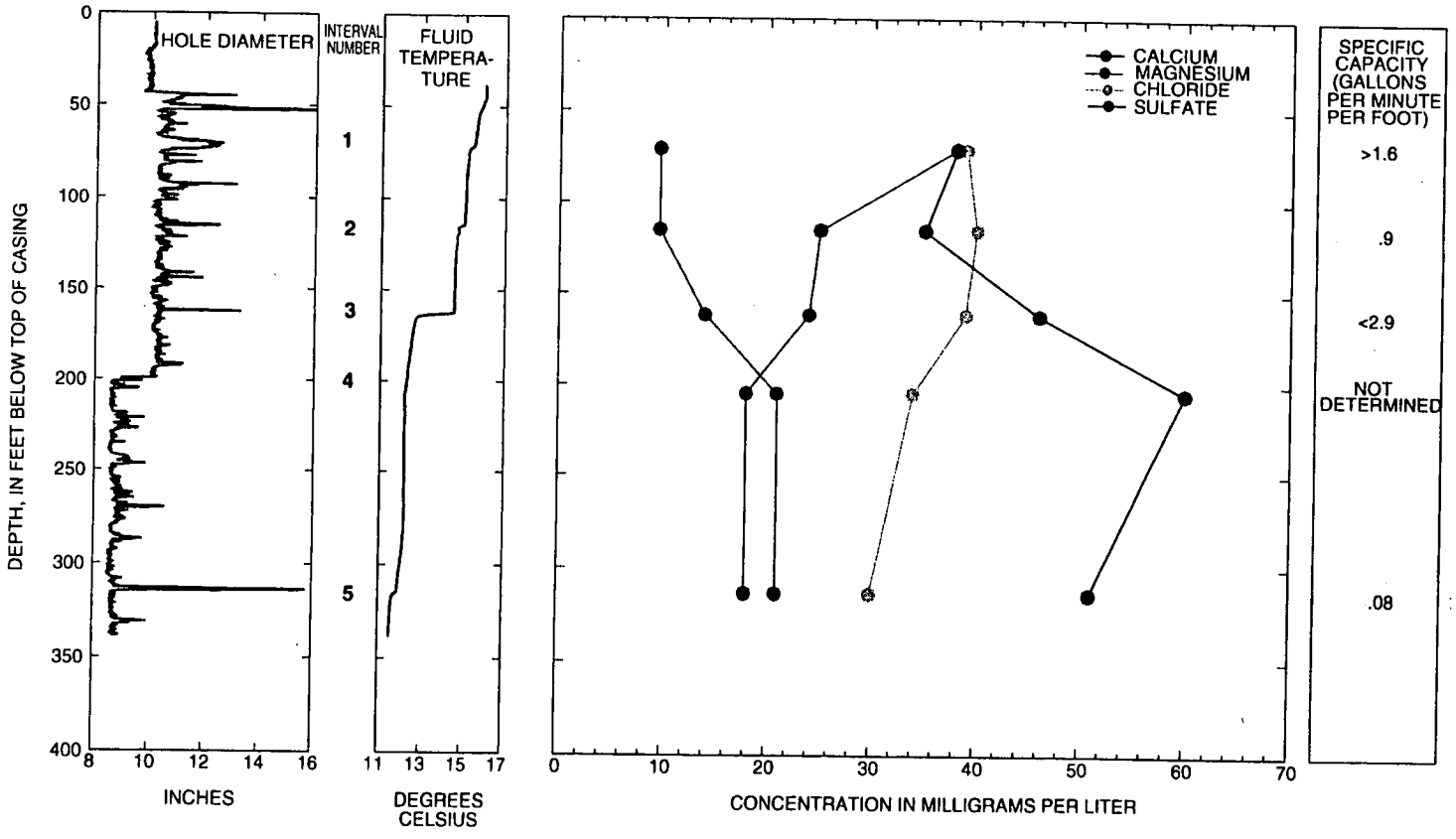


Figure 28. Concentration of calcium, chloride, magnesium, and sulfate with depth in water samples from supply well 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

CORRELATION OF BOREHOLE GEOPHYSICAL LOGS

Lithologic units penetrated by supply wells 1 and 2 were determined by correlating natural-gamma and single-point resistance logs (Sloto and others, 1996). Lithologic units A, C, E, G, I, K, and M are silty, finer-grained units and are either mudstone or siltstone (fig. 29). Lithologic units B, D, F, H, J, L, and N are sandstone or sandy, coarser-grained units. Water-bearing fractures are not necessarily present in the same lithologic units in both supply wells. Although the wells penetrate the same lithologic units (fig. 29), the location of only three water-bearing fractures are common to both wells. Common water-bearing fractures in both wells are in sandy lithologic unit H and at the contacts between lithologic units D and E and units L and M. For supply well 1, four water-bearing fractures are at the contact between silty and sandy lithologic units; three water-bearing fractures are in silty lithologic units A, C, and G; and two are in sandy lithologic units H and J. For supply well 2, four water-bearing fractures are at the contact between silty and sandy lithologic units; three water-bearing fractures are in silty lithologic units B, H, and L; and one is in sandy lithologic unit K.

The same lithologic unit may have different hydraulic properties in each supply well. The highest specific capacity (5.7 (gal/min)/ft) of the intervals tested in supply well 1 was at 179.8–188 ft btoc, which is at the top of sandy lithologic unit F. The highest specific capacity (less than 2.9 (gal/min)/ft) of the intervals tested in supply well 2 was at 157–165.2 ft btoc, which is at the bottom of sandy lithologic unit F. The second highest specific capacity (3.7 (gal/min)/ft) of the intervals tested in supply well 1 was at 345.3–389 ft btoc, which is at the top of lithologic unit M. The lowest specific capacity (0.08 (gal/min)/ft) of the intervals tested in supply well 2 was at 310.5–318.7 ft btoc, which also is at the top of lithologic unit M.

The highest concentrations of PCE in water samples from supply well 1 were from intervals 6 (236.8–245 ft btoc) and 7 (249.8–258 ft btoc). Interval 7 is in lithologic unit H, and interval 6 is just above lithologic unit H (fig. 29). The aquifer-isolation tests indicate these intervals are connected hydraulically. The highest concentrations of PCE in water samples from supply well 2 were from interval 4 (197.7–205.9 ft btoc). Interval 4 is in lithologic unit H (fig. 29). This lithologic unit appears to be the major source of contamination for both supply wells. Assuming a strike of N. 76° E. and a dip of 7° NW., the projected outcrop of lithologic unit H is approximately 2,300–2,450 ft southeast of supply well 1 and 1,850–2,050 ft southeast of supply well 2 (fig. 30). The projected outcrop is updip and hydraulically upgradient from the supply wells. The projected outcrop is approximately halfway between the supply wells and the regional ground-water divide running through the base (fig. 30), which is approximately 4,000 ft southeast of the supply wells.

DIRECTION OF GROUND-WATER FLOW

Water-level data provide important information on horizontal and vertical ground-water-flow directions and gradients. Water-level data from a monitor well cluster (wells drilled in close proximity) screened at different depths provide information on vertical head differences and the direction of vertical flow. Water-level data from monitor wells screened in the same depth interval provide information on horizontal gradients and the direction of horizontal flow.

Regional Potentiometric Surface

A map showing the regional potentiometric surface at and in the vicinity of the Willow Grove NAS/JRB was prepared by Sloto and others (2001). A part of the map, reproduced here as figure 31, shows a regional ground-water divide running northeast-southwest to the southeast of Site 1. From this divide, ground water flows northwest through Site 1 toward Park Creek, a tributary to Little Neshaminy Creek. This is the direction of regional ground-water flow.

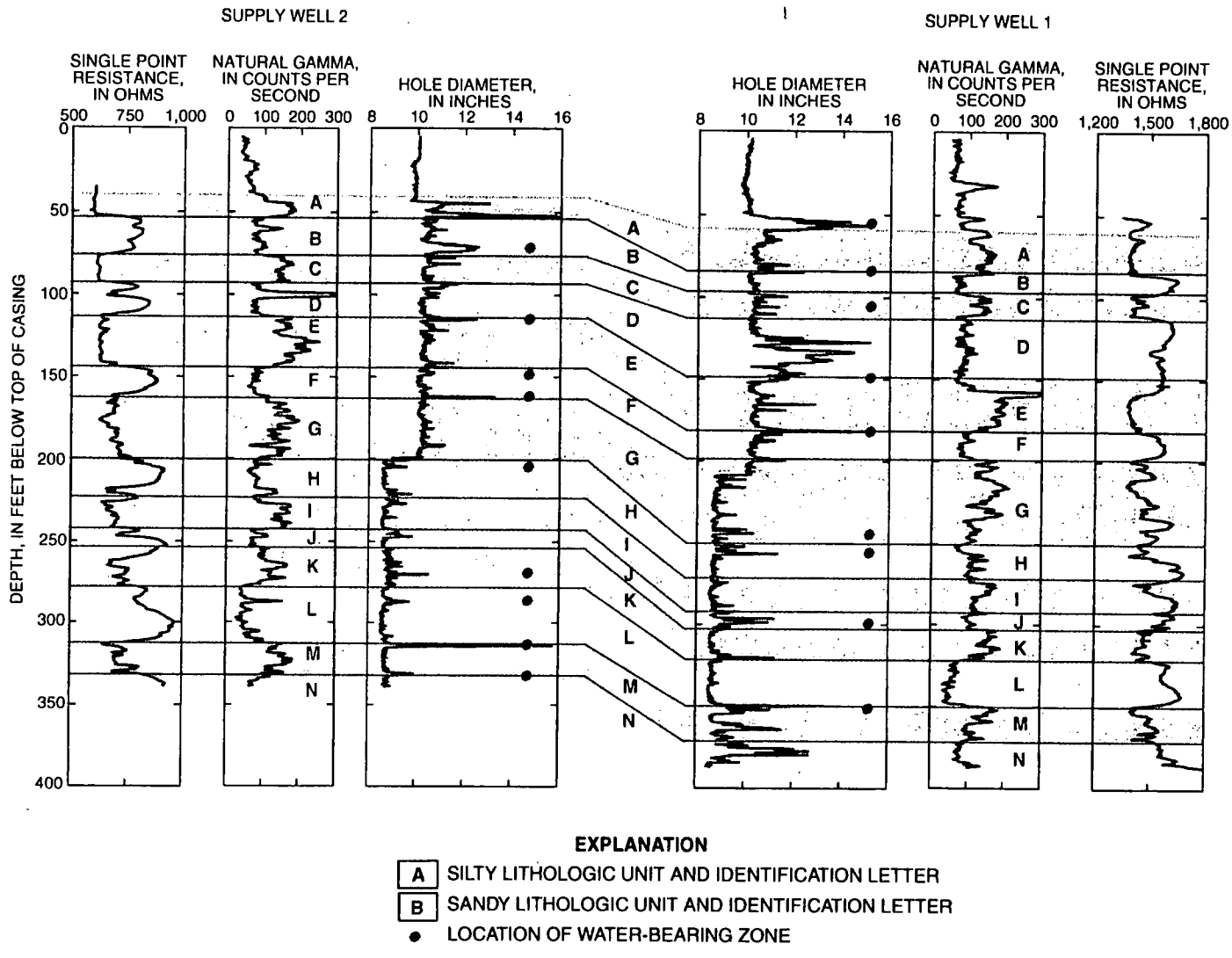


Figure 29. Correlation of borehole geophysical logs from supply wells 1 (MG–209) and 2 (MG–210), Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

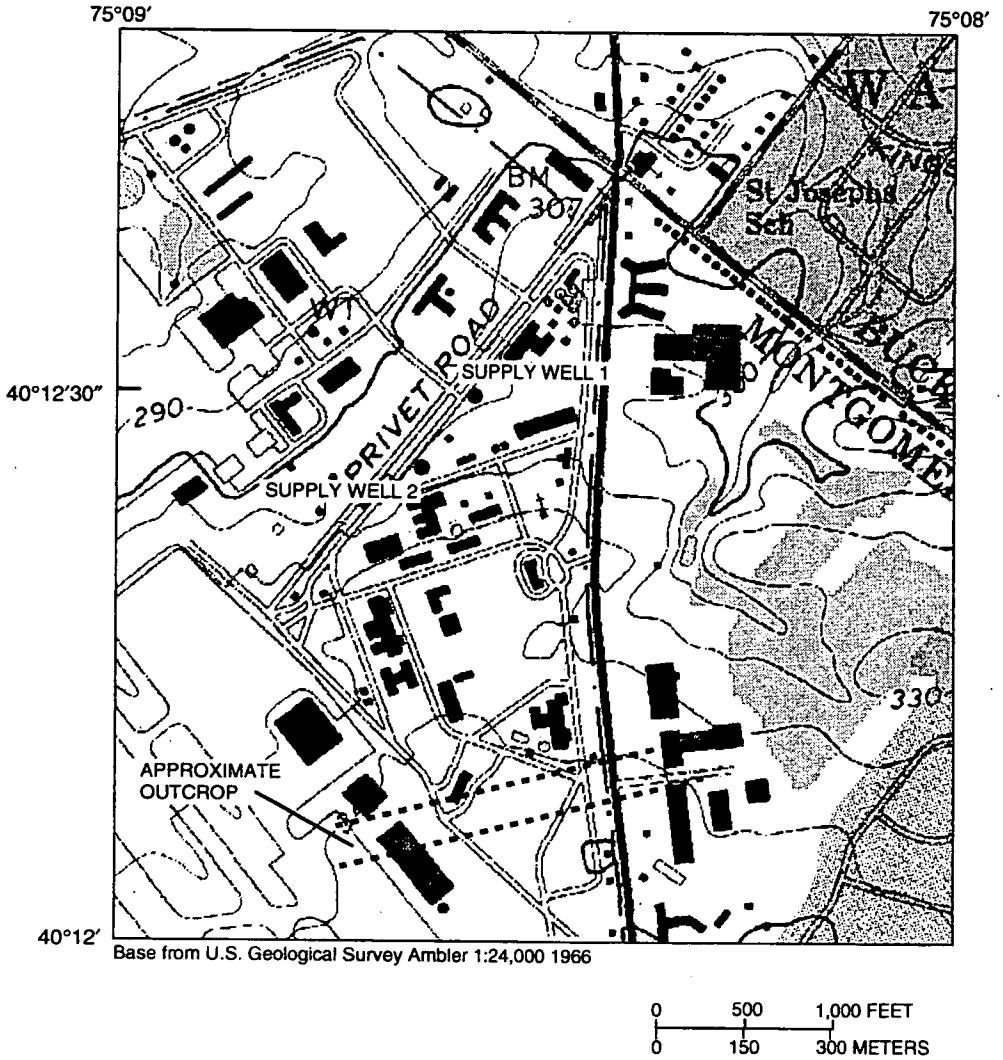
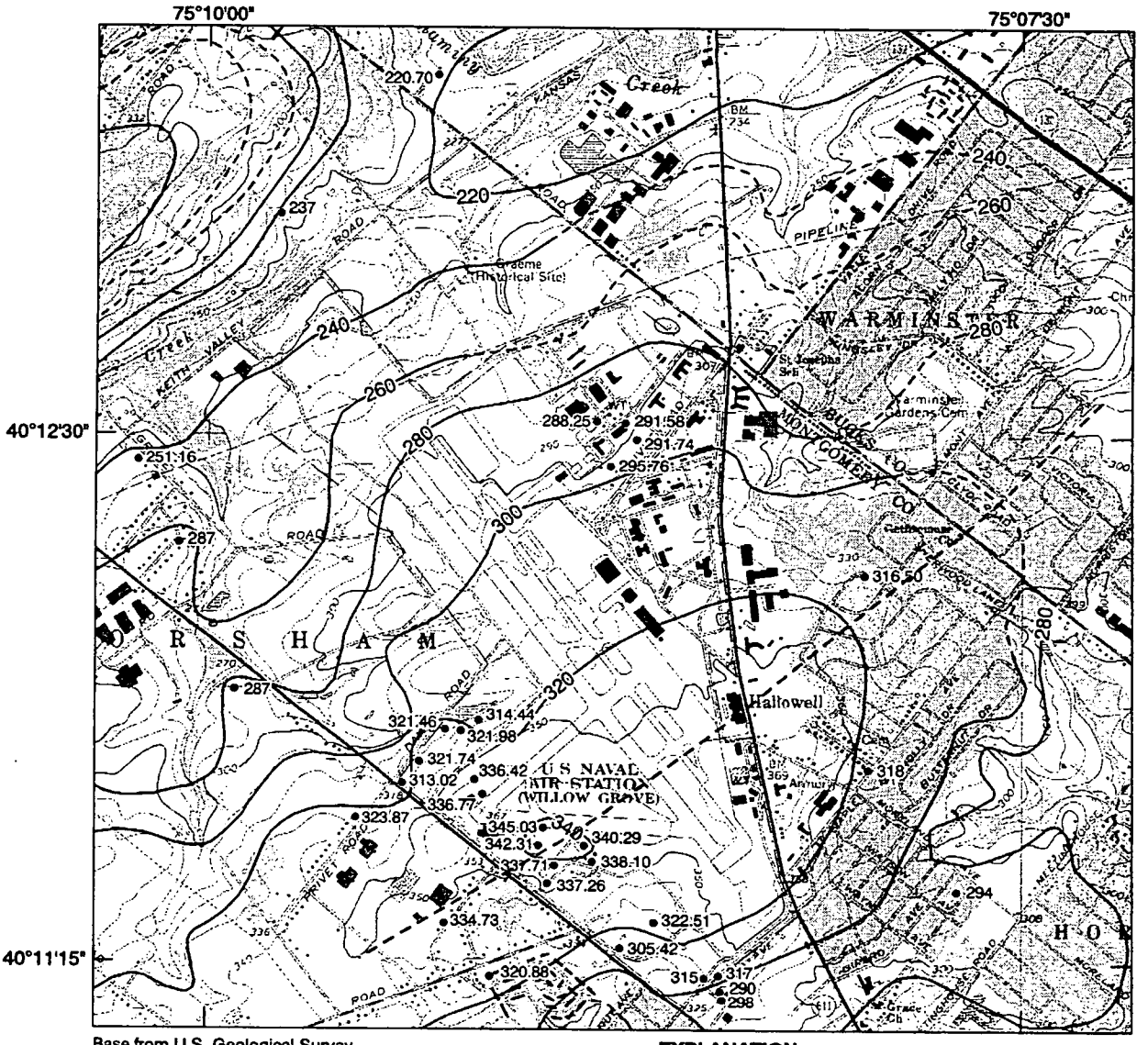


Figure 30. Approximate location of outcrop area for lithologic unit H, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.



Base from U.S. Geological Survey
Ambler 1:24,000, 1983
Hatboro 1:24,000, 1983

EXPLANATION

——— 320 - - - POTENTIOMETRIC CONTOUR – Shows elevation of the potentiometric surface as defined by measured water levels, altitudes of streams, and topography. Dashed where approximately located. Contour interval is 20 feet. Elevation in feet above sea level.

- - - - - - - GROUND-WATER DIVIDE

● 352.02 WATER-LEVEL MEASUREMENT SITE – Symbol gives location of site. Number is elevation of water level measured in a drilled well in feet above sea level.

0 1/2 1 MILE

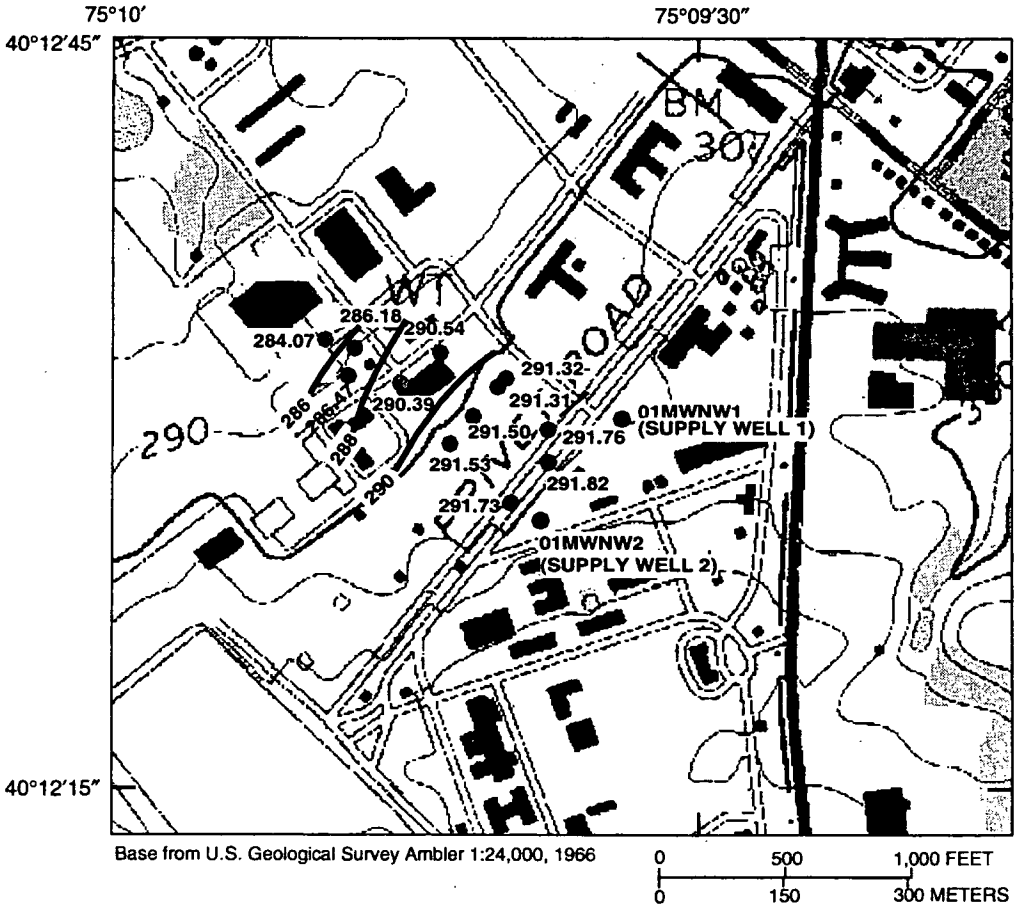
0 1/2 1 KILOMETER

Figure 31. Potentiometric surface and regional ground-water divide, October 7–8, 1999, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania. (Modified from Sloto and others (2001))

Pot ntiom tric Surface at Sit 1

To map the potentiometric surface at Site 1, water-level data were grouped into two depth ranges (7–39 ft bls and 69–100 ft bls) for contouring. The potentiometric surface defined by water levels in wells screened between 7 and 39 ft bls is shown on figure 32. This interval is the shallower of the two intervals, and the potentiometric surface represents the water table. The map shows ground-water flow to the northwest. The hydraulic gradient is relatively low in the area around the supply wells.

The potentiometric surface defined by water levels in wells screened between 69 and 100 ft bls is shown on figure 33. The map shows a relatively high hydraulic gradient near supply well 2. The direction of ground-water flow near supply well 2 is to the north. To the northwest of supply well 2, the hydraulic gradient becomes lower, then higher again. In this vicinity, ground-water flow is toward the northwest.



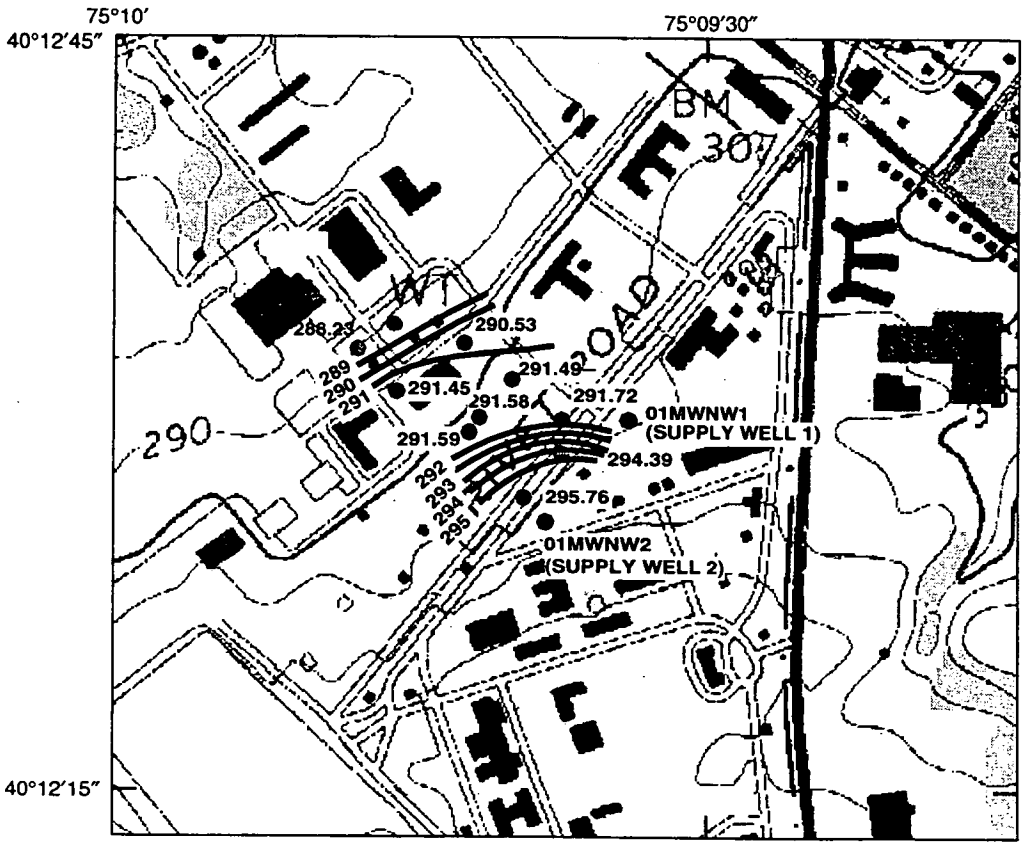
EXPLANATION

290 — POTENTIOMETRIC CONTOUR--Shows the elevation of the potentiometric surface as defined by measured water levels. Contour interval is 2 feet. Elevation in feet above sea level.

291.31 ● WATER-LEVEL MEASUREMENT SITE--Symbol gives location of well. Number is elevation of water level measured in drilled well in feet above sea level.

01MWNW1 ● SUPPLY WELL AND IDENTIFICATION NUMBER

Figure 32. Potentiometric surface defined by water levels in wells screened between 7 and 39 feet below land surface, October 7, 1999, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.



Base from U.S. Geological Survey Ambler 1:24,000, 1966

EXPLANATION

291 — POTENTIOMETRIC CONTOUR--Shows the elevation of the potentiometric surface as defined by measured water levels. Contour interval is 1 foot. Elevation in feet above sea level.

291.49 ● WATER-LEVEL MEASUREMENT SITE--Symbol gives location of well. Number is elevation of water level measured in drilled well in feet above sea level.

01MWNW1 ● SUPPLY WELL AND IDENTIFICATION NUMBER.

Figure 33. Potentiometric surface defined by water levels in wells screened between 69 and 100 feet below land surface, October 7, 1999, Willow Grove Naval Air Station/Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.

V rtical Head Gradi nts

For all monitor well clusters except 01MW06 and 01MW08, water-level measurements made on October 7, 1999 (table 1), show the vertical head direction was downward from the shallow to the deeper part of the aquifer. The vertical head gradient (0.001) was upward at well cluster 01MW08, and water levels were approximately the same in the shallow and deep wells in cluster 01MW06. Gradients were greatest near the supply wells (0.078 for well cluster 01MW05 and 0.054 for well cluster 01MW04). The vertical gradients to the northwest become less (0.001 for well clusters 01MW01 and 01MW03) and then greater (0.016 for well cluster 01MW07 and 0.029 for well cluster 01MWWW1). The vertical gradient pattern mimics the horizontal gradient defined by water levels in wells screened between 69 and 100 ft bls.

Pumping the supply wells at times causes the vertical gradient to reverse in wells 01MW05S and 01MW05I during pumping. Hydrographs for well cluster 01MW05 for March 16–27, 2000, are shown on figure 34. During this time, supply well 2 was pumping intermittently. Hydrographs for well cluster 01MW05 for April 11–25, 2000, are shown on figure 35. During this time, supply well 1 was pumping intermittently. During April 11–22, the water level was higher in well 01MW05S (screened 18.5–38.5 ft bls) than in well 01MW05I (screened 75–85 ft bls), and vertical flow was downward from the shallow to the deeper part of the aquifer (fig. 35). During March 19–27, the vertical flow direction reversed at times during the recovery cycle of supply well 2, and flow then was upward from the deeper to the shallow part of the aquifer (fig. 34). The vertical flow direction also reversed at times during April 23–25 during the recovery cycle of supply well 1; the vertical flow direction was upward from the deeper to the shallow part of the aquifer (fig. 35).

Pumping of the supply wells has a greater effect on water levels in the deeper (semiconfined to confined) part of the aquifer than in the shallow (water table) part of the aquifer (figs. 34 and 35). Pumping supply well 1 lowers the water level in well 01MW05I by more than 6 ft, and pumping supply well 2 lowers the water level in well 01MW05S by as much as 3 ft.

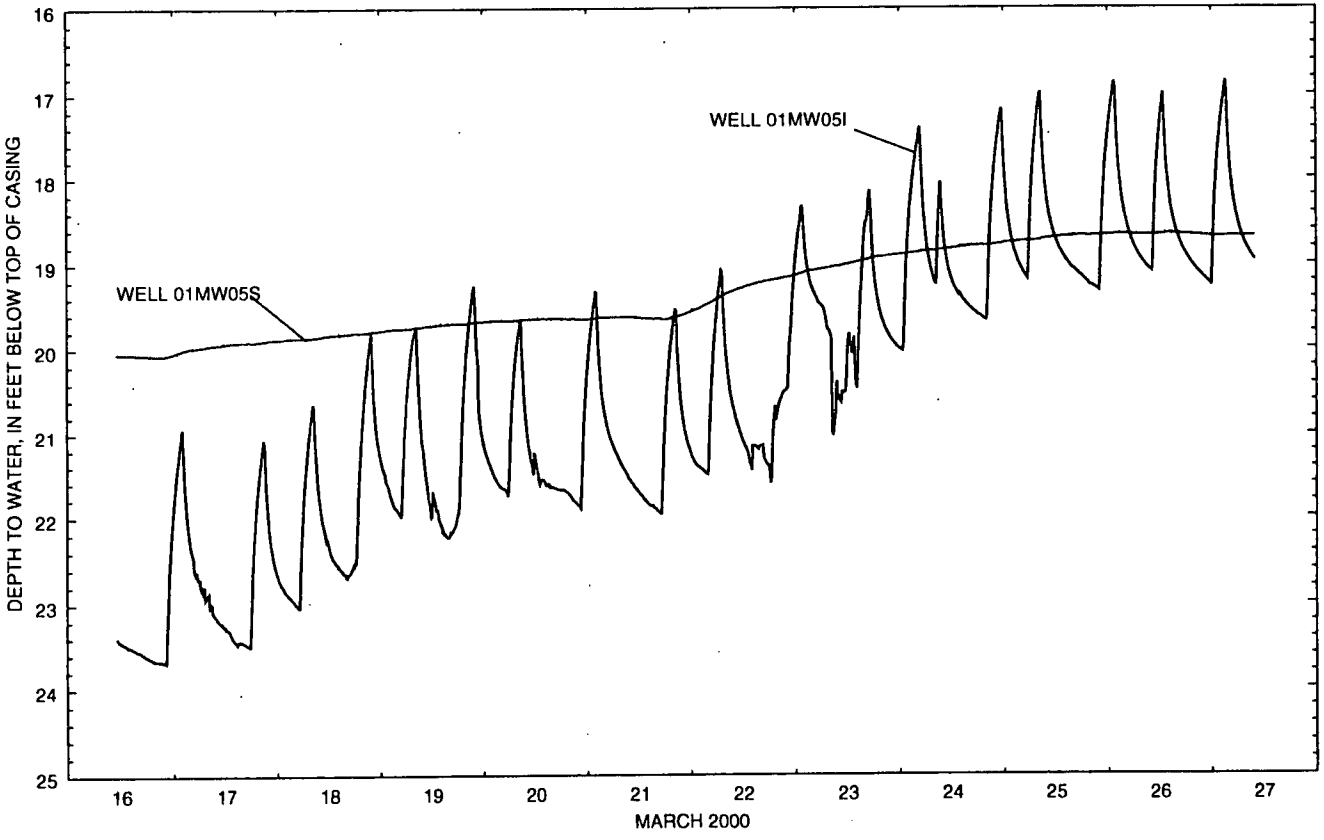


Figure 34. Hydrographs from wells 01MW05S and 01MW05I, March16–27, 2000, Willow Grove Naval Air Station/ Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.
[Supply well 1 is pumping intermittently. Data were provided by TetraTech NUS, Inc.]

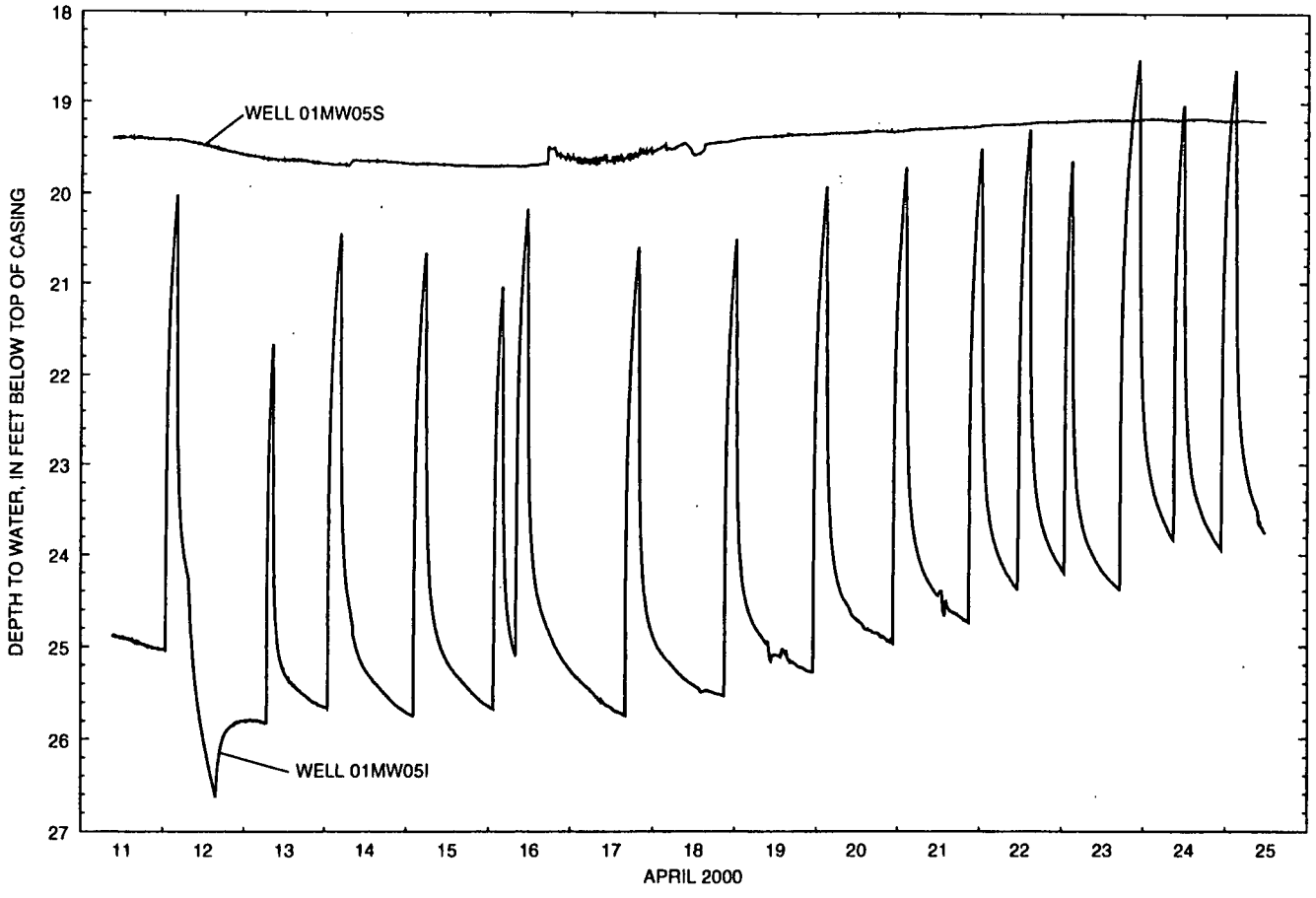


Figure 35. Hydrographs from wells 01MW05S and 01MW05I, April 11–25, 2000, Willow Grove Naval Air Station/ Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania.
[Supply well 2 is pumping intermittently. Data were provided by TetraTech NUS, Inc.]

SUMMARY AND CONCLUSIONS

A hydrogeological investigation is being conducted as part of the U.S. Navy's Installation Restoration Program to address ground-water contamination at the Willow Grove NAS/JRB in Horsham Township, Montgomery County, Pa. The U.S. Navy requested the USGS provide technical assistance to their hydrogeological investigation. Specifically, the USGS was asked to conduct borehole geophysical logging and aquifer-isolation (packer) tests in supply wells 1 and 2 to characterize the geophysical and hydraulic properties, characterize the water quality of water-producing fractures, and collect and analyze water-level data. This information can be used to further identify the sources of contamination and to evaluate alternative management strategies for improving well efficiency and water quality.

Ground water pumped from supply wells 1 and 2 at the Willow Grove NAS/JRB provides water for use at the base, including potable water for drinking. The supply wells have been contaminated by VOC's, particularly TCE and PCE, and the water is treated to remove the VOC's. The Willow Grove NAS/JRB and surrounding area are underlain by the Stockton Formation, which forms a complex, heterogeneous aquifer.

The hydraulic and chemical characteristics of discrete water-bearing zones were characterized by isolating each water-bearing zone in the supply wells with straddle packers. Intervals selected for aquifer-isolation tests were based on interpretation of the borehole geophysical logs and borehole television surveys. Eight aquifer-isolation tests were conducted in supply well 1, and five aquifer-isolation tests were conducted in supply well 2. Specific capacity and depth of fracture in the wells were not related. During each aquifer-isolation test, water samples were collected and analyzed for VOC's and inorganic constituents.

A suite of borehole geophysical logs was collected in supply well 1 by the USGS. The caliper log shows the well is 389 ft deep and is cased to 50 ft btoc. On the basis of the interpretation of the borehole geophysical logs and heatpulse-flowmeter measurements for supply well 1, water enters the upper part of the borehole through fractures at 50–59 and 106 ft btoc and flows downward. Water flowing downward exits the borehole through a fracture at 182 ft btoc. Water also enters the borehole through fractures at 241–244, 256, and 350–355 ft btoc and flows upward. Water flowing upward exits the borehole through fractures at 182 and 199 ft btoc.

Eight intervals were selected for aquifer-isolation tests in supply well 1. Fractures at 50–59, 79–80, 106, 124–152, 182, 241–244, 256, and 350–354 ft btoc were isolated. A specific capacity could not be calculated for the fracture isolated at 50–59 ft btoc because the pump in supply well 2 shut off, and the water level in the isolated interval recovered faster than the drawdown from pumping throughout the test. For the other isolated intervals, specific capacities ranged from 0.26 to 5.7 (gal/min)/ft. The highest specific capacity was for the fracture isolated at 179.8–188 ft btoc.

The highest concentrations of PCE and TCE were in water samples collected from fractures isolated between 236.8 and 245 ft btoc (interval 6) and between 249.8 and 258 ft btoc (interval 7). Concentrations of PCE and TCE were similar in those samples as were concentrations of dissolved oxygen and total dissolved solids, which indicates these fractures are connected hydraulically. The concentration of PCE generally increased with depth to a maximum of 39 µg/L at a depth of 249.8–258 ft btoc and then decreased to 21 µg/L at a depth of 345.3–389 ft btoc.

A suite of borehole geophysical logs was collected in supply well 2 by the USGS. The caliper log shows the well is 340 ft deep and is cased to 43 ft btoc. On the basis of the borehole geophysical logs and heatpulse-flowmeter measurements, water enters the borehole through fractures at 68–74 and 115 ft btoc and flows downward. Water flowing downward exits the borehole through a fracture at 162 ft btoc. Water enters the borehole through a fracture at 205 ft btoc and flows upward and downward. The water flowing upward exits the borehole through the fracture at 162 ft btoc. Water flowing downward exits the borehole through fractures at 270 and 314 ft btoc. A fracture at 287 ft btoc contributes water to this downward flow. Water also enters the borehole through a fracture at 331 ft btoc near the bottom of the borehole and flows upward. This water exits the borehole through the fracture at 314 ft btoc.

Five intervals were selected for aquifer-isolation tests in well supply well 2. Fractures at 68–74, 115, 162, 205, and 314 ft btoc were isolated. A specific capacity could not be calculated for the

fracture isolated at 205 ft btoc because the water level in the isolated fracture was rising during the latter part of the test. For the other isolated fractures, specific capacities ranged from 0.08 to less than 2.9 (gal/min)/ft. The highest specific capacity was for the fracture isolated at 157–165.2 ft btoc. Concentrations of detected VOC's in water samples were estimated at 3.6 µg/L or less. TCA, which was detected in water samples from supply well 1, was not detected in water samples from supply well 2.

Lithologic units penetrated by supply wells 1 and 2 were determined by correlating natural-gamma and single-point-resistance borehole geophysical logs. Water-bearing fractures are not necessarily present in the same lithologic units in both supply wells. Although the wells penetrate the same lithologic units, the lithologic location of only three water-bearing fractures are common to both wells.

The same lithologic unit may have different hydraulic properties in both wells. The highest specific capacity (5.7 (gal/min)/ft) of the intervals tested in supply well 1 was at 179.8–188 ft btoc, which is at the top of sandy lithologic unit F. The highest specific capacity (less than 2.9 (gal/min)/ft) of the intervals tested in supply well 2 was at 157–165.2 ft btoc, which is at the bottom of sandy lithologic unit F. The second highest specific capacity (3.7 (gal/min)/ft) of the intervals tested in supply well 1 was at 345.3–389 ft btoc, which is at the top of lithologic unit M. The lowest specific capacity (0.08 (gal/min)/ft) of the intervals tested in supply well 2 was at 310.5–318.7 ft btoc, which also is at the top of lithologic unit M.

The highest concentrations of PCE (34 and 39 µg/L) in water samples from supply well 1 were from intervals 6 (236.8–245 ft btoc) and 7 (249.8–259 ft btoc), respectively. Interval 7 is in lithologic unit H, and interval 6 is just above lithologic unit H. The aquifer-isolation tests indicate these intervals are connected hydraulically. The highest concentrations of PCE (3.6 µg/L) in water samples from supply well 2 were from interval 4 (197.7–205.9 ft btoc). Interval 4 is in lithologic unit H. Assuming a strike of N. 76° E. and a dip of 7° NW., the projected outcrop of lithologic unit H is approximately 2,300–2,450 ft southeast of supply well 1 and 1,850–2,050 ft southeast of supply well 2. The projected outcrop is updip and hydraulically upgradient from the supply wells.

A regional ground-water divide is present to the southeast of Site 1. From this divide, ground water flows northwest through Site 1 toward Park Creek, a tributary to Little Neshaminy Creek. This is the direction of regional ground-water flow. Two potentiometric-surface maps were prepared for Site 1. Water-level data were grouped into two depth ranges, one for shallow wells screened between 7 and 39 ft bls, and one for deeper wells screened between 69 and 100 ft. For both depth intervals, the direction of ground-water flow is toward the northwest.

For all monitor well clusters except 01MW06 and 01MW08, water-level measurements made on October 7, 1999, show the vertical head gradient was downward from the shallow to the deeper part of the aquifer. The vertical head gradients ranged from 0.001 to 0.078. The vertical gradient pattern mimics the horizontal gradient defined by water levels in wells screened between 69 and 100 ft bls.

During April 11–25, 2000, supply well 1 was pumping intermittently; the water level was higher in well 01MW05S (screened 18.5–38.5 ft bls) than in well 01MW05I (screened 75–85 ft bls), and vertical flow was downward from the shallow to the deeper part of the aquifer. During March 16–27, 2000, supply well 2 was pumping intermittently; the vertical flow direction reversed at times during the recovery cycle of supply well 2, and flow then was upward from the deeper to the shallow part of the aquifer. The vertical flow direction also reversed at times during April 23–25 during the recovery cycle of supply well 1; the vertical flow direction was upward from the deeper to the shallow part of the aquifer.

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Interpretation of Borehole Geophysical Logs, Aquifer-Isolation Tests, and Water Quality, Supply Wells 1 and 2, Willow Grove Naval Air Station/ Joint Reserve Base, Horsham Township, Montgomery County, Pennsylvania

USGS/WRIR 01-4264