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Remedial Investigation Report

for

Area B Groundwater

Naval Air Warfare Center

Warminster, Pennsylvania

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0291

May 2000

TETRA TECH NUS, INC.

180

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Subject: Final Area B Groundwater Operable Unit 4 (OU-4)
Remedial Investigation RI Report
Naval Air Warfare Center (NAWC) Warminster, Pennsylvania

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Tetra Tech NUS is pleased to submit the final Area B Groundwater RI Report. Copies have been forwarded to the individuals listed below.

Respectfully;

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REMEDIAL INVESTIGATION REPORT
FOR
AREA B GROUNDWATER
NAVAL AIR WARFARE CENTER
WARMINSTER, PENNSYLVANIA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
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EXECUTIVE SUMMARY

INTRODUCTION

This Remedial Investigation (RI) report presents and summarizes the results of groundwater investigations conducted in Area B of the former Naval Air Warfare Center (NAWC) Warminster, Pennsylvania. Area B consists of the former disposal areas Site 5, Site 6, and Site 7. This report concentrates on the groundwater potentially impacted by these disposal sites. This work has been pursued as part of the Navy's Installation Restoration (IR) Program under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The Navy's IR Program investigates potential contamination of Navy and Marine Corps facilities resulting from past operations to institute corrective measures as needed.

PURPOSE AND OBJECTIVES

This report combines the relevant parts of all known previous studies and reports into one cohesive remedial investigation document and presents conclusions and recommendations based on known conditions and the results of the human health risk assessment update performed for this report.

In addition, this report serves as the basis for making a decision regarding the final remedy selection for Area B groundwater. In 1993 the Navy and EPA issued a Record of Decision (ROD) for an interim remedy to address low-level trichloroethene (TCE) contamination in shallow Area B groundwater (a portion of OU-1). The purpose of the interim remedy was to minimize migration of TCE from Area B. The ROD designated pump and treat as the remedy to be implemented and required that additional groundwater studies be performed to define the nature and extent of the contamination. Additional groundwater studies were initiated immediately after issuance of the interim ROD and have continued through 1998. Extraction wells were installed in December 1994; however, groundwater sample results from the extraction wells indicated that contamination in the suspected plume area was below cleanup levels. Based on this finding and the results of the ongoing investigations which indicated that TCE contamination was not migrating within Area B, active remediation through pump and treat was not implemented. This report presents the results and findings of Area B groundwater investigations leading up to and conducted after the issuance of the interim ROD and supports the selection of a final remedy.

GENERAL BACKGROUND AND FACILITY HISTORY

NAWC Warminster is located in the township of Warminster, Bucks County, Pennsylvania. The facility was originally the location of Brewster Aeronautical Corporation, a manufacturer of military aircraft. In 1944, the Navy assumed full control of the Brewster plant. The Naval Air Modification Unit was installed at the base to add design modifications to military aircraft produced at other locations. After World War II, activities at the base were altered; in 1949, the facility was designated the Naval Air Development Center (NADC), and its main mission, research, development, testing, and evaluation for Naval aircraft systems, was established. NADC Warminster also conducted studies in anti-submarine warfare systems and software development. The facility name was changed from NADC to NAWC, Aircraft Division, on January 1, 1992. In 1996, NAWC Warminster was selected for realignment under the Base Realignment and Closure (BRAC) Program managed by the Department of Defense (DOD). This realignment, which is part of a DOD restructuring effort mandated by Congress, was implemented in September 1997. The restructuring resulted in the relocation of NAWC Warminster national defense activities to Naval Air Station (NAS) Patuxent River, Maryland. The base is now closed and is being redeveloped for non-military use by the Federal Lands Reuse Authority (FLRA).

Historically, wastes were generated at the base during aircraft maintenance and repair, pest control, firefighting training, machine and plating shop operations, spray painting, and various materials research and testing activities in laboratories. These wastes included paints, solvents, sludges from industrial wastewater treatment, and waste oils. Waste materials were disposed on site at eight disposal sites. Area B has been designated at that area that contains three of these sites; Sites 5, 6, and 7.

Site 5 reportedly consisted of up to eight trenches that were used for the disposal of demolition wastes, paint, solvents, scrap metal, aircraft paints, cans, and asphalt. The trenches were reportedly operated from 1955 to 1970. Navy enlisted housing units have since been constructed within this area. Site 5 was investigated as part of the Phase III RI (Brown & Root Environmental, 1996a) and is the subject of an ongoing focused RI being conducted by the Navy.

Sites 6 and 7 are collocated north of Site 5. Site 6 consisted of pits where paint, solvents, demolition waste, oil, flammable waste, and grease trap waste were disposed, backfilled, and covered. The disposal reportedly took place from 1960 to mid-1980. Site 7 was reported as an area where one or two trenches were used for the disposal of approximately 700 cubic yards of industrial waste sludge cake generated at the on-base wastewater treatment facility. The

disposal reportedly took place between 1950 and 1955. Sites 6 and 7 have been extensively studied and the Navy is in the process of selecting a final remedy for these sites (OU-7).

AREA B STUDIES AND ACTIONS

On October 4, 1989 NAWC Warminster was placed on the final National Priorities List (NPL). Since 1989, several remedial investigations (RI) and feasibility studies (FS) have been conducted at NAWC for the various areas of concern. This report summarizes those activities associated with Area B and focuses on Area B groundwater.

The Phase I RI was conducted from 1989 to 1991 and included a cursory soil gas study and electromagnetic survey to better define the location of the site boundaries and the potential source areas. Limited test pitting was also conducted to delineate the disposal areas. Shallow and overburden wells were installed and sampled to characterize groundwater quality and to determine groundwater flow direction. The Phase II RI was conducted in 1992 and 1993. Activities included installing additional overburden and shallow bedrock monitoring wells, sampling and analyzing groundwater, surface water, sediment, and soils, and evaluating aquifer characteristics through water-level monitoring and a pumping test. Groundwater-related RI and FS reports for OU-1 were released in April 1993. Based on TCE levels slightly in excess of the MCL in three monitoring wells, the RI and FS reports projected the presence of a TCE contamination plume within Area B.

In September 1993, the Navy and the EPA signed a ROD for OU-1 that consists of contaminated overburden and shallow bedrock groundwater attributable to Area A and Area B at the base. The ROD selected an interim clean-up plan to minimize the migration of contaminated groundwater while additional studies were to be performed to determine the full nature and extent of groundwater contamination. The clean-up plan called for actively pumping and treating groundwater from Area B (as well as from Area A) while additional groundwater studies were being performed.

In December 1994 and January 1995, the Navy installed two extraction wells and six observation wells downgradient of Sites 5, 6, and 7 within the projected TCE plume. Yield tests, water-level measurements, and water quality sampling were conducted to evaluate aquifer characteristics in support of the OU-1 ROD groundwater remedy. Analytical results indicated that no VOCs were detected in excess of MCLs within the projected downgradient plume area. TCE was identified in only one sample at levels close to the detection limit.

During this same time period additional hydrogeologic investigations were being conducted in Area B as required by the ROD. These investigations were conducted from 1993 through 1994. Activities included the installation and sampling of monitoring wells at multiple depths in and around Area B. Groundwater quality trends and hydrogeologic characteristics within the study area were evaluated to further define the nature and extent of the contamination and potential migration patterns. Water level studies and pumping tests were performed to better define the nature of the hydrogeologic setting. Based on this work, a draft hydrogeologic investigation report for Area B was released in April 1995.

After completion of the extraction well yield tests and the hydrogeologic investigation, the Navy, EPA, and PADEP evaluated current and historical groundwater data from Area B and specifically reviewed the data available for the projected TCE plume area. Contaminant trends over time were evaluated and it was concluded that TCE concentrations in the well that contained the highest levels of TCE (up to 13 ug/l) appeared to be stable while TCE levels were either not detected or were present at levels consistently below the MCL in downgradient monitoring wells. Considering this contaminant trend along with the results from the extraction well results, a consensus decision was reached to discontinue the plan to actively pump groundwater from Area B but to continue monitoring and additional investigations. It was also agreed that this decision was consistent with the objectives stated in the interim ROD which was to minimize migration of contaminants within Area B groundwater.

A Phase III RI was conducted in 1995. The objective of the Phase III RI was to characterize sources of contamination, primarily soils and wastes at known and potential waste disposal sites. RI work within Area B consisted of soil gas and electromagnetic studies to define potential source and/or disposal areas, surface and subsurface soil sampling, and sampling of area streams and sediments. The Phase III RI did not address groundwater. A draft Phase III RI report was issued in October 1996. A focused RI and FS was conducted at Sites 5 and 6 from 1996 through 1999. Like the Phase III RI this effort did not address groundwater but addressed potential sources of groundwater contamination and other media of concern within Area B. Based on the initial findings of the OU-7 remedial investigation, the Navy conducted a removal action within Sites 6 and 7 in 1997. Contaminated soils and wastes that were identified as possible source areas for groundwater contamination were excavated from three areas and disposed of offsite. The excavations extended in depth to the bedrock surface and laterally to the point where sample analysis confirmed the lack of contamination above action levels. Final RI and FS reports have been issued for OU-7 and the final remedy selection process for media other than groundwater for this area is ongoing.

During this same time period, 1994 through 1999, additional hydrogeologic investigations were conducted throughout Area B. Additional monitoring well installation, water level studies, and groundwater quality investigations were conducted as part of area wide and focused studies. The Navy implemented a perimeter monitoring program in 1994 that includes the periodic collection and analysis of groundwater samples from selected monitoring wells around the entire former base, including some in the vicinity of Area B. This effort is ongoing. In addition to these sampling events, a comprehensive area-wide water level measurement and groundwater sampling program was conducted in June and July 1998. This study included all available Area B wells in addition to wells located in the general area outside of Area B.

This RI report uses Area B historical RI findings of investigation, perimeter monitoring results, and the results of the June/July 1998 comprehensive round to evaluate current status and potential human health or environmental risk from Area B groundwater. The risk assessment was conducted using the June/July 1998 Area B data because this is the most current comprehensive data set available for the area.

HYDROGEOLOGY

The geology of Area B consists of a thin veneer of residual soils overlying sedimentary bedrock of the Stockton Formation. The soils consist primarily of silt and clay, with some sand, and extend to an average depth of about 10 feet below ground surface. The transition from soils to competent bedrock occurs gradually over a distance of about 5 to 10 feet typically, due to the effects of weathering on the bedrock surface. The bedrock surface within Area B slopes gently to the south and southeast mimicking ground topography.

The bedrock of the Stockton Formation consists of alternating sequences of fine- and coarse-grained, gently dipping rock units. Lithologic units vary in thickness from less than a foot to a maximum observed thickness of about 60 feet within Area B. Locally, bedding within the Stockton Formation strikes approximately north 71 degrees east and dips approximately 5 degrees to 8 degrees to the northwest. This dip of the rock units is approximately opposite to the overall topographic slope of the ground surface within Area B. Beds encountered at shallow (< 100 to 150 feet) depths within northern portion of the study area crop out to the south, near the southern boundary of NAWC.

Fractures were encountered at varying depths of the well borings drilled in and around Area B. Based on geophysical and boring log information, the fractures included both bedding-plane fractures and cross-formation joints. Fractures were observed within both the sandstone and

mudstone units, with the fractures in the sandstones more likely to yield significant quantities of water.

The fractured bedrock of the Stockton Formation is the major source of groundwater in the vicinity of NAWC Warminster. The middle arkose member of the Stockton Formation is considered to be the most productive bedrock aquifer in Bucks County. The Stockton Formation in the vicinity of NAWC Warminster forms a complex, multi-aquifer system. The individual water-bearing zones of the Stockton Formation may belong to one of three different aquifer types which, in descending subsurface order, include; Overburden (weathered bedrock) aquifer; Shallow bedrock aquifer; Deeper bedrock aquifer. The shallow bedrock aquifer may extend to depths of about 75 to 120 feet below the ground surface. The shallow bedrock aquifer is recharged by vertical percolation through the overburden and is the primary reservoir for groundwater storage in the Stockton Formation.

The overall direction of groundwater flow across Area B is to the south. Potentiometric surface measurements show groundwater gradients at increasing depths within the Stockton Formation, in and around Area B. Shallow groundwater (less than 60 feet deep) flow across Area B is generally to the south. Intermediate-depth (60 to 110 feet) groundwater flow across Area B is to the south and is similar to the shallow groundwater flow pattern. The horizontal flow gradient varies from north to south: it is slightly steeper to the north and lower to the south, which is consistent with the change in ground surface slope across the area. As with the shallow and intermediate-depth groundwater, deep (greater than 110 feet deep) groundwater flow across Area B is generally to the south at an approximate overall horizontal gradient.

Based on groundwater-level measurements made in wells completed at different depths within well cluster locations, the overall vertical groundwater flow gradient is downward. Hydraulic heads within the shallow bedrock wells were generally higher than the water levels in the deeper wells, with a few exceptions. This pattern of vertical flow was expected and reflects that the source of water to the deeper groundwater flow zones within the bedrock is primarily leakage from overlying flow zones.

The migration of contaminants in groundwater across Area B is influenced by several factors. Groundwater primarily moves through interconnected networks of fractures within the bedrock. Lateral groundwater (and contaminant) migration directions are to the south across Area B and are controlled by topography and by the presence of the tributary of Southampton Creek south of Area B. Groundwater flow follows the slope of the ground surface topography across Area B, flowing against the dip direction of the bedrock units. It is expected that groundwater from Area B will eventually discharge to streams within the Southampton Creek drainage.

NATURE AND EXTENT OF CONTAMINATION

Three separate groundwater investigations were conducted in Area B prior to the issuance of the interim ROD in 1993. These investigations were the Pre-Remedial and Phase I and Phase II RIs. The investigations focused on the overburden and shallow bedrock groundwater zones. The analytical results detected the presence of low levels of TCE in several monitoring wells located in the central portion the study area.

TCE was the only VOC identified in excess of the MCL (5 ug/l). TCE was detected at levels above the MCL in three wells at concentrations ranging from 6 ug/l to 13 ug/l. Other monitoring wells adjacent to and downgradient of these wells contained TCE levels ranging from non detect to 4 ug/l. Monitoring wells located at the far downgradient portion of Area B did not contain any TCE.

In addition to TCE, these investigations identified the presence of several metals in Area B groundwater. Further study and evaluation of the analytical results and the results of upgradient and base-wide background levels indicated that the concentrations detected within Area B were consistent with regional levels.

Based on the presence of TCE levels above the MCL in three wells the Phase II RI concluded that shallow groundwater associated with Area B presented an unacceptable risk to human health. Based on available TCE data and inferred groundwater flow directions, it was projected or hypothesized that a TCE contaminant plume existed within Area B. These findings and conclusions lead to the issuance of the interim ROD for Area B groundwater.

As required by the interim ROD additional hydrogeologic investigations were conducted in Area B from 1993 through 1994. These investigations included the installation of additional monitoring wells and the sampling and analysis of Area B groundwater as well as the performance of pumping tests and an evaluation of analytical results over time. TCE was again identified as the major contaminant of concern for Area B groundwater. Analytical results were consistent for TCE levels in the central portion of the projected TCE plume area; however, only two wells contained TCE over the MCL. Levels in the two wells that previously contained the highest levels of TCE (8 ug/l and 13 ug/l) remained at similar levels (7 ug/l and 12 ug/l). TCE in the third well, which had previously been detected at 6 ug/l, was detected at 4 ug/l. TCE levels in the other Area B wells remained below the MCL including those immediately downgradient of the projected TCE plume area. In addition, newly installed wells within the projected TCE plume area contained TCE below MCLs.

As part of the hydrogeologic investigation a 72-hour pumping test was conducted using a monitoring well within the downgradient portion of the projected TCE plume. The pumping test was performed to collect additional contamination data as well as to support the installation of extraction wells as required by the interim ROD. Analytical results from samples taken during the pumping test detected TCE at levels below the MCL throughout the test. TCE was detected at 4 ug/l during the initial stages of the test and at 3 ug/l during the latter part and conclusion of the test.

In 1995 the Navy installed two extraction wells in the downgradient portion of the projected TCE plume. Samples were collected from these wells during 12-hour yield tests and a 72-hour pumping test conducted in preparation for the full implementation of a groundwater extraction and treatment system. TCE was detected at 1.5 ug/l (well below the MCL) in only one sample collected during this testing.

After completion of the extraction well tests, the historical data for Area B groundwater was evaluated and reviewed with EPA and PADEP. Based on the results of an historical trend analysis and the findings and results of the hydrogeologic investigation and extraction well testing, it was concluded that TCE levels were stable in the area of the one well that consistently contained concentrations above the MCL. It was further concluded that TCE was not migrating downgradient of this location and that the projected plume may be decreasing in size and in concentration. Based on this evaluation it was determined that active pumping of Area B groundwater was not required to minimize TCE migration.

As required by the interim ROD the Navy continued to monitor and study Area B groundwater. The Navy implemented a perimeter monitoring program in 1994 and this program is ongoing. The program consists of the periodic sampling and analysis of groundwater throughout the base area. Monitoring wells in and around Area B are included in this perimeter monitoring program. In addition to this program, the Navy installed additional monitoring wells within Area B to better characterize groundwater quality and flow patterns during the period from 1995 to 1998. Samples were collected from these wells as they were installed and during a comprehensive round of sampling conducted in 1998.

Fifty-three Area B monitoring wells were sampled during the 1998 comprehensive groundwater monitoring event. TCE was detected at concentrations slightly above the MCL in only one well. This one well contained 7 ug/l of TCE. Six other wells contained TCE at levels ranging from 1 ug/l to 4 ug/l. The distribution or extent of the TCE contamination is similar to that identified in previous investigations but the concentrations are significantly lower. No other Area B contaminant was identified above an MCL.

Twelve rounds of perimeter monitoring have been conducted in Area B from September 1994 through June 1999. Four wells located in the downgradient portion of Area B have been consistently sampled throughout this period. TCE levels have consistently been reported as non-detect to estimated trace-levels in these wells. TCE was detected once at the detection limit (1 ug/l) in one sample in 1994 but has not been detected above that level since that time.

A historical review of TCE levels over time for wells within Area B indicates that the TCE plume projected to exist in 1993 does not currently exist and indicates that TCE is present in only low-level concentrations. TCE within the projected plume area has decreased in concentration and extent over time. Of the three wells that contained TCE levels (6 ug/l to 13 ug/l) above the MCL in 1992 and were used to project the presence of a contaminant plume, only one well was found to contain TCE (7 ug/l) slightly above the MCL during the 1998 sampling event. One of the other wells contained TCE at 4 ug/l and TCE was not detected in the third well. Additional monitoring wells installed and sampled within and downgradient of the plume area have detected TCE at only sporadic low-levels at or near the detection limit.

BASELINE RISK ASSESSMENT

A base-line risk assessment using analytical results from the 1998 comprehensive round of sampling was performed assuming that Area B groundwater would be used for residential purposes. The risk assessment evaluated potential child and adult exposure scenarios and calculated the potential risk associated with lifetime residential exposure. It should be noted that Area B groundwater is not currently used for residential purposes and that public water is available to residents in the near-by communities.

The risk assessment was performed according the most recent EPA guidance. Estimated potential risks were calculated for the reasonable maximum exposure (RME) scenario and for the central tendency exposure (CTE) scenario if the RME exceeded acceptable ranges. The RME represents the conservative, upper end or most reasonably assumed maximum potential exposure to contamination. The CTE represents the central or average potential exposure reasonably expected to occur under the use scenario.

EPA has defined the cancer risk range of 10^{-4} to 10^{-6} as the "target range" for most hazardous waste facilities evaluated. Cumulative cancer risks greater than 10^{-4} generally will indicate that some degree of remediation is required, and cancer risks below 10^{-6} normally will not result in

remedial efforts. When the calculated risk falls between 10^{-4} to 10^{-6}, decisions are typically made on a case by case basis.

The estimated RME lifetime cancer risk associated with the potential residential use of Area B groundwater is 1.8×10^{-6} (child 4.0×10^{-7} and adult 1.4×10^{-6}). This estimated risk is at the lower end of the EPA target range. This calculated risk may be interpreted as representing one to two additional cases of cancer in a population of one million people using the Area B groundwater for residential purposes. No CTE was calculated as this estimated risk is within the EPA target risk range and is comparable to the EPA acceptable risk of one additional case of cancer for one million people.

Noncancer risks were evaluated using a Hazard Index (HI) system. EPA has established this system to evaluate the potential for noncarcinogenic health effects of contamination. An HI of 1.0 or less is not expected to result in health effects. The HI for an exposure scenario and for specific target organs are both evaluated under this system. In general, if the total HI exceeds 1.0 than the specific target organs expected to be effected by the contaminants is further evaluated to determine the HI for that organ. The HI value is not a numeric indication of risk. Rather, an HI that exceeds 1.0 indicates that noncancer health effects can not be ruled out.

The estimated RME HI for a resident child and resident adult using Area B groundwater is 4.1 and 1.8, respectively. The estimated CTE HI calculated as 0.52 for the child and 0.16 for the adult resident. An evaluation of the contaminants and the potential risks presented by each, indicated that manganese is the only contaminant that presents a potential risk greater than 1.0.

Because the RME HI for both the child and adult exceed the target HI of 1.0, further evaluation the data set for manganese, the only contaminant that exceeded the target, was performed. This review identified that the maximum total (unfiltered) manganese concentration found in Area B groundwater was used in calculating the RME HI. This was done in accordance with EPA guidance for the evaluation of the RME. However, an examination of the metals data set indicates that the manganese concentrations that result in an HI of 1.0 or greater are present in only one well cluster. In addition, a review of historical Area B and base-wide regional groundwater data indicates that this manganese level is consistent with background levels for total or unfiltered groundwater samples. The estimated risk associated with this manganese level is overestimated and is not specific to contamination attributable to Area B and is considered to be consistent with background risks.

RECOMMENDATIONS

Considering the historical and current data available, it is recommended that no further remedial action be taken for Area B groundwater.

1.0 INTRODUCTION

In response to Contract Task Order (CTO) No. 291 under Contract N62472-90-D-1298, Tetra Tech NUS, Incorporated (TtNUS) was assigned by the Naval Facilities Engineering Command (NAVFAC) Northern Division (NORTHDIV), as part of continuing investigations at the former Naval Air Warfare Center (NAWC) Warminster, Pennsylvania, to perform a comprehensive groundwater evaluation for Area B at the base. Area B consists of the former disposal areas Site 5, Site 6, and Site 7 at the former NAWC Warminster. This work has been pursued as part of the Navy's Installation Restoration (IR) Program under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The Navy's IR Program investigates potential contamination of Navy and Marine Corps facilities resulting from past operations to institute corrective measures as needed.

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

1.1 PURPOSE

This report addresses groundwater issues arising from past practices at Area B and makes recommendations for further action. The report presents and discusses the site history, characteristics, hydrogeology, and general background information used to support the conclusions and recommendations, presented in Section 7.

Groundwater quality issues associated with Sites 5, 6, and 7 (Area B Groundwater) have been studied extensively and reported previously by the Navy in a series of investigation reports. Area B groundwater has been designated as part of Operable Unit 1 (Area B OU-1) by the Navy for administrative purposes under the EPA CERCLA program. The Navy issued an interim Record of Decision (ROD) for OU-1 in 1993 and initiated interim remedial actions for Area B OU-1 in 1994 and 1995. As part of the interim remedial action the Navy installed groundwater extraction wells and initiated pumping activities. During the initial phases of the pumping, contaminant levels in newly installed Area B extraction wells were found to be at concentrations below action levels. The Navy also, as part of the interim remedy, continued to conduct additional investigations and hydrogeologic studies in the area.

This report combines the relevant parts of previous studies and reports into one cohesive remedial investigation document. The findings presented in this report are to be used to support the selection of a final

remedy for Area B OU-1 groundwater.

1.2 NAWC WARMINSTER BACKGROUND AND HISTORY

This section describes NAWC Warminster and provides a brief synopsis of the facility's background and history.

1.2.1 Facility Description

NAWC Warminster is located in the township of Warminster, Bucks County, Pennsylvania. The facility can be found on the USGS Hatboro 7.5-minute topographic quadrangle map, a portion of which is reproduced as Figure 1-1. The total area of NAWC Warminster is approximately 734 acres. The facility lies in a populated suburban area surrounded by private homes, various commercial/industrialactivities, and a golf course. On-base areas include various buildings and other complexes connected by paved roads, the runway and ramp area, mowed fields, and a small wooded area.

The facility is located on a ridge, generally oriented east-west, with elevations ranging from 297 feet at the northwestern property boundary to 377 feet at the eastern boundary. Slopes are gentle and average 3 to 5 percent. The northern portion of the facility (about 65 percent) drains into small, unnamed tributaries of Little Neshaminy Creek. The remaining portion drains into unnamed tributaries of Pennypack Creek.

The main areas of investigation at NAWC Warminster include several waste sites covering more than 15 acres (Figure 1-2). All sites are located within the NAWC Warminster property and include the following:

- Three waste burn and disposal pits (Sites 1, 3, and 6).
- Two sludge disposal pit areas (Sites 2 and 7).
- Two landfills located on the north and south sides of the active runway (Sites 4 and 5).
- One fire training area (Site 8).
- A series of eight unlined impoundments (Impoundment Area).

These sites, along with other suspected sources at the base, have been grouped into four general areas based on their proximity to one another, similarities regarding source and waste characteristics, and their common effects on nearby receptors (e.g., aquifers, surface water bodies, and human populations) (Figure 1-2). The general areas are

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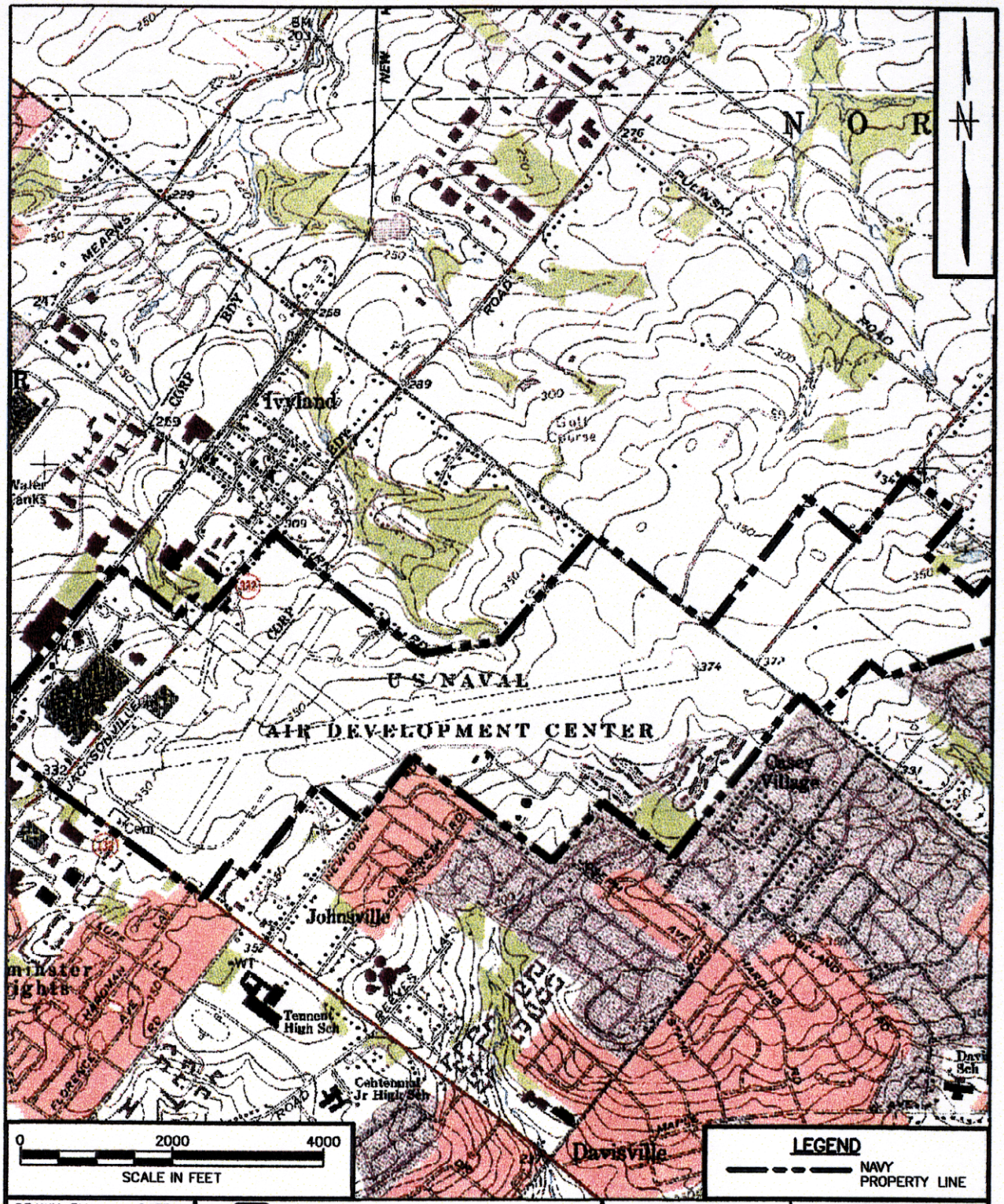

DRAWN BY A.S.M. DATE 11/24/1998	Tetra Tech NUS Inc.	CONTRACT NO. N62472-90-D-1298	OWNER NO. CTO 0252
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COST/SCHED-AREA		APPROVED BY DATE	
SCALE 1 in.=2000 ft.		DRAWING NO. FIGURE 1-1	REV. 0

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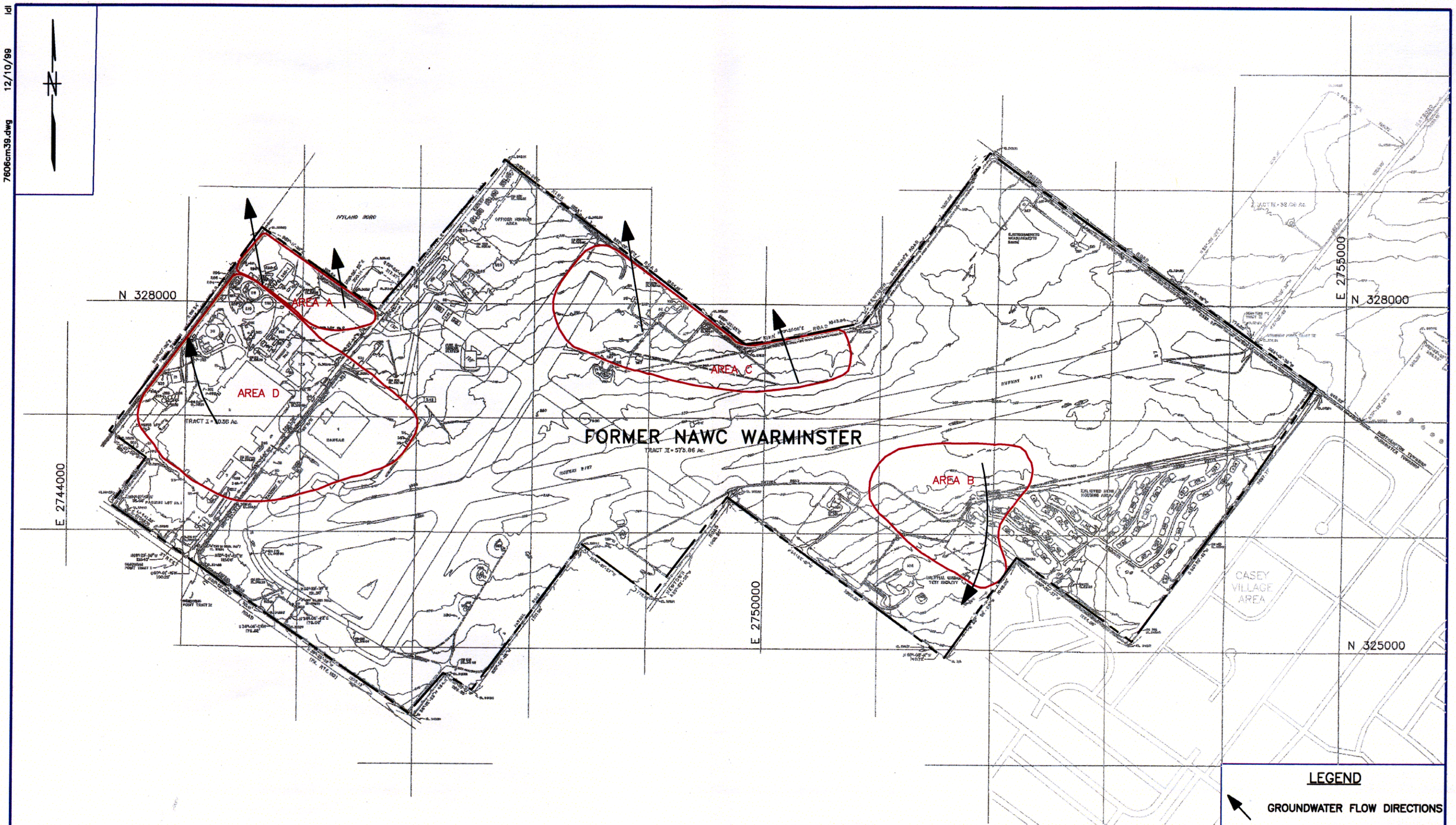

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SCALE IN FEET

DRAWN BY LDL	DATE 12/10/99	Tetra Tech NUS, Inc.	STUDY AREAS NAWC WARMINSTER WARMINSTER, PA	CONTRACT NO. 7606
CHECKED BY	DATE			OWNER NO. 0101
REVISED BY	DATE			APPROVED BY / DATE 5/11/00
SCALE AS NOTED				DRAWING NO. FIGURE 1-2 / REV.

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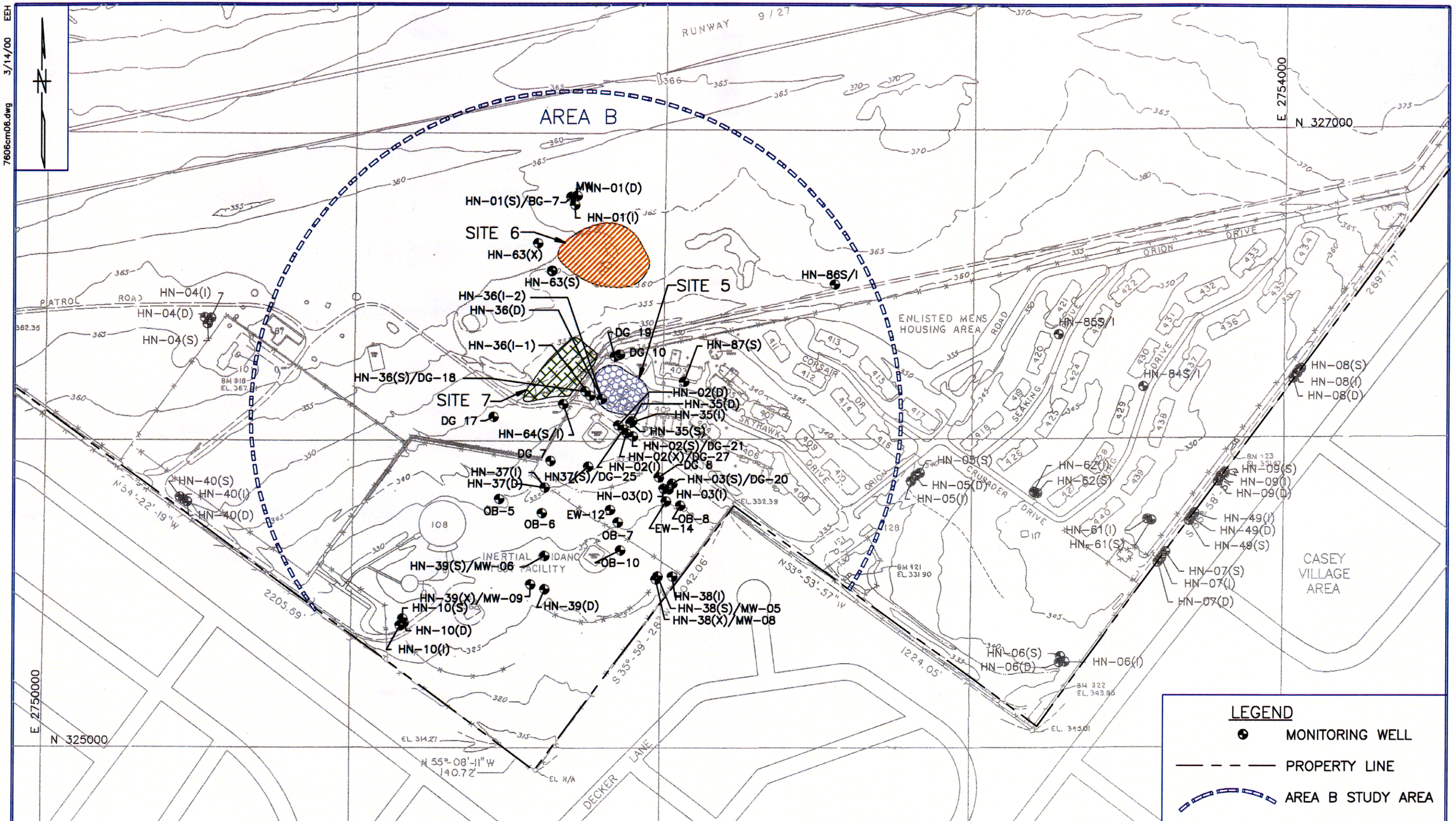

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Tetra Tech NUS, Inc.

AREA B SITE FEATURES

NAWC WARMINSTER, PA

CONTRACT NO. 7606

OWNER NO. 0101

APPROVED BY DATE 5/17/00

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REV.

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- Area A, which is located in the northwestern corner of the base (Sites 1, 2, and 3).
- Area B, which is located south of the main runway (Sites 5, 6, and 7).
- Area C, which is located north of the main runway (Sites 4 and 8).
- Area D, consisting of the main building complex at the base.

Historically, wastes were generated at the base during aircraft maintenance and repair, pest control, firefighting training, machine and plating shop operations, spray painting, and various materials research and testing activities in laboratories. These wastes included paints, solvents, sludges from industrial wastewater treatment, and waste oils. None of the sites are currently used for waste disposal.

The longest runway, which is inactive, is generally located along the topographically highest area at the facility. Many of the primary facility buildings are located west of the airstrip, along Jacksonville Road. A housing development for military enlisted personnel is within the southeastern portion of NAWC Warminster. A wastewater treatment plant is located in the northwestern corner of the facility.

Approximately 100 employees currently work at the former base, and 1,000 people reside at the enlisted personnel housing area. The residents living at the enlisted personnel housing area are the nearest population center. The closest off-base home is about 200 feet away.

Geologically, NAWC Warminster is underlain by the Stockton Formation, which provides water for more than 100,000 people within the area. Local surface water bodies are used for recreation and industrial purposes.

1.2.2 Facility History

The facility was originally the location of Brewster Aeronautical Corporation, a manufacturer of military aircraft. In 1944, the Navy assumed full control of the Brewster plant. The Naval Air Modification Unit was installed at the base to add design modifications to military aircraft produced at other locations. After World War II, activities at the base were altered; in 1949, the facility was designated the Naval Air Development Center (NADC), and its main mission, research, development, testing, and evaluation for Naval aircraft systems, was established. NADC Warminster also conducted studies in anti-submarine warfare systems and software development. The facility name was changed from NADC to NAWC, Aircraft Division, on January 1, 1992. In 1996, NAWC Warminster was selected for realignment under the Base Realignment and Closure (BRAC) Program managed by the Department of Defense (DOD). This realignment, which is part of a DOD restructuring effort mandated by Congress, was implemented in September 1997. The restructuring

resulted in the relocation of NAWC Warminster national defense activities to Naval Air Station (NAS) Patuxent River, Maryland. The base is now closed and is being redeveloped for non-military use by the Federal Lands Reuse Authority (FLRA).

1.2.3 Environmental Investigations

The U.S. Environmental Protection Agency (EPA) officially recognized the NAWC Warminster sites as possibly needing investigation in September 1979. Since 1979, NAWC Warminster, regulatory agencies, and others have been involved in various regional environmental response actions for the study area.

In November 1979, EPA completed a PA. In 1980, the Department of the Navy began its environmental investigative work at NAWC Warminster. The first study, known as the Clay/Law Report, inventoried disposal activities at each of the eight sites. A variety of environmental investigations have been performed at these sites since that time under the direction of the Navy.

The Navy's first investigations were performed under the Navy Assessment and Control Installation Pollutants (NACIP) program in 1980 to assess the potential for VOCs to emanate from the NAWC Warminster facility. In 1980, the Navy performed soil boring investigations at NAWC Warminster and found trichloroethylene (TCE) at a maximum concentration of 78 ug/kg near the wastewater treatment plant in Area A (SMC Martin, May 28, 1980). A groundwater investigation conducted by the Navy at NAWC Warminster in the same year encountered TCE at a maximum concentration of 130 ug/l in the shallow groundwater and 7 ug/l in the deeper groundwater in Area A. The groundwater report concluded that leakage from the wastewater sludge lagoons could have contributed to the regional TCE contamination (SMC Martin December 10, 1980).

In 1983, the Navy completed a hydrogelogical investigation at NAWC Warminster consisting of a records search to identify potential former disposal sites, installation of 14 monitoring wells, and groundwater sampling and analysis at the eight suspected sites (JRB Associates, March 17, 1983). Analytical results confirmed VOC concentrations in groundwater at levels generally below typical regional concentrations.

In 1984, a second round of groundwater samples from the eight sites and an evaluation of potential migration of contaminants from NAWC sites to groundwater was performed (Walter B. Satterthwaite Associates, May 1984).

In 1985, EPA completed a PA/SI Report. In 1986, NAWC Warminster was proposed for inclusion on the National Priorities List (NPL) based on a Hazard Ranking System (HRS) score greater than 28.50. EPA used the HRS to assess the relative threat from releases of hazardous substances from the eight NAWC

Warminster sites to surrounding groundwater and surface water. The facility score was based on the estimated likelihood that a hazardous substance would be released from the sites, the toxicity and amount of hazardous substances at the sites, and the people and sensitive environments potentially affected by contamination at the sites.

On October 4, 1989, NAWC Warminster was placed on the final NPL. That same year, EPA submitted a draft Interagency Agreement to the Navy to formalize and schedule remedial activities. The contents of this agreement were negotiated in 1990.

Since 1989, several remedial investigations and feasibility studies have been conducted at NAWC Warminster for the various areas of concern (i.e., Area A, Area B, Area C, and Area D). The Phase I RI was performed between October 1989 and April 1991 by SMC Environmental Services Group (SMC Martin, 1991). Phase II was performed between May 1992 and April 1993 (HNUS, 1992, 1993a). In April 1993, the Navy released a focused FS for groundwater contamination attributable to Areas A and B (HNUS 1993). In addition, the Navy initiated additional hydrogeologic studies and investigations for Area B in 1993 and issued an Area B Hydrogeologic Report in April 1995 (HNUS, 1995). Phase III, which addresses potential source areas and their impacts to soils, surface waters, and sediments, began in January 1995 and is ongoing (Brown & Root Environmental, 1996a). Source area RI/FS investigations and reports have been completed for Sites 6 and 7, and are underway for Site 5. A source area removal action was performed by the Navy for Sites 6 and 7 in 1997. A final RI and FS for these sites were issued in November and December 1999 (TtNUS 1999) and the Navy is in the process of selecting a final remedy for implementation. The Navy has also performed additional groundwater investigations in and around Area B since the issuance of the 1995 hydrogeologic report and has been conducting facility perimeter monitoring since 1994. This report summarizes the results and findings presented in these and other reports.

A Technical Review Committee [now the Restoration Advisory Board (RAB)] has been assisting in the planning and review of environmental investigation, remedial alternative evaluation, and remediation activities, along with future land use planning. The RAB consists of representatives of the Navy, EPA, the Pennsylvania Department of Environmental Protection (PADEP), the Bucks County Health Department, the Northampton Township Municipal Authority, the Warminster Township Municipal Authority, Ivyland Borough, and Upper Southampton Township, as well as members of the community and concerned environmental organizations.

The results and findings of all previous investigations are maintained in two local information repositories that contain the Administrative Record for NAWC Warminster. One repository is located at the base; the second can be found at the Bucks County Library, Doylestown Branch.

1.3 AREA B HISTORY AND DESCRIPTION

This section provides a brief background of Area B and a summary of the investigations and actions related to this study area. More detailed information can be found in the Phase II Remedial Investigation Report for Operable Unit 1, NAWC Warminster, Pennsylvania (Halliburton NUS, 1993a), the Draft Area B Hydrogeologic Report, NAWC Warminster, Pennsylvania (Halliburton NUS, 1995), the Summary Report for Area B Groundwater Monitoring, NAWC Warminster (Tetra Tech NUS, October 1998), the Remedial Investigation Report for Operable Unit 7, Soils and Waste at Sites 6 and 7 (TtNUS, 1999), and the Feasibility Study for Operable Unit 7, Soils and Waste at Sites 6 and 7 (TtNUS, 1999).

1.3.1 Area B History

Area B includes Sites 5, 6, and 7 (see Figure 1-3), which were reportedly used for disposal of wastes potentially containing CERCLA hazardous substances. Site 5 was initially reported in the Navy Shore Facility Fact Form (1980) to have been used for waste disposal purposes. Site 5 reportedly consisted of up to eight trenches that were used for the disposal of demolition wastes, paint, solvents, scrap metal, aircraft paints, cans, and asphalt. With the exception of a reported 30 drums of asphalt, the quantity of materials disposed was reported as unknown. The trenches were reportedly operated from 1955 to 1970, were approximately 12 feet by 70 feet by 8 feet in dimension, and were covered with 2 feet of fill and graded and seeded. Navy enlisted housing units have since been constructed within this area. Site 5 was investigated as part of the Phase III RI (Brown & Root Environmental, 1996a) and is the subject of an ongoing focused RI being conducted by the Navy.

Sites 6 and 7 are collocated north of Site 5 and the patrol road. The Navy initially reported disposal of waste at Sites 6 and 7 in the Navy Shore Activity Disposal Fact Form (1980), which indicated that Site 6 consisted of pits where paint, solvents, demolition waste, oil, flammable waste, and grease trap waste were disposed, backfilled, and covered. The disposal reportedly took place from 1960 to mid-1980. No information was provided regarding dimensions of the pits or the quantity of waste disposed.

Site 7 was reported as an area where one or two trenches were used for the disposal of approximately 700 cubic yards of industrial waste sludge cake generated at the on-base wastewater treatment facility. The disposal reportedly took place between 1950 and 1955 in one or two trenches that were 12 feet by 100 feet by 8 feet deep. After disposal, the trenches were reportedly covered with 2 feet of soil, graded, and seeded. Sites 6 and 7 have been extensively studied and the Navy is in the process of selecting a final remedy for these sites.

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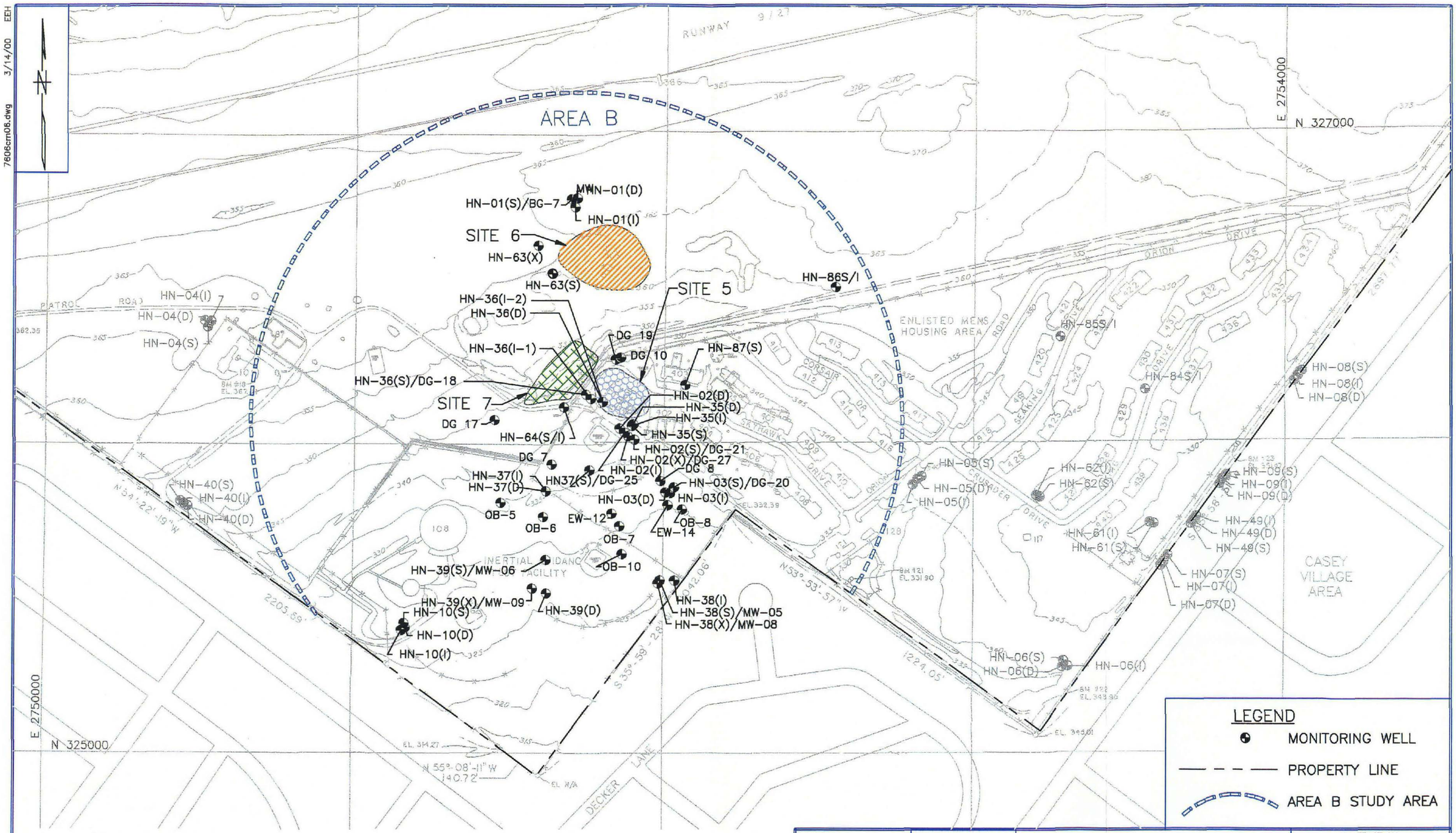

LEGEND

- MONITORING WELL
- PROPERTY LINE
- AREA B STUDY AREA

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SCALE IN FEET

DRAWN BY LDL/EEH DATE 3/14/00	Tetra Tech NUS, Inc.	AREA B SITE FEATURES	CONTRACT NO. 7606
CHECKED BY DATE		NAWC WARMINSTER, PA	OWNER NO. 0101
REVISED BY DATE			APPROVED BY DATE 5/17/00
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The groundwater in and around Area B has been studied by the Navy and others (EPA, PADEP, and local municipalities) since the early 1980's. These studies have also included investigations of areas outside of Area B and outside of NAWC Warminster. The findings presented in these studies have helped define the hydrogeologic conditions and groundwater flow patterns in the area. Portions of these studies, as they relate to groundwater flow conditions, are included and referenced in this report. Groundwater quality data collected as part of these other studies that are not related to Area B are not discussed or evaluated in this final RI for Area B OU-1 groundwater.

The following presents a summary of the major investigations and actions associated with Area B. Subsequent sections of this report discuss these investigations and present the findings associated with Area B groundwater.

Investigations

- Pre-Remedial Investigations (1982): Shallow overburden groundwater was investigated as part of an initial hydrogeologic investigation. Shallow overburden wells were installed and sampled (JRB Associates, 1983).

- Phase I RI (1989 - 1991): Activities included a cursory soil gas study and electromagnetic survey to locate approximate site boundaries and potential source areas. Limited test pitting was also conducted to better define the extent of the disposal areas. Shallow bedrock and overburden wells were installed and sampled to characterize groundwater quality and flow direction, (SMC Martin, 1991).

- Phase II RI and FS (1992 - 1993): RI/FS work helped determine the nature and extent of groundwater contamination, evaluate shallow groundwater flow and add to the hydrogeologic database, and ascertain possible remedial alternatives. Activities included installing additional overburden and shallow bedrock monitoring wells, sampling and analyzing groundwater, surface water, sediment, and soils, and evaluating aquifer characteristics through water-level monitoring and a pumping test. Groundwater-related RI and FS reports for OU-1 were released in April 1993 (HNUS, 1992, 1993a, and 1993b). The Navy and EPA selected an interim remedy for OU-1 based on the findings presented in these reports.

- Area B Hydrogeologic Investigations (1993 - 1994): Groundwater conditions in and around Area B were investigated. Activities included the installation and sampling of monitoring wells at multiple depths in and around Area B. Groundwater quality trends and hydrogeologic characteristics within the study area were evaluated to further define the nature and extent of the contamination and potential migration patterns. Water level studies and pumping tests were performed to better define the nature of the

hydrogeologic setting. Based on this work, a draft hydrogeologic investigation report for Area B was released in April 1995 (HNUS, 1995b)

- Phase III RI (1995 -): The Phase III RI objective was to characterize sources of contamination, primarily soils and wastes at known and potential waste disposal sites. RI work within Area B consisted of soil gas and electromagentic studies to define potential source and/or disposal areas, surface and subsurface soil sampling, and sampling of area streams and sediments. The Phase III RI did not address groundwater. A draft Phase III RI report was issued in October 1996 (Brown & Root Environmental 1996).

- Sites 6 and 7 (OU-7) RI/FS (1996 – 1999): Investigations and evaluations focused on media other than groundwater. Studies were performed to locate and investigate disposal areas within Sites 6 and 7. Activities included evaluating data from past investigations, conducting additional electromagnetic surveys, advancing subsurface borings to bedrock, excavating numerous test pits, and collecting and analyzing samples of soils and wastes. Initial investigation findings were used by the Navy to direct removal actions in 1997. Following the removal actions at Sites 6 and 7, RI and FS reports were finalized in 1999 (TtNUS 1999). The findings of the remedial investigation indicated that residual contamination at Sites 6 and 7 did not present a threat to groundwater. The Navy is currently in the process of selecting a final remedy for OU-7.

- Additional Hydrogeologic Investigations (1994 – 1999): Additional monitoring well installation, water level studies, and groundwater quality investigations were conducted as part of area wide and focused studies. The Navy implemented a perimeter monitoring program in 1994 that includes the periodic collection and analysis of groundwater samples from selected monitoring wells around the entire former base, including some in the vicinity of Area B. This effort is ongoing. The latest round of data available is presented in the Summary Report for the Twelfth Round of Perimeter Monitoring (TtNUS, 1999). In April 1998, additional monitoring wells were installed in the Navy enlisted housing area to better define groundwater elevations and flow patterns in this area. These wells were also sampled to investigate the presence of contamination. Well installation details and analytical results were presented in a letter report issued in July 1998 (Letter Report, Navy Enlisted Housing Well Installation and Sampling, TtNUS 1998). In addition to these sampling events, a comprehensive area-wide water level measurement and groundwater sampling program was conducted in June and July 1998. This study included all available Area B wells in addition to wells located in the general area outside of Area B. The results of this study were presented in the Summary Report for Area B Groundwater Monitoring, issued in October 1998 (TtNUS,1998).

Response Actions

- OU-1: In 1993, due to the detection of low-levels of TCE (slightly above the Maximum Contaminant

Level (MCL) of 5 ug/l) in three shallow monitoring wells, the presence of a low-concentration TCE plume was projected. In September 1993, the Navy and EPA signed a Record of Decision (ROD) that selected an interim remedy for shallow groundwater in Area B. The interim remedy consisted of the installation and operation of a groundwater extraction system and treatment system to minimize migration of contamination and the performance of additional groundwater studies and monitoring to determine the nature and extent of contamination and to monitor the effectiveness of the extraction system. In December 1994 and January 1995, the Navy installed two extraction wells (EW-12 and EW-14) and six observation wells (OB-5 through OB-10) in Area B. During the initial operation of the extraction wells, detected groundwater contaminant concentrations were consistently at trace levels at or below quantitation limits, well below the MCL.. (OHM Remediation Services Corporation, 1995). Therefore, after consultation with the EPA and PA DEP, the Navy discontinued construction of the Area B groundwater remedy and did not connect the two extraction wells (EW-12 and EW-14) to a groundwater treatment plant constructed onsite to treat groundwater extracted from other areas of the base. Additional groundwater studies and monitoring have been conducted and are ongoing, as required by the ROD, to assess groundwater conditions and to confirm the lack of contamination within Area B groundwater.

- OU-7: Based on the initial findings of the OU-7 remedial investigation, the Navy conducted a removal action within Sites 6 and 7 in 1997. Contaminated soils and wastes that were identified as possible source areas for groundwater contamination were excavated from three areas and disposed of offsite. The excavations extended in depth to the bedrock surface and laterally to the point where sample analysis confirmed the lack of contamination above action levels. Final RI and FS reports have been issued for OU-7 and the final remedy selection process for media other than groundwater for this area is ongoing.

1.4 CURRENT STATUS

As mentioned previously, numerous investigations and rounds of groundwater sampling and analysis have been completed in the vicinity of Area B as part of the phased RI and implementation of the interim remedy. Groundwater investigations have included pumping/aquifer testing, comprehensive groundwater sampling and analysis, water-level studies, and evaluation of the hydrogeological data collected. This RI report presents and evaluates the status of Area B groundwater, considering available data from previous studies. Hydrogeologic and groundwater level data generated by studies in areas adjacent to or around Area B are also referenced where appropriate. Analytical data generated for areas outside of and not associated with Area B are not presented and evaluated. The results and findings presented in this report will support the selection of a final remedy for Area B OU-1 (groundwater associated with Sites 5, 6, and 7).

1.5 REPORT ORGANIZATION

This section provides the background and historical information needed to support the technical discussion and evaluations found in the following sections. Section 2 presents the scope of the hydrogeologic and groundwater quality studies that have been performed. Section 3 discusses the regional and detailed local geology and hydrogeology that govern how contaminants exist and travel within the study area. Section 4 presents an evaluation of the data collected, describing the nature and extent of groundwater contaminants in the study area. Section 5 discusses the typical or potential site-specific chemical toxicity and mobility. Section 6 presents the results, conclusions, and limitations of the human health risk assessment performed for Area B groundwater. Section 7 provides a summary of conclusions.

2.0 AREA B HYDROGEOLOGIC INVESTIGATION

2.1 SCOPE OF INVESTIGATION

Area B groundwater (Area B OU-1) is defined as that groundwater potentially impacted by contamination attributable to Sites 5, 6, and 7 at the former NAWC Warminster. Each site and the collective groundwater associated with the area have been studied extensively during the phased remedial investigations in the vicinity of Area B. In 1993, due to several low-level detections of Trichloroethene (TCE) within Area B groundwater identified during the Phase II RI, an interim remedial action was selected and an interim ROD was issued.

The interim remedial action selected included groundwater extraction and treatment to minimize contaminant migration and continued monitoring and studies to better define the nature and extent of groundwater contamination within Area B. The Navy installed extraction wells in December 1994 and January 1995 and initiated additional studies to assess hydrogeologic conditions and the nature and extent of the contamination as required by the interim remedy. During the initial operation of the extraction wells only trace levels of contaminants were detected at concentrations below regulatory limits. The target contaminants identified in the studies leading up to the implementation of the remedy were not identified in samples collected from the extraction wells after 72 hours of operation. Because of the lack of contamination, the EPA, the Pennsylvania Department of Environmental Protection (PADEP), and the Navy agreed to delay further extraction and treatment of groundwater. It was also agreed that further monitoring and investigations of Area B groundwater would be performed to assess the hydrogeologic conditions and to confirm the lack of, or define the nature and extent of, contamination.

A series of groundwater investigations have been performed in and around Area B since 1993 to augment the investigations that occurred before the interim remedy was selected. This section of the RI report presents the scope of those investigations, the investigations that were conducted leading up to the issuance of the ROD for an interim action, and the scope of the initial actions taken in implementing that remedy. Some of the investigations conducted were area-wide investigations that included groundwater sampling and analysis outside of Area B. These investigations are discussed and referenced in this section and in Section 3 to the extent that they provide information and hydrogeologic data that pertains to groundwater flow and occurrence in the study area. Presentation and discussion of analytical results from monitoring wells outside of Area B are not presented in this report as they do not pertain to groundwater conditions attributable to Sites 5, 6, and 7.

2.2 MONITORING WELL INSTALLATION

A total of 88 wells, including monitoring wells, extraction wells, and observation wells, have been installed in and around Area B since investigations first began in 1982. The well construction details are summarized in Table 2-1, the well locations are shown in Figure 2-1, and a chronological summary of well installation is included in Table 2-2. Borehole drilling logs and well construction diagrams, if available, are included in Appendix A. The well installation details are summarized in the following sections.

2.2.1 Pre-Remedial Investigation Well Installation Information

Five shallow overburden monitoring wells were installed during a pre-remedial investigation conducted in Area B during 1982. The wells were installed to characterize groundwater quality and flow direction at sites 5, 6 and 7. All of the wells were installed in July 1982 as 2-inch diameter, screened completions ranging from 10 to 16 feet deep within the overburden deposits immediately overlying consolidated bedrock. The borehole drilling and monitoring well installation procedures are described in the Hydrogeological Investigation of the Naval Air Development Center Waste Disposal Sites (JRB Associates, 1983).

2.2.2 Phase I Remedial Investigation Well Installation Information

Seven shallow bedrock monitoring wells and one shallow overburden monitoring well were installed during the Phase I Remedial Investigation conducted in Area B during 1990 (Table 2-2, Figure 2-1). The wells were installed to characterize groundwater quality and flow direction within the shallow bedrock aquifer in addition to the overburden aquifer at sites 5, 6 and 7. All of the wells were installed in November 1990 as 6-inch diameter, open borehole completions within the shallow bedrock or as 4-inch diameter screened completions within the overburden deposits immediately overlying consolidated bedrock. The borehole drilling and monitoring well installation procedures are described in the Rough Draft RI Report for the Naval Air Development Center (SMC Environmental Services Group, 1991).

2.2.3 Phase II Remedial Investigation Well Installation Information

Two shallow bedrock and two shallow overburden monitoring wells were installed during the Phase II Remedial Investigation conducted in Area B during 1992 (Table 2-2, Figure 2-1). The wells were installed

TABLE 2-1
REMEDIAL INVESTIGATION REPORT FOR AREA B GROUNDWATER
WELL CONSTRUCTION DETAILS

WELL NUMBER	MONITORED INTERVAL (feet)	WELL DEPTH CLASSIFICATION
HN-01S/BG-7	18.5-37	Shallow
HN-01I	68-92	Intermediate
HN-01D	108-127	Deep
HN-02X/DG-27	6.2-13.2	Overburden
HN-02S/DG-21	15-33	Shallow
HN-02I	85-104	Intermediate
HN-02D	116-133	Deep
HN-03X/DG-8	5.05-9.6	Overburden
HN-03S/DG-20	17.6-32	Shallow
HN-03I	81-102	Intermediate
HN-03D	115-140	Deep
HN-04S	20-37	Shallow
HN-04I	55-73	Intermediate
HN-04D	105-124	Deep
HN-05S	36-55	Shallow
HN-05I	70-88	Intermediate
HN-05D	180-204	Deep
HN-06S	30-53	Shallow
HN-06I	80-103	Intermediate
HN-06D	134-154	Deep
HN-07S	29-45	Shallow
HN-07I	64-85	Intermediate
HN-07D	144-162	Deep
HN-08S	29-48	Shallow
HN-08I	60-78	Intermediate
HN-08D	157-178	Deep
HN-09S	29-52	Shallow
HN-09I	75-103	Intermediate
HN-09D	138-161	Deep
HN-10S	26-40	Shallow
HN-10I	80-101	Intermediate
HN-10D	225-245	Deep
HN-35S	35-48	Shallow
HN-35I	87-105	Intermediate
HN-35D	115-130	Deep
HN-36X/DG-9	6.8-14.7	Overburden
HN-36S/DG-18	22-27	Shallow
HN-36I1	82-100	Intermediate
HN-36I2	101-115	Intermediate
HN-36D	133-147	Deep
HN-37X/DG-7	5.6-15.05	Overburden
HN-37S/DG-25	21-41	Shallow
HN-37I	75-103	Intermediate
HN-37D	116-141	Deep
HN-38X/MW-08	2-7	Overburden
HN-38S/MW-05	25-35	Shallow

TABLE 2-1
REMEDIAL INVESTIGATION REPORT FOR AREA B GROUNDWATER
WELL CONSTRUCTION DETAILS

WELL	MONITORED	WELL
HN-38I/HN-38	97-119	Intermediate
HN-39X/MW-09	2-7	Overburden
HN-39S/MW-06	18-50	Shallow
HN-39D/HN-39	125-150	Deep
HN-40S	55-69	Shallow
HN40I	88-114	Intermediate
HN-40D	120-148	Deep
HN-41S	41-54	Shallow
HN-41I	72-93	Intermediate
HN-41D	151-176	Deep
HN-43S	43-64	Shallow
HN-43I	90-104	Intermediate
HN-43D	117-135	Deep
HN-49S	36-51	Shallow
HN-49I	55-75	Intermediate
HN-49D	118-135	Deep
HN-61S	81-95.5	Intermediate
HN-61I	110-124.5	Deep
HN-62S	35-50	Shallow
HN-62I	70.5-85.5	Intermediate
HN-63X/BG-01	7-15.9	Overburden
HN-63S	27-46	Shallow
HN-64S	29-50	Shallow
HN-64I	82-104	Intermediate
HN-84S	36-51	Shallow
HN-84I	107-120	Deep
HN-85S	19-34	Shallow
HN-85I	72-86	Intermediate
HN-86S	34-52	Shallow
HN-86I	72-86	Intermediate
HN-87S	46-62	Shallow
DG-10	7.65-15	Overburden
DG-17	16.5-38	Shallow
DG-19	21.75-47	Shallow
EW-12	20-100	Intermediate
EW-14	20-100	Intermediate
OB-8	20-100	Intermediate
OB-9	20-100	Intermediate
OB-10	20-100	Intermediate

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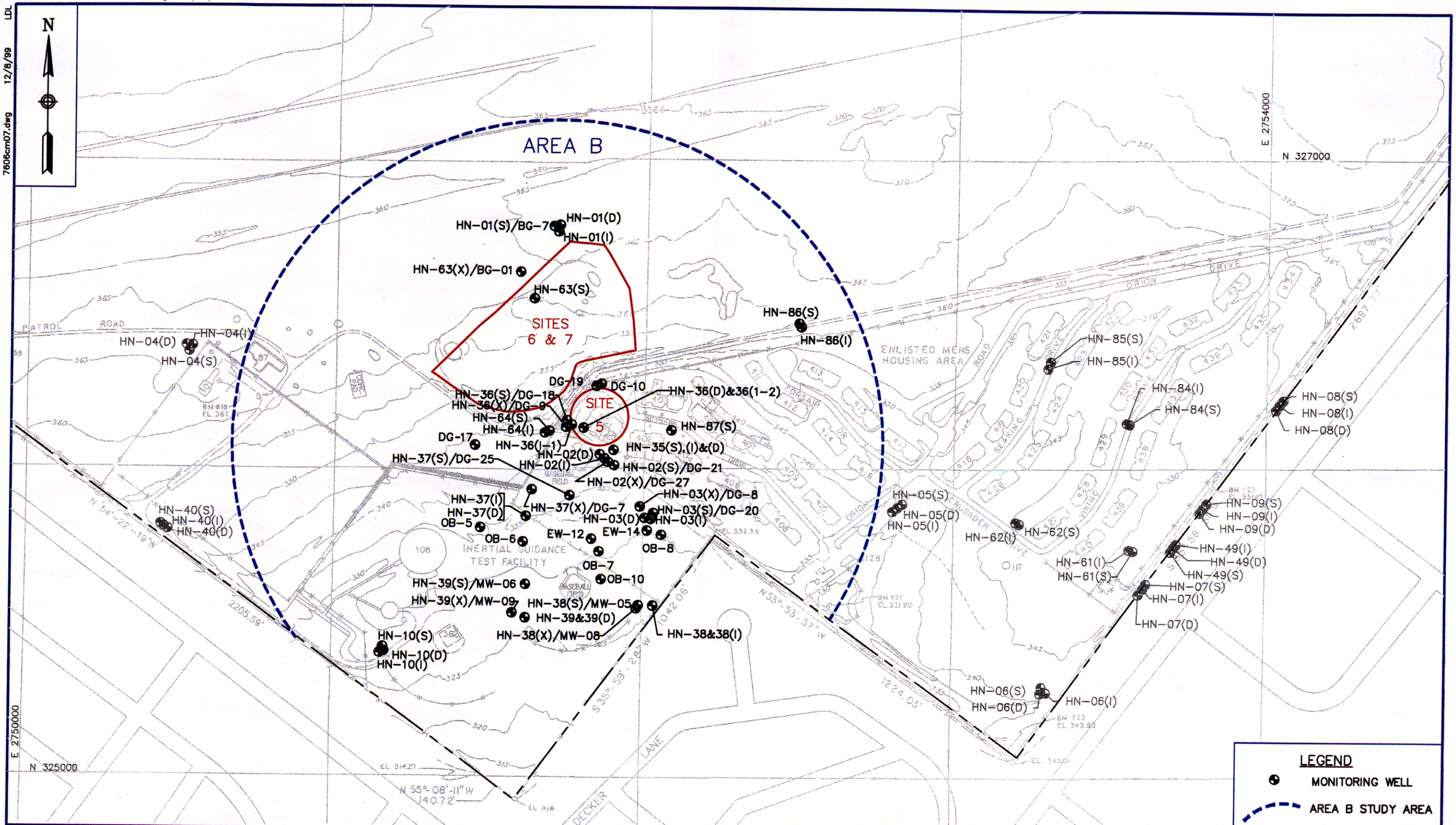

DRAWN BY LDL	DATE 3/22/00	Tetra Tech NUS, Inc.	WELL LOCATIONS AREA B NAWC WARMINSTER, PA
CHECKED BY	DATE		
REVISED BY	DATE		
SCALE AS NOTED			

CONTRACT NO. 7606
OWNER NO. 0102
APPROVED BY DATE
DRAWING NO. FIGURE 2-1 REV.

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TABLE 2-2

REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER
HISTORICAL SUMMARY OF MONITORING WELL INSTALLATION

Present Well Number	Former Well Designation	Well Installation Period									
		Pre-Remedial July 1982	Phase I RI Oct. - Nov. 1990	Phase II RI June 1992	Area B Hydrogeologic Investigation			Interim Remedy Dec. 1994 - Jan. 1995	Additional Investigations		
					Oct. - Dec. 1993	May - Aug. 1994	Oct. - Nov. 1994		Dec. 1995	April 1996	April 1998
HN-01S	BG-7		X								
HN-01I					X						
HN-01D					X						
HN-02X	DG-27		X								
HN-02S	DG-21		X								
HN-02I					X						
HN-02D					X						
HN-03X	DG-8	X									
HN-03S	DG-20		X								
HN-03I					X						
HN-03D					X						
HN-04S					X						
HN-04I					X						
HN-04D					X						
HN-05S					X						
HN-05I					X						
HN-05D					X						
HN-06S					X						
HN-06I					X						
HN-06D					X						
HN-07S					X						
HN-07I					X						
HN-07D					X						
HN-08S					X						
HN-08I					X						
HN-08D					X						
HN-09S					X						
HN-09I					X						
HN-09D					X						
HN-10S					X						
HN-10I					X						
HN-10D					X						
HN-35S						X					
HN-35I						X					

TABLE 2-2
REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER
HISTORICAL SUMMARY OF MONITORING WELL INSTALLATION

Present Well Number	Former Well Designation	Well Installation Period									
		Pre-Remedial July 1982	Phase I RI Oct. - Nov. 1990	Phase II RI June 1992	Area B Hydrogeologic Investigation			Interim Remedy Dec. 1994 - Jan. 1995	Additional Investigations		
					Oct. - Dec. 1993	May - Aug. 1994	Oct. - Nov. 1994		Dec. 1995	April 1996	April 1998
HN-35D						X					
HN-36X	DG-9	X									
HN-36S	DG-18		X								
HN-36I1						X					
HN-36I2						X					
HN-36D						X					
HN-37X	DG-7	X									
HN-37S	DG-25		X								
HN-37I						X					
HN-37D						X					
HN-38X	MW-08			X							
HN-38S	MW-05			X							
HN-38I	HN-38D					X					
HN-39X	MW-09			X							
HN-39S	MW-06			X							
HN-39D	HN-39					X					
HN-40S						X					
HN-40I						X					
HN-40D						X					
HN-41S						X					
HN-41I						X					
HN-41D						X					
HN-43S						X					
HN-43I						X					
HN-43D						X					
HN-49S							X				
HN-49I							X				
HN-49D							X				
HN-61S									X		
HN-61I									X		
HN-62S									X		
HN-62I									X		
HN-63X	BG-01	X									
HN-63S										X	

E 2-2

REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER
HISTORICAL SUMMARY OF MONITORING WELL INSTALLATION

Present Well Number	Former Well Designation	Well Installation Period									
		Pre-Remedial July 1982	Phase I RI Oct. - Nov. 1990	Phase II RI June 1992	Area B Hydrogeologic Investigation			Interim Remedy Dec. 1994 - Jan. 1995	Additional Investigations		
					Oct. - Dec. 1993	May - Aug. 1994	Oct. - Nov. 1994		Dec. 1995	April 1996	April 1998
HN-64S										X	
HN-64I										X	
HN-84S											X
HN-84I											X
HN-85S											X
HN-85I											X
HN-86S											X
HN-86I											X
HN-87S											X
DG-10		X									
DG-17			X								
DG-19			X								
EW-12								X			
EW-14								X			
OB-5								X			
OB-6								X			
OB-7								X			
OB-8								X			
OB-9								X			
OB-10								X			
Total Number of Wells		5	8	4	27	19	3	8	4	3	7

to further characterize groundwater quality and flow direction within the shallow bedrock and overburden aquifers downgradient of sites 5, 6 and 7 and downgradient of the existing monitoring well network. Specifically, two overburden and shallow bedrock well clusters were placed within the facility boundary, downgradient of wells where low levels of chlorinated VOCs were detected during the Phase I RI. All of the wells were installed in June 1992 as 6-inch diameter, open borehole completions within the shallow bedrock and as 4-inch diameter screened completions within the overburden deposits immediately overlying consolidated bedrock. The borehole drilling and monitoring well installation procedures are described in the Phase II RI Report for Operable Unit 1, NAWC Warminster (Halliburton NUS Corporation, 1993a).

2.2.4 Area B Hydrogeologic Investigation Well Installation Information

Monitoring wells were installed during Area B groundwater investigations to quantify the hydrogeologic conditions throughout the area and to further delineate the nature and extent of groundwater contamination. A total of 49 monitoring wells were installed during the Area B hydrogeologic investigation (Table 2-2, Figure 2-1). The monitoring wells were generally installed in clusters, to define both vertical and lateral trends in groundwater conditions. The well clusters consisted of shallow, intermediate, and deep bedrock wells at most locations and of shallow and intermediate well pairs or as individual shallow wells at some locations. The number and depth of wells installed at a given location were dependent on the presence of any pre-existing wells at the location and on the data gaps identified during the scoping of the investigation.

In general, the target intervals for the well installation were from the top of bedrock to a subsurface depth of 50 feet for the shallow bedrock wells, from a subsurface depth of 50 to 100 feet for the intermediate wells, and from a subsurface depth of 100 to 150 feet for the deep wells. These target intervals were established based on observations from both the current and previous investigations at NAWC Warminster that indicated that the Stockton Formation beneath the site generally consists of highly fractured bedrock to a subsurface depth of approximately 50 to 60 feet and a less fractured, more competent bedrock below this depth. The target intervals were based upon the goal of obtaining discrete samples in order to determine the vertical distribution of the hydraulic head and to define the vertical extent of contamination. These target intervals, however, were used only as general guidelines. The actual depth of each monitoring well was based upon the depths that significant water-bearing zones were encountered.

The boreholes for each monitoring well were drilled, using air hammer methods, until a significant water-bearing zone within the appropriate target interval was encountered. Geophysical tools were run in most boreholes to determine subsurface conditions, including lithology, fractured intervals, water entry or exit

zones, and vertical direction of groundwater flow. The geophysical logs generated included caliper, natural gamma, single-point resistivity, fluid temperature, and fluid resistivity logs. Brine tracing logs and a downhole video camera were also run in selected boreholes. Specific borehole drilling, monitoring well construction and well development details are described in the Draft Area B Hydrogeologic Report (Halliburton NUS Corporation, 1995).

Seven shallow bedrock, 10 intermediate bedrock and 10 deep bedrock monitoring wells were installed during the first phase of well installation of the Area B hydrogeologic investigation conducted during 1993. The well clusters were installed upgradient and downgradient of sites 5, 6 and 7 to further evaluate the impact of these sites on the local groundwater quality, including the intermediate and deep bedrock aquifers. Additional well clusters were installed along the NAWC boundary to the east of Area B to obtain hydrogeologic and analytical data to fully define groundwater conditions in this area. All of the wells were installed in October through December, 1993 as 4-inch diameter, screened completions within the shallow, intermediate and deep bedrock aquifers. Detailed borehole drilling and monitoring well installation procedures are described in the Area B Hydrogeologic Report for Naval Air Warfare Center, Warminster Pennsylvania (Halliburton NUS Corporation, 1995).

Four shallow bedrock, 8 intermediate bedrock and 7 deep bedrock monitoring wells were installed during the second phase of well installation of the Area B hydrogeologic investigation conducted during 1994. Ten wells were installed downgradient of sites 5, 6 and 7 to provide hydraulic head data from selected stratigraphic intervals during the Area B pumping test. Three additional shallow, intermediate and deep well clusters were installed along the NAWC boundary to the west of Area B to obtain hydrogeologic and analytical data as part of the perimeter monitoring program in this area. All of the wells were installed in May through August, 1994 as 2-inch diameter, screened completions within the shallow, intermediate and deep bedrock aquifers. Detailed borehole drilling and monitoring well installation procedures are described in the Draft Area B Hydrogeologic Report (Halliburton NUS Corporation, 1995).

One shallow, intermediate and deep bedrock monitoring well cluster was installed during a third phase of well installation of the Area B hydrogeologic investigation conducted during 1994. This well cluster was installed to provide additional groundwater quality data along the NAWC boundary to the east of Area B between two existing perimeter well clusters. All three wells were installed in October and November, 1994 as 2-inch diameter, screened completions within the shallow, intermediate and deep bedrock aquifers. Detailed borehole drilling and monitoring well installation procedures are described in the Draft Area B Hydrogeologic Report (Halliburton NUS Corporation, 1995).

2.2.5 OU-1 Interim Remedy Well Installation Information

Two extraction wells and six observation wells were installed as part of a groundwater pump and treat interim remedy for OU-1 by OHM Remedial Services Corporation in December 1994 through January 1995 (Table 2-2, Figure 2-1). Extraction wells EW-12 and EW-14 were completed as 10-inch-diameter open bedrock boreholes from depths of 20 to 100 feet and 10 to 100 feet respectively, and observation wells OB-5 through OB-10 were completed as 6-inch-diameter open bedrock boreholes from approximate depths of 20 to 100 feet. The well drilling and installation procedures are described in the Extraction Well EW-12 and Extraction Well EW-14 Final Yield Test Reports for Pump and Treat System for Interim Remedial Action, NAWC Warminster (OHM 1995, 1995a and 1995b).

2.2.6 Additional Hydrogeologic Investigation Well Installation Information

Two shallow and intermediate bedrock monitoring well clusters were installed during additional investigations conducted near Area B during 1995 (Table 2-2, Figure 2-1). These well clusters were installed to further characterize groundwater quality data and groundwater flow direction near the NAWC boundary to the east of Area B. All four wells were installed in December, 1995 as 2-inch diameter, screened completions within the shallow, intermediate and deep bedrock aquifers. The borehole drilling and monitoring well installation procedures are the same as those described in the Draft Area B Hydrogeologic Report (Halliburton NUS Corporation, 1995).

One shallow bedrock monitoring well and one shallow and intermediate bedrock monitoring well cluster were installed during additional investigations conducted at Area B sites 6 and 7 during 1996 (Table 2-2, Figure 2-1). These wells were installed to refine inferred groundwater flow directions in this area and to help characterize the extent of shallow and intermediate bedrock groundwater contamination immediately downgradient of these sites. All three wells were installed in April, 1996 as 2-inch diameter, screened completions within the shallow and intermediate bedrock aquifers. The borehole drilling and monitoring well installation procedures are the same as those described in the Draft Area B Hydrogeologic Report (Halliburton NUS Corporation, 1995).

One shallow bedrock monitoring well and three shallow and intermediate bedrock monitoring well clusters were installed in the Shenandoah Woods housing area to the east of sites 5, 6 and 7 during additional investigations conducted near Area B during 1998 (Table 2-2, Figure 2-1). These wells were installed to help characterize groundwater flow directions and groundwater quality conditions in this area. All seven wells were installed in April and May, 1998 as 2-inch diameter, screened completions within the shallow

and intermediate bedrock aquifers. The rationale and technical approach for the installation of these wells is presented in the Technical Memorandum for Groundwater Investigation in the Navy Enlisted Housing Area (Tetra Tech NUS, 1998a). The borehole drilling and monitoring well installation procedures are the same as those described in the Draft Area B Hydrogeologic Report (Halliburton NUS Corporation, 1995).

2.3 GROUNDWATER SAMPLING

Sampling and analysis of groundwater was conducted during multiple investigations over a period of 16 years to determine groundwater quality conditions in the vicinity of Area B sites 5, 6, and 7, and in areas near the base boundary to the east and west of Area B. All available shallow bedrock and overburden monitoring wells were sampled during the Pre-Remedial and Phase I and II Remedial Investigations. All available shallow, intermediate and deep bedrock monitoring wells and selected extraction and observation wells were sampled during the Hydrogeologic Investigation and subsequent additional investigations. Some of the sampling rounds were comprehensive relative to the number and distribution of wells present at the time of sampling while others focused on specific wells or groups of wells. A summary of the wells sampled during each round, except for during the pumping tests which are discussed separately, is provided in Table 2-3.

2.3.1 Pre-Remedial Investigation Groundwater Sampling

Groundwater samples were obtained from the existing monitoring wells during two sampling events conducted for the Pre-Remedial Investigation in Area B. The first sampling event took place in July, 1982 and the second occurred in September, 1982. All of the overburden monitoring wells were sampled during each round except for BG-1 which was dry. During the first sampling event, each well was purged dry three times with a centrifugal pump, allowed to recover for 12 to 24 hours, then sampled with a decontaminated Teflon bailer. Samples from this round were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), Total Metals and Cyanide. During the second sampling event, each well was purged dry once with a centrifugal pump, allowed to recover for 12 to 24 hours, then sampled with a decontaminated Teflon bailer. Samples from this round were analyzed for VOCs only. Field measurements of pH, temperature and conductivity were obtained from each round. The groundwater sampling procedures and results are contained in the Hydrogeological Investigation of the Naval Air Development Center Waste Disposal Sites (JRB Associates, 1983) and are discussed in Section 4 of this report.

2.3.2 Phase I Remedial Investigation Groundwater Sampling

Groundwater samples were obtained from the new and existing monitoring wells during one sampling event conducted in December 1990 for the Phase I Remedial Investigation in Area B. All of the overburden and

TABLE 2-3
REMEDIAL INVESTIGATION REPORT FOR AREA B GROUNDWATER
HISTORICAL SUMMARY OF MONITORING WELL SAMPLING

Well	Former	Pre-Interim ROD Investigations			Hydrogeologic Investigation		Additional Investigations		Perimeter Monitoring Program Sampling											
Number	Designation	Pre-Remedial	Phase I RI	Phase II RI	1/94	8/94 - 2/95	6/98	6/98	9/94	12/94	4/95	7/95	9/95	1/96	4/96	10/96	3/97	9/97	12/98	6/99
HN-01S	BG-7		X	X	X			X												
HN-01I					X			X												
HN-01D					X			X												
HN-02X	DG-27		X	X				X												
HN-02S	DG-21		X	X	X			X												
HN-02I					X			X												
HN-02D					X			X												
HN-03X	DG-8	X	X	X																
HN-03S	DG-20		X	X	X			X												
HN-03I					X			X												X
HN-03D					X			X												
HN-04S					X															
HN-04I					X															
HN-04D					X															
HN-05S					X			X												
HN-05I					X			X												
HN-05D					X			X												
HN-06S					X			X									X			
HN-06I					X			X									X			
HN-06D					X			X									X			
HN-07S					X			X								X				
HN-07I					X			X								X				
HN-07D					X			X												
HN-08S					X			X		X		X	X			X				
HN-08I					X			X		X		X	X							
HN-08D					X			X				X	X							
HN-09S					X			X			X			X		X			X	
HN-09I					X			X			X			X						
HN-09D					X			X			X			X						
HN-10S					X			X	X	X	X	X	X	X	X	X	X	X	X	X
HN-10I					X			X	X	X	X	X	X	X	X	X	X	X	X	X
HN-10D					X			X	X	X	X	X	X	X	X	X	X	X	X	X
HN-35S								X												X
HN-35I								X												
HN-35D								X												
HN-36X	DG-9	X	X	X																
HN-36S	DG-18		X	X	X			X												X
HN-36I1						X		X								X				
HN-36I2						X		X								X				
HN-36D						X		X								X				
HN-37X	DG-7	X	X																	
HN-37S	DG-25		X	X	X			X										X		
HN-37I						X		X												
HN-37D						X		X												
HN-38X	MW-08							X	X											
HN-38S	MW-05			X	X			X		X	X	X	X	X			X	X	X	X
HN-38I	HN-38D					X		X	X	X	X	X	X	X			X	X	X	X
HN-39X	MW-09			X				X	X											
HN-39S	MW-06			X	X			X		X	X	X								
HN-39D	HN-39					X		X	X	X	X	X								

REMEDIAL INVESTIGATION REPORT FOR AREA B GROUNDWATER
HISTORICAL SUMMARY OF MONITORING WELL SAMPLING

Well	Former	Pre-Interim ROD Investigations			Hydrogeologic Investigation		Additional Investigations		Perimeter Monitoring Program Sampling											
Number	Designation	Pre-Remedial	Phase I RI	Phase II RI	1/94	8/94 - 2/95	6/98	6/98	9/94	12/94	4/95	7/95	9/95	1/96	4/96	10/96	3/97	9/97	12/98	6/99
HN-40S						X			X	X	X	X	X	X		X	X	X		X
HN-40I						X		X	X	X	X	X	X	X						
HN-40D						X		X	X		X	X	X	X						
HN-41S								X	X	X	X	X	X	X		X	X	X		X
HN-41I								X	X	X	X	X	X	X						
HN-41D									X	X	X	X	X	X						
HN-43S								X	X	X	X	X	X	X		X	X	X		X
HN-43I								X	X	X	X	X	X	X						
HN-43D								X	X	X	X	X	X	X						
HN-49S						X		X			X	X	X	X		X	X	X		
HN-49I						X		X		X	X	X	X	X		X	X	X	X	X
HN-49D						X		X		X	X	X	X	X		X	X	X		
HN-61S								X						X		X	X	X	X	X
HN-61I								X								X	X	X		X
HN-62S								X						X		X			X	X
HN-62I								X						X						
HN-63X	BG-01																			
HN-63S								X							X					
HN-64S								X										X		X
HN-64I								X							X			X		
HN-84S							X	X												
HN-84I							X	X												
HN-85S							X	X												
HN-85I							X	X												
HN-86S							X	X												
HN-86I							X	X												
HN-87S							X	X												
DG-10		X	X	X											X					
DG-17			X	X	X			X												
DG-19			X	X	X			X												X
SW-08																				
SW-09																				
SW-11																				
EW-12						X		X												
EW-14						X		X												
OB-5																				
OB-6																				
OB-7															X					
OB-8								X												
OB-9																				
OB-10								X							X					

shallow bedrock monitoring wells were sampled during this round except for BG-1 which was dry. Prior to sampling, each well was purged of three well volumes or until dry with a submersible or centrifugal pump and the water level was allowed to recover. The wells were sampled with a dedicated polyvinyl-chloride (PVC) bailers. All samples were analyzed for TCL VOCs, SVOCs, Pesticides and PCBs and TAL Metals. Field measurements were obtained for pH, temperature, Eh and specific conductivity. The groundwater sampling procedures and results are contained in the Rough Draft RI Report for the Naval Air Development Center (SMC Environmental Services Group, 1991) and are discussed in Section 4 of this report.

2.3.3 Phase II Remedial Investigation Groundwater Sampling

Groundwater samples were obtained from the new and existing monitoring wells during one sampling event conducted in June and July 1992 for the Phase II Remedial Investigation in Area B. All of the overburden and shallow bedrock monitoring wells were sampled during this round except for BG-1 and MW-08 which were dry and DG-7 which was filled or obstructed with debris. Prior to sampling, each well was purged of three well volumes or until dry with a submersible pump, centrifugal pump or bailer and the water level was allowed to recover. The wells were sampled with decontaminated stainless steel, bottom loading bailers. All samples were analyzed for TCL VOCs and TAL Total Metals, Dissolved Metals and Cyanide. Selected samples were analyzed for TCL SVOCs, Pesticides and PCBs. Selected samples were also analyzed for several engineering parameters including alkalinity, total organic carbon, total dissolved solids, total suspended solids, biological oxygen demand, ammonia, sulfates, chlorides, nitrates and chemical oxygen demand. Field measurements were obtained for pH, temperature and specific conductivity. The groundwater sampling procedures and results are contained in the Phase II RI Report for Operable Unit 1, NAWC Warminster (Halliburton NUS Corporation, 1993) and are discussed in Section 4 of this report.

2.3.4 Area B Hydrogeologic Investigation Groundwater Sampling

Sampling and analysis of groundwater was conducted during the Hydrogeologic Investigation to determine groundwater quality conditions in the vicinity of Area B and the portion of the base between Area B and the eastern facility boundary. All bedrock monitoring wells were sampled. The primary groundwater sampling program was conducted during January 1994. A total of 36 monitoring wells were sampled, including the 27 newly installed screened wells at clusters HN-1 through HN-10 (7 shallow bedrock, 10 intermediate bedrock, and 10 deep bedrock), and 9 pre-existing shallow, open-borehole bedrock wells. Sampling of an additional 15 monitoring wells occurred during August, September, and December, 1994 and in January and February of 1995 as well clusters HN-35 through HN-40 and HN-49 were installed.

The groundwater sampling and analysis program and sampling procedures are described in the Work Plan

Addendum (Halliburton NUS, 1993b) and the Quality Assurance Project Plan (Halliburton NUS, 1993c) for Area B Hydrogeologic Investigation. All wells were purged prior to sampling. Wells with yields of 1 gallon per minute or greater were purged of a minimum of three well volumes of groundwater and until the monitored parameters (pH, temperature, conductivity) of three consecutive samples of purge water fell within 10 percent of one another. The pumping rate was monitored to assure that the wells were not purged at a higher rate than the natural yield of the formation. Wells with yields of less than 1 gallon per minute were purged dry and allowed to recover overnight to the pre-pumping static water level prior to sampling. All wells were sampled with decontaminated, stainless-steel, bottom-loading bailers.

During the 1994 sampling events, all groundwater samples were analyzed for low-concentration volatile organics. Selected samples were analyzed for Target Analyte List (TAL) metals (total and dissolved phases) and Target Compound List (TCL) semivolatile organics and PCBs/pesticides. Field measurements collected during sampling included pH, temperature, and conductivity.

The January and February 1995 sampling events included monitoring wells in cluster HN-36 (both events), cluster HN-37 (January only), and for monitoring wells HN-02I, HN-02D, DG-18, and DG-21 and extraction wells EW-12 and EW-14 (for February only). These groundwater samples were analyzed for TCL volatile organics and for arsenic during the February 1995 event.

In addition to these monitoring events, groundwater samples were collected during the 1994 pumping test. Time series samples of the groundwater from pumping well HN-02I were collected at intervals of approximately 10, 100, 1000, and 4300 minutes into the pumping test during August 1994, and were analyzed for TCL volatiles.

The analytical results from these groundwater sampling events are discussed in Section 4 of this report. A detailed presentation of the data is contained in the Draft Area B Hydrogeologic Report (Halliburton NUS Corporation, 1995). The results are also summarized in the Technical Memorandum – Compilation of Sampling Data for the Area B Plume (Halliburton NUS Corporation, 1995a). Appendix C of the Draft Area B Hydrogeologic Report contains the complete analytical results for the groundwater sampling performed during the Area B Hydrogeologic Investigation.

2.3.5 OU-1 Interim Remedy Groundwater Sampling

One VOC sample was collected during the EW-12 12-hour yield test on January 4, 1995 from the sampling port in the pump effluent line prior to GAC treatment approximately 8 hours and 10 minutes after pumping began. One VOC sample was collected during the EW-14 12-hour yield test on January 12, 1995 from the

sampling port in the pump effluent line prior to GAC treatment approximately 10 hours and 25 minutes after pumping began. Time series VOC samples were obtained from EW-12 during the 72-hour pumping test on January 18, 19 and 20 1995 at elapsed times of 24, 48 and 72 hours from the start of pumping. Samples obtained after 24 hours were collected from a sampling port in the pump effluent line prior to GAC treatment and directly from the well using a Teflon bailer. Samples obtained after 48 and 72 hours were collected only from the sampling port in the pump effluent line prior to GAC treatment. All samples obtained during each of the three yield tests were analyzed for TCL VOCs by EPA Method 601.

The analytical results of this sampling are summarized in Section 4 of this report and discussed in the in the Final Yield Test Reports for Extraction Wells EW-12, EW-12 (72-Hour) and EW-14 (OHM, 1995, 1995a and 1995b). These results are also included in the Technical Memorandum – Compilation of Sampling Data for the Area B Plume (Halliburton NUS Corporation, 1995a).

2.3.6 Additional Investigation Groundwater Sampling

The Navy initiated a perimeter groundwater monitoring program for the former NAWC Warminster in 1994. Twelve rounds of perimeter groundwater sampling were conducted from September 1994 through June 1999, each including approximately 16 to 23 wells in and around Area B per sample round. The perimeter sampling rounds generally sampled many of the same wells during each round and were confined mainly to well clusters located along the NAWC Warminster property boundary. The methodology and results of these sampling events are included in the Summary Report for Twelfth Round of Perimeter Monitoring (Tetra Tech NUS, 1999). Analytical results for wells associated with or located within Area B are presented and discussed in Section 4 of this report.

In addition to the perimeter monitoring program, two additional sampling events have been conducted in and around Area B. In June 1998, the seven monitoring wells installed in the Navy enlisted housing area in April 1998 (clusters HN-84 through HN-87) were sampled and analyzed for low-concentration TCL-VOCs. Wells 100 feet or less in depth were sampled using low-flow (500 ml/min. to 1,000 ml/min.) sampling techniques. Wells greater than 100 feet in depth were sampled after purging three to five volumes of standing water from the well. Recorded well yields, field parameters, and water level monitoring were used to direct the purge rate and volume.

An area-wide sampling and analysis of groundwater in the vicinity of Area B and the portion of the base between Area B and the eastern facility boundary was performed during June and July 1998. All available bedrock and overburden monitoring wells and selected extraction and observation wells were sampled. This is the most comprehensive Area B groundwater sampling program conducted to date. Samples for analysis

were obtained from 70 monitoring wells (3 overburden, 27 shallow bedrock, 22 intermediate bedrock, and 18 deep bedrock), two open-borehole bedrock observation wells, and two open-borehole bedrock extraction wells.

All groundwater samples were analyzed for Target Compound List (TCL) VOCs using a low-concentration detection limit. In addition, 13 samples were analyzed for Target Analyte List (TAL) metals and cyanide, three samples were analyzed for semivolatile organic compounds (SVOCs), pesticides, and PCBs, and one sample was analyzed for dissolved TAL metals and cyanide. Appropriate quality assurance/quality control (QA/QC) samples (e.g., field blanks, trip blanks, rinsate blanks, duplicates, and matrix spike/matrix spike duplicates) were collected and analyzed. A summary of the wells sampled and the analyses performed is provided in Table 2-4. All samples were collected and analyzed according to the scope of work for Area B groundwater monitoring (B&R Environmental, 1998a). Within Area B, Well HN-63X (BG-01) was not sampled due to dry conditions. Wells HN-03X (DG-8), HN-37X (DG-7), and OB-9 were filled or obstructed with debris and were also not sampled. Wells HN-36X (DG-9) and DG-10 could not be located in the field and were presumed to be buried. All of these wells, with the exception of OB-9, were overburden wells that were either dry or contained only trace levels of VOCs during the preremedial and Phase I and Phase II RI sampling events. These wells were not sampled in any subsequent investigations. Well OB-9 was an observation boring drilled during the interim, remedy implementation and had never been sampled. Although samples from south base boundary Wells HN-40S and HN-41D were collected and shipped to the laboratory, the laboratory was unable to analyze these samples within the appropriate holding time for VOCs. Samples were not re-collected from these wells. Wells HN-04S, HN-04I and HN-04D were not sampled but were used for water-level measurement only. Wells OB-5, OB-6 and OB-7 were not sampled or used for water-level measurements.

The majority of monitoring wells were sampled using EPA QA directives for low-flow purging and sampling of groundwater monitoring wells (EPA Region III QA Directives, Bulletin QAD023, August 8, 1994). Wells with yields of 1 gallon per minute (gpm) or greater were purged in accordance with the Work Plan Addendum (Halliburton NUS, 1993b) and the Quality Assurance Project Plan (Halliburton NUS, 1993c) for Area B Hydrogeologic Investigation. These wells were purged a minimum of three well volumes and until the monitored parameters (pH, temperature, conductivity, and turbidity) of three consecutive samples of purge water fell within 10 percent of one another. The pumping rate was monitored to assure that the wells were not purged at a higher rate than the natural yield of the formation. The analytical results of the groundwater sampling are discussed in Section 4 of this report.

TABLE 2-4
REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER
SUMMARY OF JUNE 1998 AREA-WIDE SAMPLING EVENT

WELL NUMBER	MONITORED INTERVAL (feet)	WELL DEPTH CLASSIFICATION	GROUNDWATER SAMPLES OBTAINED					WATER LEVEL MEASURED	COMMENTS
			VOA	SVOA	PCB/Pest	Total Metals	Dissolved Metals		
HN-01S/BG-7	18.5-37	Shallow	X			X		X	
HN-01I	68-92	Intermediate	X					X	
HN-01D	108-127	Deep	X					X	
HN-02X/DG-27	6.2-13.2	Overburden	X			X			Not used for flow
HN-02S/DG-21	15-33	Shallow	X					X	
HN-02I	85-104	Intermediate	X					X	
HN-02D	116-133	Deep	X					X	
HN-03X/DG-8	5.05-9.6	Overburden							Filled/Obstructed
HN-03S/DG-20	17.6-32	Shallow	X					X	
HN-03I	81-102	Intermediate	X					X	
HN-03D	115-140	Deep	X					X	
HN-04S	20-37	Shallow						X	Water-level only
HN-04I	55-73	Intermediate						X	Water-level only
HN-04D	105-124	Deep						X	Water-level only
HN-05S	36-55	Shallow	X					X	
HN-05I	70-88	Intermediate	X					X	
HN-05D	180-204	Deep	X					X	
HN-06S	30-53	Shallow	X					X	
HN-06I	80-103	Intermediate	X					X	
HN-06D	134-154	Deep	X					X	
HN-07S	29-45	Shallow	X					X	
HN-07I	64-85	Intermediate	X					X	
HN-07D	144-162	Deep	X					X	
HN-08S	29-48	Shallow	X					X	
HN-08I	60-78	Intermediate	X					X	
HN-08D	157-178	Deep	X					X	
HN-09S	29-52	Shallow	X			X		X	
HN-09I	75-103	Intermediate	X					X	
HN-09D	138-161	Deep	X					X	
HN-10S	26-40	Shallow	X					X	
HN-10I	80-101	Intermediate	X					X	
HN-10D	225-245	Deep	X					X	
HN-35S	35-48	Shallow	X					X	
HN-35I	87-105	Intermediate	X					X	
HN-35D	115-130	Deep	X					X	
HN-36X/DG-9	6.8-14.7	Overburden							Not accessible
HN-36S/DG-18	22-27	Shallow	X			X		X	
HN-36I1	82-100	Intermediate	X					X	
HN-36I2	101-115	Intermediate	X					X	Not used for flow
HN-36D	133-147	Deep	X					X	
HN-37X/DG-7	5.6-15.05	Overburden							Filled/Obstructed
HN-37S/DG-25	21-41	Shallow	X					X	
HN-37I	75-103	Intermediate	X					X	
HN-37D	116-141	Deep	X					X	
HN-38X/MW-08	25-35	Overburden	X			X	X		Not used for flow
HN-38S/MW-05	2-7	Shallow	X					X	
HN-38I/HN-38	97-119	Intermediate	X					X	
HN-39X/MW-09	2-7	Overburden	X			X			Not used for flow
HN-39S/MW-06	18-50	Shallow	X			X		X	
HN-39D/HN-39	125-150	Deep	X					X	
HN-40S	55-69	Shallow						X	Holding time exceeded
HN40I	88-114	Intermediate	X					X	
HN-40D	120-148	Deep	X					X	
HN-41S	41-54	Shallow	X						
HN-41I	72-93	Intermediate	X						
HN-41D	151-176	Deep							Holding time exceeded
HN-43S	43-64	Shallow	X						
HN-43I	90-104	Intermediate	X						
HN-43D	117-135	Deep	X						
HN-49S	36-51	Shallow	X	X	X	X		X	
HN-49I	55-75	Intermediate	X			X		X	
HN-49D	118-135	Deep	X					X	
HN-61S	81-95.5	Intermediate	X					X	
HN-61I	110-124.5	Deep	X					X	

TABLE 2-4
REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER
SUMMARY OF JUNE 1998 AREA-WIDE SAMPLING EVENT

WELL NUMBER	MONITORED INTERVAL (feet)	WELL DEPTH CLASSIFICATION	GROUNDWATER SAMPLES OBTAINED					WATER LEVEL MEASURED	COMMENTS
			VOA	SVOA	PCB/Pest	Total Metals	Dissolved Metals		
HN-62S	35-50	Shallow	X					X	
HN-62I	70.5-85.5	Intermediate	X					X	
HN-63X/BG-01	7-15.9	Overburden							Dry
HN-63S	27-46	Shallow	X					X	
HN-64S	29-50	Shallow	X	X	X	X		X	
HN-64I	82-104	Intermediate	X	X	X	X		X	
HN-84S	36-51	Shallow	X					X	
HN-84I	107-120	Deep	X					X	
HN-85S	19-34	Shallow	X					X	
HN-85I	72-86	Intermediate	X					X	
HN-86S	34-52	Shallow	X					X	
HN-86I	72-86	Intermediate	X					X	
HN-87S	46-62	Shallow	X			X		X	
DG-10	7.65-15	Overburden							Not Accessible
DG-17	16.5-38	Shallow	X					X	
DG-19	21.75-47	Shallow	X			X		X	
EW-12	20-100	Intermediate	X						Not used for flow
EW-14	20-100	Intermediate	X						Not used for flow
OB-8	20-100	Intermediate	X						Not used for flow
OB-9	20-100	Intermediate							Filled/Obstructed
OB-10	20-100	Intermediate	X						Not used for flow

2.4 WATER-LEVEL MEASUREMENTS

One round of water level measurements was performed during pre-remedial investigation of Area B on July 27, 1982. Water level measurements were obtained from all available wells present at this time, including five permanent overburden monitoring wells and four temporary overburden observation points. One monitoring well (BG-1) and two observation points were dry during this round of measurements. The groundwater elevation data are presented in the Hydrogeological Investigation of the Naval Air Development Center Waste Disposal Sites (JRB Associates, 1983).

Two rounds of water level measurements were performed during the Phase I Remedial Investigation of Area B on December 13, 1990 and January 22, 1991. Water level measurements were obtained from all available wells present at this time, including six overburden monitoring wells and seven shallow bedrock monitoring wells. Monitoring well BG-1 was dry during the January round of measurements. The groundwater elevation data are presented in the Rough Draft RI Report for the Naval Air Development Center (SMC Environmental Services Group, 1991).

Two rounds of water level measurements were performed during the Phase II Remedial Investigation of Area B on July 7, 1992 and August 13, 1992. Water level measurements were obtained from all available wells present at this time, including seven overburden monitoring wells (well DG-7 was filled-in or obstructed and was not available for measurements) and nine shallow bedrock monitoring wells. Monitoring well BG-1 was dry during the July round of measurements and monitoring wells BG-1, MW-08 and MW-09 were dry during the August round of measurements. The groundwater elevation data are presented in the Phase II RI Report for Operable Unit 1, NAWC Warminster (Halliburton NUS Corporation, 1993).

A short-term (1-month) groundwater-level monitoring program was conducted in selected Area B wells during the Hydrogeologic Investigation to investigate the duration and magnitude of water-level fluctuations, to determine the response of the aquifer to precipitation events, to determine the effects of nearby pumping wells on groundwater levels, and to provide data to be used for the design of an Area B aquifer pumping test. Water-level recording instruments equipped with pressure transducers were installed in the shallow, intermediate, and deep monitoring wells at clusters HN-03, HN-05, and HN-07 and in the deep monitoring well at cluster HN-09 (see Figure 2-1). These instruments recorded the static water levels at 15-minute intervals from March 28 or March 31, 1994 to April 27, 1994. The water-level data obtained during the long-term monitoring program are discussed in Section 3 and presented in graphic form in Appendix C.

Three comprehensive rounds of water level measurements were obtained from monitoring wells within and near Area B during the Hydrogeologic Investigation on April 27, August 17, and December 13, 1994. Water

level measurements were obtained from all available shallow, intermediate and deep bedrock wells present during each round. Measurements were not obtained or evaluated for the overburden wells. During April 27, measurements were obtained from a total of 37 wells, including the existing Area B shallow bedrock wells and newly installed well clusters HN-01 through HN-10. During August 17, measurements were obtained from a total of 50 wells, including the same wells plus newly installed well clusters HN-35 through HN-40. During December 13, measurements were obtained from a total of 53 wells, including the same wells plus newly installed well clusters HN-35 through HN-40 and HN-49. Several of the wells included in these measurement rounds are located near the facility boundary to the east and west of Area B sites 5, 6 and 7. These data are presented and interpreted in the Draft Area B Hydrogeologic Investigation Report (HNUS, 1995) and are discussed in Section 3 of this report.

One comprehensive round of water-level measurements was obtained from monitoring wells within and near Area B during additional investigations on June 3, 1998. Water level measurements were obtained from all available shallow, intermediate and deep bedrock wells present during this round. Measurements were obtained from a total of 66 wells. Several of the wells included in this measurement round are located near the facility boundary to the east and west of Area B sites 5, 6 and 7. These data are presented and interpreted in the Summary Report for Area B Groundwater Monitoring (TTNUS, 1998).

Water level measurements were obtained using a calibrated tape and electronic indicator, marked to 1/100th of a foot, and were referenced to marked points on top of each well casing. The rounds of measurements were generally collected within a time period of approximately 6 hours in order to minimize the effects of short-term water-level fluctuations. Appendix __ contains the complete set of data obtained during the June 1998 round of water levels.

2.5 AQUIFER PUMPING TESTS

2.5.1 Area B Hydrogeologic Investigation Pumping Test

A 72-hour pumping test was conducted in Area B during the Hydrogeologic Investigation in August 1994 to provide information regarding the transmissivity, storativity, and cross-formational (vertical) and intra-formational (parallel to strike and dip) anisotropy of the shallow portion of the Stockton Formation. The test results were used to define the local hydrogeologic conditions and to evaluate groundwater and contaminant migration rates within and from Area B. The various components of this pumping test included

- The performance of a step-drawdown test in pumping well HN-02I to determine the optimum pumping rate to be used for the long-term test. Monitoring of the pumping well and approximately 16 primary

observation wells during the step drawdown test and evaluation of the test results.

- Collection of trend water-level data for the pumping well and primary observation wells during an approximately 72-hour period prior to the long-term test to determine if any baseline corrections should be made to the measured groundwater levels collected during the pumping test.

- Preparation of all equipment required to perform the long-term pumping test including, but not limited to, the submersible pump and discharge piping, electric power connections, a discharge flow meter, a sampling port, activated carbon treatment drums, and pressure transducers and data loggers.

- Performance of the long-term (72-hour) pumping test including periodic verification and recording of the pumping rate using both the flow meter and timed volume measurements. Water-level measurements were obtained and recorded from the pumping well, 16 primary observation wells, and 12 secondary observation wells using manual water-level indicator readings or automatic data logger and pressure transducer readings.

- Collection of recovery water-level measurements from the pumping well and all observation wells that showed significant pumping-induced drawdown during an approximately 12-hour period immediately upon completion of the test. In addition, rounds of water levels were collected from the pumping well and all observation wells approximately 24 and 48 hours after the conclusion of the pumping test.

- Measuring atmospheric pressure and precipitation during the trend data interval, the long-term pumping test, and the recovery data interval to investigate any atmospheric effects on groundwater levels.

The Final Technical Memorandum - Area B Pumping Test Plan (Halliburton NUS, 1994) provides a detailed description of the pumping test technical approach and procedures. The pumping test results are described in the Draft Area B Hydrogeologic Investigation Report (HNUS, 1995) and in Section 3 of this report. Drawdown graphs and calculations are presented in Appendix C.

2.5.2 Interim Remedial Action Pumping Tests

Twelve hour yield tests were conducted in each of the two extraction wells, EW-12 and EW-14, installed during the interim Remedial Action in order to establish optimum placement of the next well as required by the remedial system design specifications. A 72-hour yield test was performed in well EW-12 subsequent to the 12-hour yield tests in order to provide additional information regarding long term effects of storage on well yield, and to induce greater drawdown in the pumping and observation wells for a more reliable aquifer

evaluation. In addition, the 72-hour test was performed to collect a more representative groundwater sample after pumping for an extended time. Yield test procedures, data evaluation and reporting requirements were detailed in the Work Plan and Work Plan Addendum for Yield Testing Procedure for Pump and Treat System for Interim Remedial Action (OHM, 1994).

The yield tests were performed in 1995. The EW-12 12-hour yield test ran for a duration of 12 hours and included three separate steps or pumping rates of 7 gallons per minute (GPM) for 1 hour, 15.5 GPM for the following 2 hours, and 30 GPM for the remaining 9 hours. The EW-14 12-hour yield test ran for a duration of 12 hours and included two separate steps or pumping rates of 8.5 GPM for 2 hours and 13.5 GPM for the remaining 9 hours. The EW-12 72-hour yield test was performed from January 17 to 20, 1995. The test ran for a duration of 73 hours and included two separate pumping rates of 55 GPM for 48 hours and 15 GPM for the remaining 25 hours.

During each pumping test, water level data were collected from the pumping well, from the other extraction well, if present, from observation wells OB-5 through OB-10 and from nearby monitoring wells. Static water levels were measured before each pumping test, water level drawdowns were measured at prescribed intervals during each test and water level recovery data was measured upon completion of each test. Water level data were recorded automatically using pressure transducers and data loggers in some wells and were measured manually with water level indicators from the remaining wells.

Yield test data evaluation included calculation of aquifer transmissivity by a variety of methods, estimates of sustainable yield for the pumping wells and calculation of lateral capture zones using a range of pumping rates and transmissivities. The yield test methods and results are detailed in the Final Yield Test Reports for Extraction Wells EW-12, EW-12 (72-Hour) and EW-14 (OHM, 1995, 1995a and 1995b) and are discussed in Section 3 of this report.

3.0 PHYSICAL CHARACTERISTICS

Several environmental studies applicable to NAWC Warminster sites have been completed over the last 10 years. A number of these studies, including those by JRB Associates (1981 and 1983), Sloto and Davis (1983), Satterthwaite (1984), Earth Technology Corporation (1985), and Sloto, Macchiaroli and Towle (1996), have provided information on local surface features, soils, meteorology, surface water hydrology, demography and land use, and hydrogeology.

A description of the physical characteristics of NAWC Warminster has been prepared on the basis of published information, reports of previous site studies, and information obtained and interpreted during the course of the Area B Hydrogeologic Investigation (HNUS, 1995), implementation of the interim remedy (OHM 1995, 1995a, and 1995b), and additional investigations conducted to support this RI. Section 3.0 provides a brief, general overview of the overall physical characteristics of the facility, as well as the specific physical characteristics for Area B based on the findings of the RI.

3.1 METEOROLOGY

The climate of the area is humid continental and is modified by the Atlantic Ocean. Temperatures range between an average of 76°F (24.4°C) in July and 32°F (0°C) in January. The average daily temperature for the NAWC location is 53.3°F (11.8°C). Precipitation averages 42.5 inches per year (106.25 cm per year), and snowfall averages 22 inches per year (55 cm per year). The distribution of precipitation is fairly even throughout the year. The relative humidity for the site averages 70 percent. The mean wind speed for this area is 9.6 mph with a prevailing direction of west-southwest (NAWC Warminster Emergency Response Plan, August 13, 1990).

3.2 SURFACE WATER HYDROLOGY AND TOPOGRAPHY

NAWC Warminster is situated on an upland area divided between two local drainage basins, the Little Neshaminy Creek Basin to the north and the Southampton Creek Basin to the south. The northern 65 percent of the facility (including Areas A and C) drains toward the north through several swales and storm sewers into small unnamed tributaries of Little Neshaminy Creek. The southern 35 percent of the facility (including Area B) drains toward the south to the headwaters of Southampton Creek, a tributary of Pennypack Creek. Both local drainage basins lie within the regional drainage basin of the Delaware River. Various studies conducted on the site have revealed that no areas within NAWC Warminster are included in the 100-year or 500-year floodplain.

NAWC Warminster is located on a local topographic high. The crest of the hilltop trends east-west within the facility and is roughly coincident with the location of the main runway. Surface topography across Area B generally slopes away from the main runway to the south, precluding surface water flow onto Sites 5, 6 and 7 from surrounding properties. Surface water flow onto Navy property from surrounding properties is possible along the southeastern boundary adjacent to the Casey Village area. Slopes range from nearly level to eight percent and average three to five percent. The surface elevations throughout Area B range from a high of approximately 370 feet mean sea level (msl) to low of approximately 320 feet msl.

Much of the natural drainage pattern of Area B has been altered by development, and drainage within the developed portions of Area B is controlled primarily through constructed drainage systems. A significant portion of precipitation runoff is directed by surface grading and paving to constructed ditches, culverts, and storm sewers. Stormwater that collects near Area B is piped underground from the south-central NAWC Warminster property boundary to a point approximately 500 feet to the south, where it flows through a residential area in a concrete channel. The channel flows through the residential subdivision for approximately 1,000 feet and travels through a road culvert before flowing into a natural streambed. This stream flows through a shaded 250-foot reach before entering a small and shallow privately owned pond, which overflows into a second small pond, which in turn flows into Southampton Creek.

Southampton Creek flows north to south, directly away from NAWC Warminster. The base flow was measured in an area where the creek is contained within a cement culvert at 98 gpm during the Phase I RI (SMC Martin, 1991). Springs and seeps contributing to surface water flow were reported or observed near the facility boundary of Area B during the preremedial and Phase I RI investigations (JRB Associates, 1981 and SMC Martin, 1991).

3.3 SOILS

According to the Soil Survey of Bucks and Philadelphia Counties, Pennsylvania (United States Department of Agriculture, Soil Conservation Service, 1975), Area B is underlain primarily by three native soil types. These are Doylestown silt loam, zero to three percent slopes, Duncannon silt loam, zero to three and three to eight percent slopes and Lawrenceville silt loam, zero to three and three to eight percent slopes.

Doylestown soils are deep, poorly drained, and nearly level to gently sloping. They occur at the bases of slopes and in depressions and formed in silty, wind-blown deposits overlying loamy material weathered from shale and sandstone. The soils consist primarily of grayish-brown and dark grayish-brown to brown and dark brown silt loam and silty clay loam that is firm, dense and brittle at places within the subsoil. These soils have slow permeability of less than 1.4×10^{-4} cm/sec. The depth to bedrock is typically 4 to 7 feet below the surface, and a seasonal high water table is at or near the surface in wet seasons.

Duncannon soils are deep, well drained, and nearly level to gently sloping. They occur on the upper elevations of low relief upland areas and formed in silty, wind-deposited sediment overlying shale and sandstone bedrock. The soils consist primarily of grayish-brown, yellowish-brown, dark brown, and dark reddish-brown silt loam and shaly silt loam. These soils have moderate permeability ranging from 4.4×10^{-4} to 1.4×10^{-3} cm/sec. The depth to bedrock and seasonal high water table are both typically greater than 4 feet below the surface.

Lawrenceville soils are deep, moderately well drained, and nearly level to gently sloping. They occur on the middle and lower elevations of low relief upland areas and formed in silty, wind-blown deposits underlain mainly by material weathered from shale and sandstone. The soils consist primarily of dark brown, yellowish-brown, and brown silt loam with some sandy loam in the substratum. These soils have moderately slow permeability ranging from 1.4×10^{-4} to 4.4×10^{-4} cm/sec. The depth to bedrock is typically from 4 to 8 feet below the surface, and the seasonal high water table may be within 18 to 36 inches of the surface in wet seasons.

Significant portions of Area B including, but not limited to, the Enlisted Men's Housing Area, Sites 5, 6 and 7, and the Inertial Guidance Facility are more accurately described as Urban Land. This classification occurs in areas where urban structures and works cover so much of the land that identification of the soils is not practical. Most areas have been graded, and the original soil material has been disturbed, filled over, or otherwise altered prior to construction. As a consequence of these activities, the soil and foundation materials may be highly variable. Also included in Urban Land are areas consisting of various types of fill material.

Soil thicknesses observed during the Phase I RI subsurface investigations at Area B were between 4 and 14 feet and were generally uniform across the sites, with only local areas of variation. Detailed descriptions of the soil and fill composition and thicknesses at Sites 5, 6 and 7 are included in the Remedial Investigation Operable Unit 7 (OU-7) Soil and Waste at Sites 6 and 7 (Tetra Tech NUS, 1999).

3.4 GEOLOGY

3.4.1 Regional Geology

NAWC Warminster is located in the Triassic Lowlands Section of the Piedmont Physiographic Province of southeastern Pennsylvania. The province is extensive and gently undulating and generally slopes to the southeast. The land forms have been modified by erosion to form moderate slopes and gently rounded hills with a dendritic drainage pattern.

The bedrock underlying NAWC Warminster belongs to the late Triassic age Stockton Formation. The Stockton Formation is unconformably underlain by basement rocks of Ordovician to PreCambrian age that crop out approximately 2 miles south of the facility. The Stockton Formation is conformably overlain by the shale- and argillite-rich Lockatong Formation, also of late Triassic age, that crops out approximately 2.5 miles north of the facility.

Within the general area surrounding NAWC Warminster, the beds of the Stockton are reported to strike to the northeast and dip from 7 to 16 degrees to the northwest, with an average regional dip of about 12 degrees (Rima, et al., 1962). Based on its outcrop width and this regional dip, the Stockton Formation is estimated to be approximately 2,200 feet thick beneath NAWC Warminster.

The Stockton Formation is extensively faulted by small displacement normal faults and is cut by well-developed joint systems. The joint sets occur in a discernible and predictable pattern. The most frequently occurring joint sets trend perpendicular and parallel to the strike of the bedding. Another commonly occurring joint set trends to the northwest at an angle of about 50 degrees from strike (Rima, et al., 1962).

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

The Stockton Formation is divided into the lower arkose, middle arkose, and upper shale members. Detailed geologic mapping of these three members is not available within Bucks County. However, projections from geologic maps for the area 1 mile west of the NAWC Warminster indicate that the facility is underlain by the middle arkose member of the Stockton Formation (Rima, et al., 1962).

The middle arkose member of the Stockton Formation consists of beds of fine- and medium-grained arkosic sandstone with interbedded red shale, siltstone, and very fine-grained red sandstone and a few beds of coarse-grained arkose. Beds of shale and siltstone are more common in the upper portion of the member, and coarser-grained units are more common in the lower portion. Many of the beds in the middle arkose member are well sorted and weakly cemented, which creates a relatively high porosity compared to the lower and upper members (Rima, et al., 1962). The thickness of the middle arkose member beneath

NAWC Warminster is unknown but is estimated to range from approximately 500 feet thick near the southeastern boundary of the facility to about 1,500 to 2,000 feet thick near the northwestern boundary.

The lower arkose member of the Stockton Formation underlies the middle arkose member and is projected to crop out approximately 2,000 feet or more southeast of the base. The lower arkose member is dominated by coarse-grained arkosic sandstone and conglomerate. Beds of medium-grained arkosic sandstone are common, though less abundant than the coarser-grained units. The lower arkose member is estimated to be approximately 1,700 to 1,800 feet thick in the vicinity of NAWC Warminster (Rima, et al., 1962).

The upper shale member of the Stockton Formation is not present in the vicinity of the base, but it overlies the middle arkose member several miles northwest of the facility. The upper shale member consists of shale, siltstone, and fine-grained arkosic sandstone. The sandstone is most common in the lower portion of this member.

3.4.2 Area B Geology

The geology of Area B consists of a thin veneer of residual soils overlying sedimentary bedrock of the Stockton Formation. The soils consist primarily of silt and clay, with some sand, and extend to an average depth of about 10 feet below ground surface. The transition from soils to competent bedrock occurs gradually over a distance of about 5 to 10 feet typically, due to the effects of weathering on the bedrock surface. The bedrock surface within Area B slopes gently to the south and southeast as shown in Figure 3-1, mimicking ground topography. Farther to the east of Area B near well cluster HN-05 the bedrock surface slopes to the southwest.

The bedrock of the Stockton Formation consists of alternating sequences of fine- and coarse-grained, gently dipping rock units. Lithologic units vary in thickness from less than a foot to a maximum observed thickness of about 60 feet within Area B. The fine-grained lithologies are described as mudstones and consist primarily of reddish-brown siltstones and shales. Coarser-grained rock units include fine- to coarse-grained arkosic sandstones that range in color from reddish to brown to gray-green. Well-defined, gradational fining-upward sequences were encountered in some areas; in other areas, fairly sharp transitions between sandstones and mudstones were identified.

Locally, bedding within the Stockton Formation strikes approximately north 71 degrees east and dips approximately 5 degrees to 8 degrees to the northwest. This dip of the rock units is approximately opposite to the overall topographic slope of the ground surface within Area B. Beds encountered at shallow to intermediate (< 100 to 150 feet) depths within Sites 5 and 6 crop out to the south, near the

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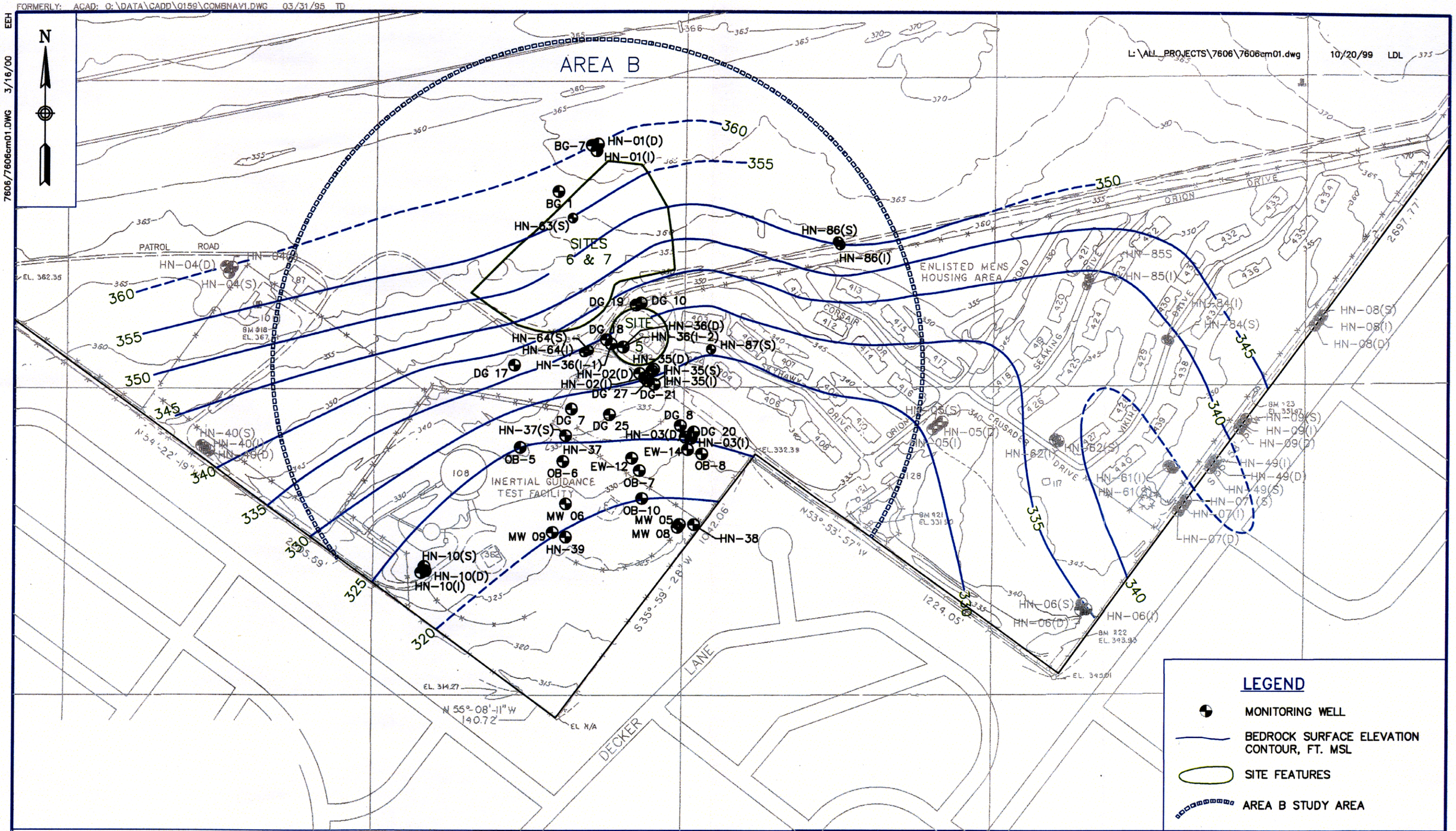

DRAWN BY LDL/EEH	DATE 3/16/00	Tetra Tech NUS, Inc.	BEDROCK SURFACE TOPOGRAPHY AREA B FORMER NAWC WARMINSTER WARMINSTER, PENNSYLVANIA
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SCALE AS NOTED			

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OWNER NO. 0101
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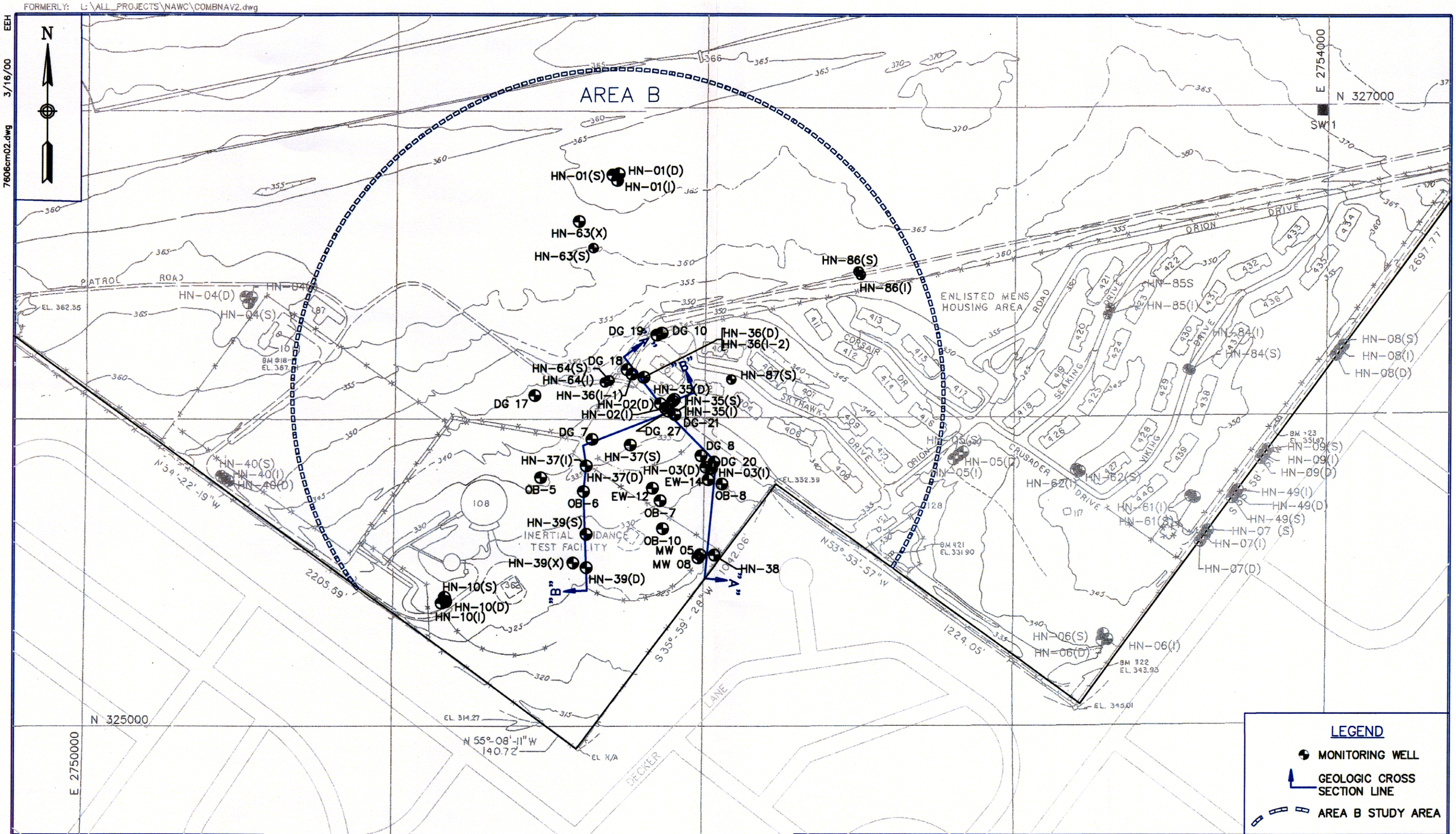

LEGEND

- MONITORING WELL
- GEOLOGIC CROSS SECTION LINE
- AREA B STUDY AREA

DRAWN BY LDL/EEH	DATE 3/16/00	Tetra Tech NUS, Inc.	GEOLOGICAL CROSS SECTION LOCATION MAP AREA B NAWC WARMINSTER, PA
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REVISED BY	DATE		OWNER NO.
SCALE AS NOTED			APPROVED BY DATE 5/12/00
			DRAWING NO. FIGURE 3-2 REV.

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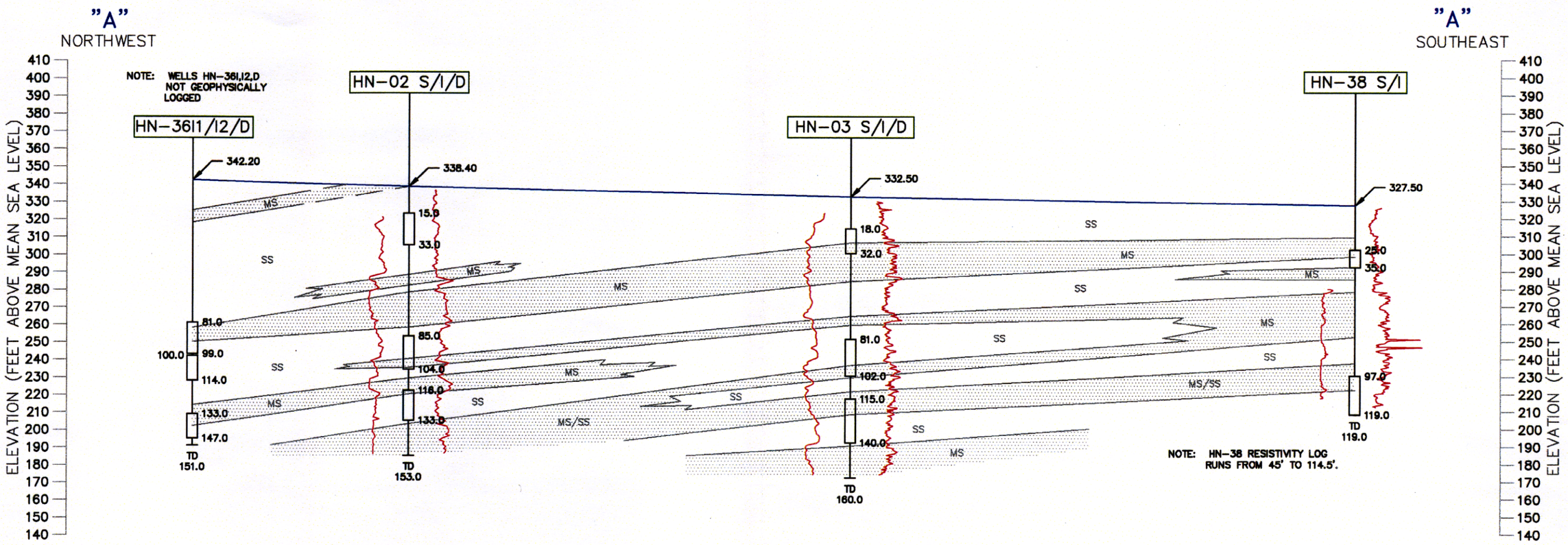
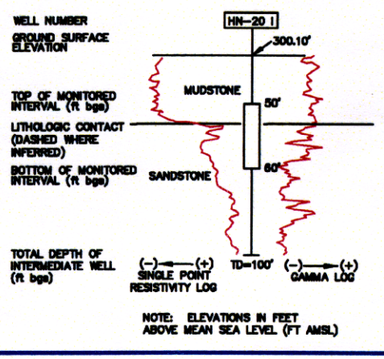


CROSS SECTION "A-A"

LEGEND



LEGEND:

SS – FINE TO MEDIUM GRAINED SANDSTONE, GRAY/BROWN/PINK

MS – MUDSTONE/SILTSTONE, RED-BROWN (SHADED IN CROSS SECTIONS)

MS/SS – INTERBEDDED ALTERNATING MUDSTONE AND SANDSTONE BEDS, INDIVIDUAL BED THICKNESS GENERALLY < 5 FEET

0 600± 1200±
HORIZONTAL SCALE IN FEET

0 60 120
VERTICAL SCALE IN FEET

NOTE: LITHOLOGIC CONTACTS ARE INFERRED FROM GEOPHYSICAL AND BORING LOGS. ACTUAL CONDITIONS MAY VARY FROM THOSE DEPICTED

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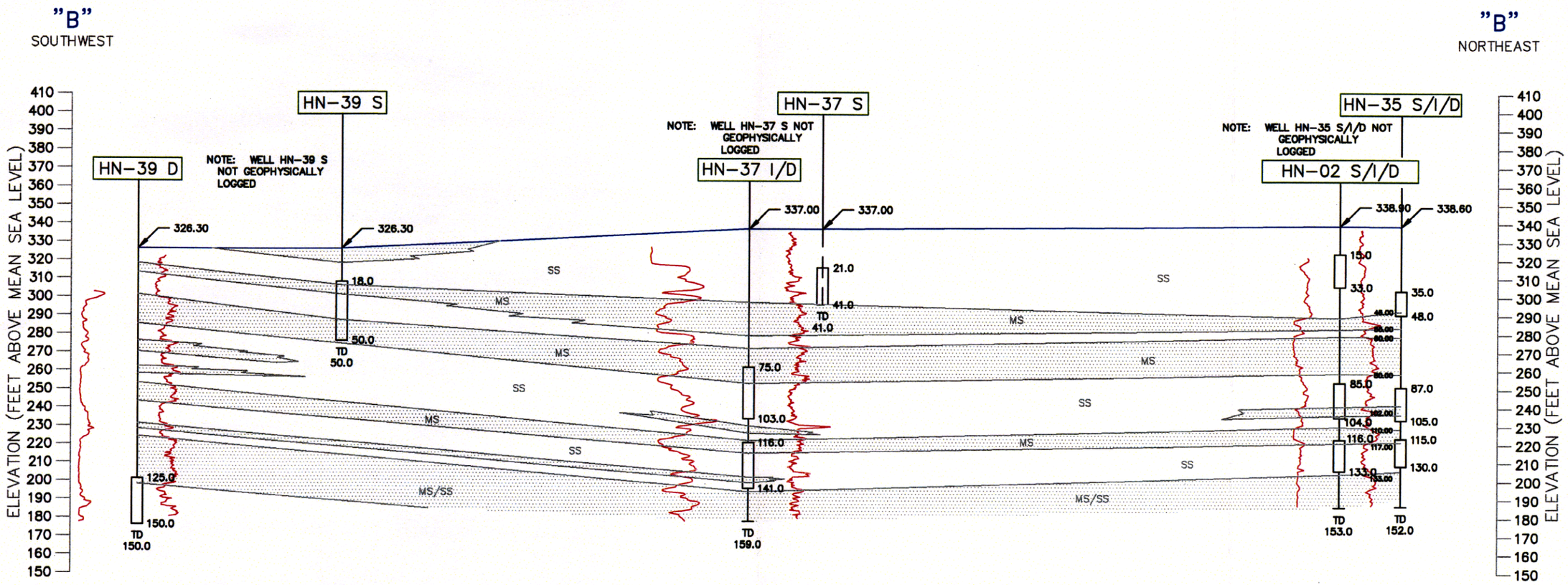

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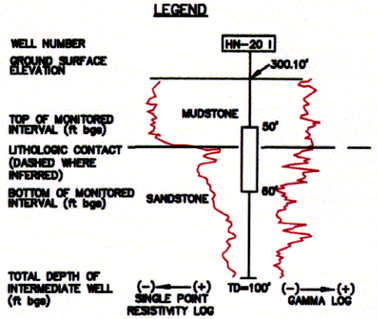

NOTE: ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL (FT AMSL)

LEGEND:

SS – FINE TO MEDIUM GRAINED SANDSTONE, GRAY/BROWN/PINK

MS – MUDSTONE/SILTSTONE, RED-BROWN (SHADED IN CROSS SECTIONS)

MS/SS – INTERBEDDED ALTERNATING MUDSTONE AND SANDSTONE BEDS, INDIVIDUAL BED THICKNESS GENERALLY < 5 FEET

NOTE: LITHOLOGIC CONTACTS ARE INFERRED FROM GEOPHYSICAL AND BORING LOGS. ACTUAL CONDITIONS MAY VARY FROM THOSE DEPICTED

0 600± 1200±
HORIZONTAL SCALE IN FEET
0 60 120
VERTICAL SCALE IN FEET

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southern boundary of NAWC. Figure 3-2 shows the locations for two geologic cross sections developed for Area B. The cross sections are shown in Figures 3-3, and 3-4. These cross sections are generalized interpretations of subsurface conditions and are based on boring log and geophysical log information. The interpretations in some cases combine several individual beds of minor thickness into larger lithologic units, based on the overall dominant characteristics of a given sequence.

Individual rock units vary both in thickness and in areal extent, with some lithologies extending for significant distances across Area B and others pinching out within relatively short distances. Thicker beds typically extend laterally for greater distances than the thinner beds, which tend to be localized in areal extent. The relationship between bedding thickness and areal extent can be seen in all three cross sections. Finer grained beds tend to be more laterally extensive than coarser grained beds, although coalescing sandstone beds may form laterally (and vertically) extensive packages of coarse-grained rock units. This pattern of bedding is consistent with the depositional environment of the Stockton Formation (alluvial fan).

Fractures were encountered at varying depths of the well borings drilled in and around Area B. Based on geophysical and boring log information, the fractures included both bedding-plane fractures and cross-formation joints. Fractures were observed within both the sandstone and mudstone units, with the fractures in the sandstones more likely to yield significant quantities of water. There are no outcrops in the vicinity of Area B at which to measure fracture orientations; however, according to Rima, et al. (1962), the most frequently occurring joint sets within the Stockton Formation trend parallel and perpendicular to strike, with a subordinate set trending approximately 50 degrees from strike.

3.5 HYDROGEOLOGY

3.5.1 Regional Hydrogeology

The fractured bedrock of the Stockton Formation is the major source of groundwater in the vicinity of NAWC Warminster. The middle arkose member of the Stockton Formation is considered to be the most productive bedrock aquifer in Bucks County.

Within the water-bearing zones in the fine- and medium-grained sandstones of the Stockton Formation, groundwater is transmitted chiefly through fractures, joints, and bedding planes (secondary permeability and porosity). Primary porosity is generally minimal in these rock units. The shale and siltstone beds are commonly too fine grained to transmit large amounts of groundwater through primary porosity, and the fractures are typically not as well developed compared to the coarser-grained units. Consequently, the shale and siltstone beds often act as confining layers to groundwater. The bulk of the groundwater is transmitted through the fractures and, to a much lesser extent, the primary porosity of the sandstones.

The Stockton Formation in the vicinity of NAWC Warminster forms a complex, multi-aquifer system. The individual water-bearing zones of the Stockton Formation may belong to one of three different aquifer types which, in descending subsurface order, include

- Overburden (weathered bedrock) aquifer
- Shallow bedrock aquifer
- Deeper bedrock aquifer

The overburden aquifer consists of soil and saprolite (weathered bedrock) derived from the erosion of the truncated edges of the inclined bedrock layers. The overburden aquifer (where present) generally extends to an average depth of about 20 feet.

The shallow bedrock aquifer may extend to depths of about 75 to 120 feet below the ground surface. The shallow bedrock aquifer is recharged by vertical percolation through the overburden and is the primary reservoir for groundwater storage in the Stockton Formation. The shallow bedrock aquifer occurs within the weathered and unweathered shallow bedrock and is generally under water-table or unconfined conditions. The shallow bedrock aquifer may consist of numerous discrete water-bearing fracture zones. Horizontal groundwater migration in response to regional gradients (controlled by topography or long-term well pumping) is significant in the shallow bedrock aquifer.

The deeper bedrock aquifers underlie the shallow bedrock aquifer and typically occur at depths greater than about 75 to 120 feet below the ground surface. Water within the deeper bedrock occurs under semi-confined or confined conditions. Leakage from one water-bearing unit to another occurs when there is a difference in the hydraulic head between the units. Groundwater flow is from the unit with a higher hydraulic head to the unit with a lower hydraulic head and can be either upward or downward. Pumping effects may either amplify or reduce the leakage rate, depending on whether the pumping increases or decreases the difference in hydraulic head.

Groundwater flow directions within the Stockton Formation are variable and are controlled by topography, bedrock structure, and the locations of groundwater discharge points such as streams and wells.

3.5.2 Area B Hydrogeology

3.5.2.1 General Conditions

Groundwater within Area B is primarily encountered within the Stockton Formation, which was the hydrogeologic unit of focus for the remedial investigation. The overlying residual soils do in places contain

minor amounts of water; however, the saturated thickness is generally limited to a few feet or less and, due to the low permeability of the soils, the volumetric groundwater flow rate within the soils is minor. Groundwater within the Stockton Formation is primarily encountered within and moves through interconnected networks of fractures that on a local scale form discrete flow zones related to lithology but on a larger scale are part of a complex, hydraulically interconnected, groundwater flow system. Primary permeabilities of the rock units that comprise the Stockton Formation are considered negligible in comparison to the secondary (fracture) permeability. In some of the coarse sandstone units, the primary porosity may be well enough developed to contribute some minor flow to a well, but it is insignificant in comparison to the fracture flow contribution. In the finer-grained mudstone units, the primary porosity/permeability is even less developed than in the sandstones.

The coarser-grained rock units within the Stockton Formation act as preferential flow zones for groundwater, and the finer-grained mudstone units generally act as semiconfining layers to groundwater flow. In all lithologies, however, significant water-yielding fractures were encountered during the Area B field investigation activities.

No differentiation of lithostratigraphic units into distinct, separate aquifers was observed in Area B, and no areally extensive confining layers were identified. The transition from unconfined water-table conditions through partially or semi-confined conditions occurs gradually with increasing depth in the bedrock of the Stockton Formation. Overall groundwater flow direction appears to be controlled primarily by hydraulic head differences throughout Area B rather than by geologic structure or stratigraphy. Therefore, wells were grouped by relative depth within bedrock in order to define a three-dimensional interpretation of groundwater flow direction and contaminant distribution within Area B groundwater.

3.5.2.2 Groundwater Flow Directions

The overall direction of groundwater flow across Area B is to the south. Potentiometric surface maps (Figures 3-5, 3-6, and 3-7) show groundwater gradients at increasing depths within the Stockton Formation, in and around Area B. The groundwater flow maps were generated using data from the most comprehensive round of water level measurements available for Area B and the surrounding area, collected during additional investigations on June 3, 1998. These groundwater elevation data are included in Appendix A and in the Summary for Area B Groundwater Monitoring report (Tetra Tech NUS, 1998). Groundwater flow patterns identified using these data are consistent with the flow patterns observed using earlier, more limited rounds of water levels.

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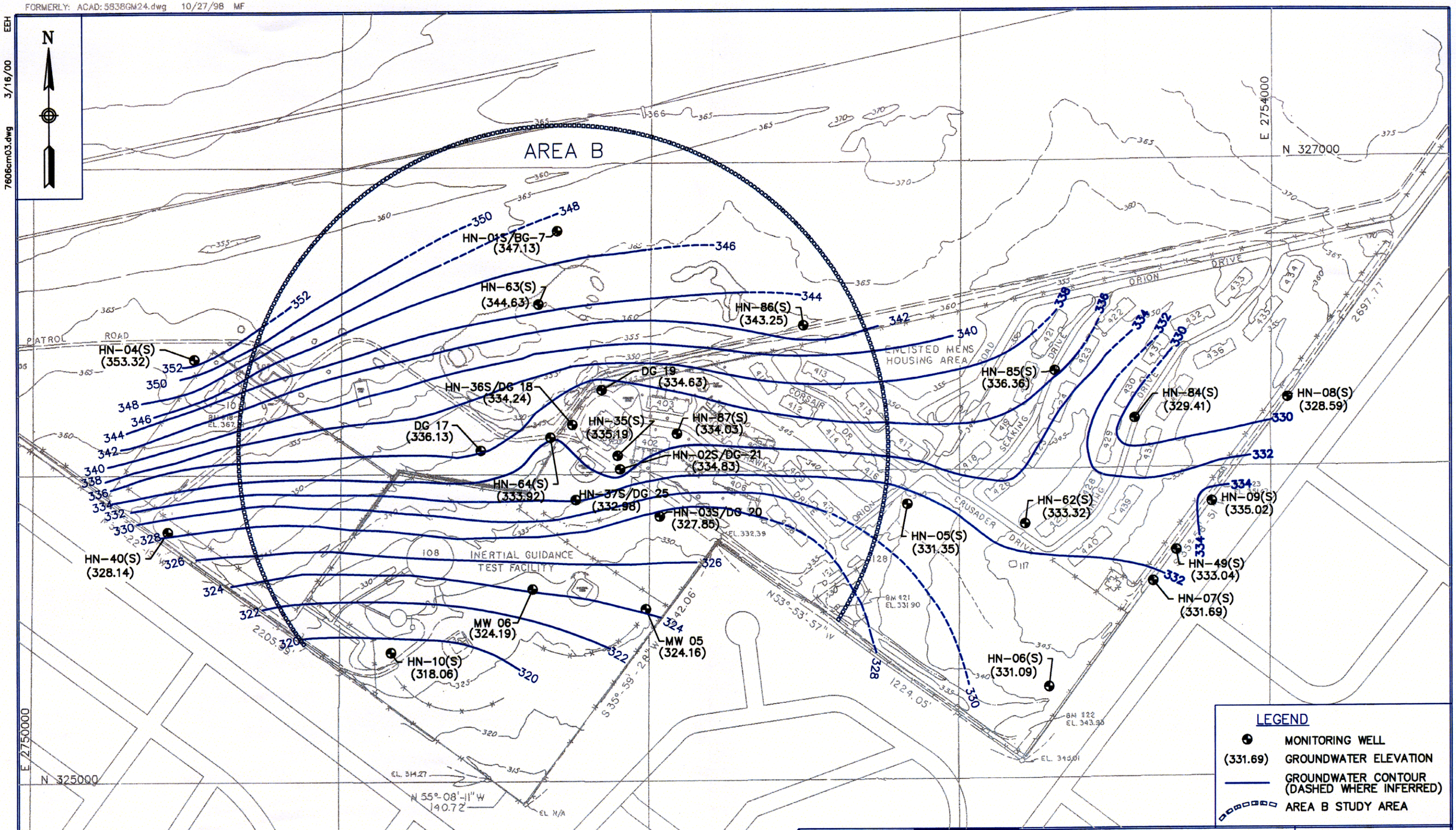

DRAWN BY LDL/EEH	DATE 3/16/00	Tetra Tech NUS, Inc.	POTENTIOMETRIC SURFACE - SHALLOW GROUNDWATER (WELL DEPTH RANGE <60 FEET) JUNE 3, 1998 AREA B FORMER NAWC WARMINSTER, PA
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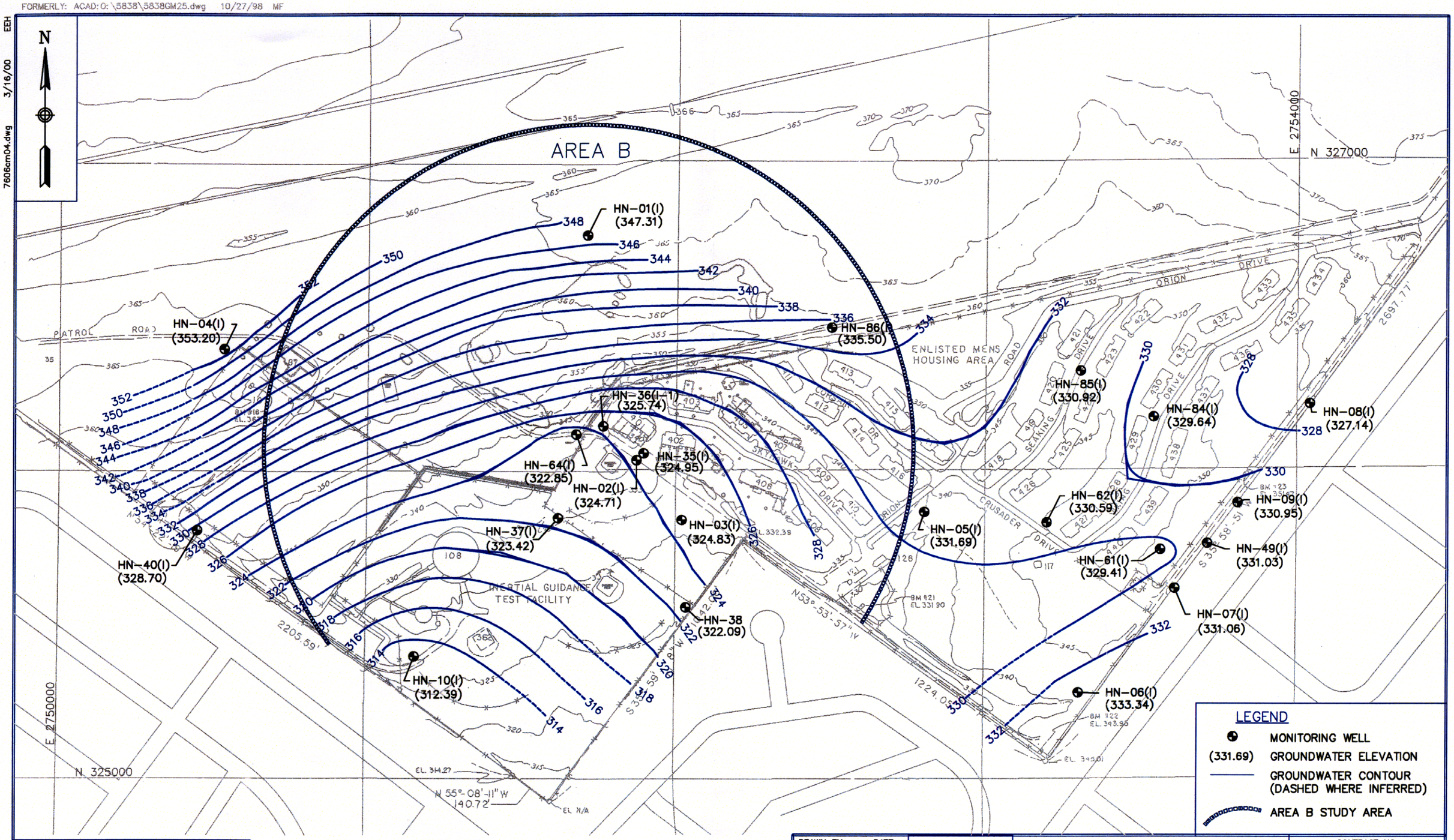

DRAWN BY LDL/EEH	DATE 3/16/00	Tetra Tech NUS, Inc.	POTENTIOMETRIC SURFACE – INTERMEDIATE GROUNDWATER (WELL DEPTH RANGE 60–110 FEET) JUNE 3, 1998 AREA B FORMER NAWC WARMINSTER, PA
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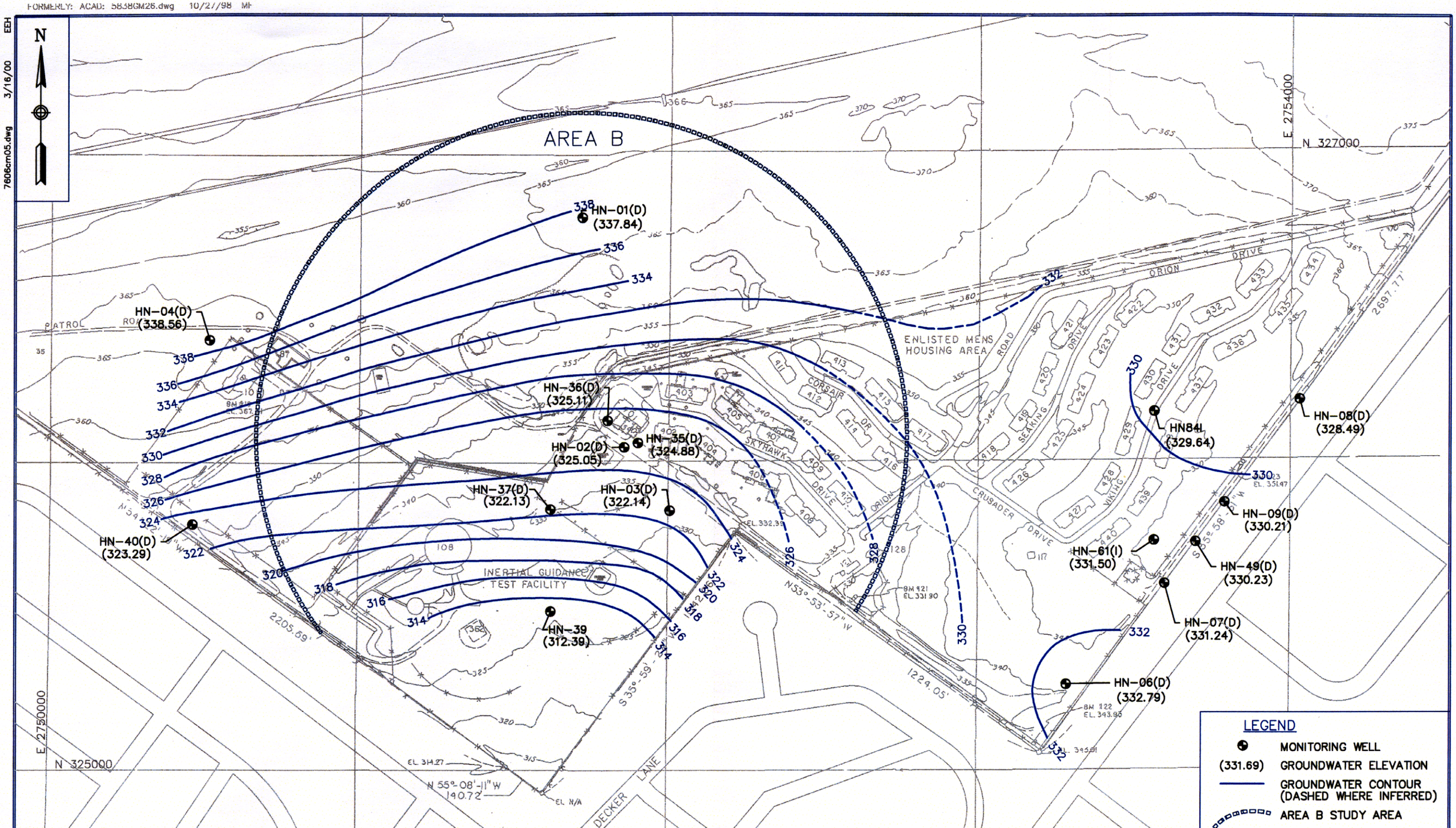

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Tetra Tech NUS, Inc.

POTENTIOMETRIC SURFACE - DEEP GROUNDWATER
(WELL DEPTH RANGE 110-160 FEET)
JUNE 3, 1998
AREA B
FORMER NAWC WARMINSTER, PA

CONTRACT NO. 7606
OWNER NO. 0101
APPROVED BY
DATE
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REV.

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Shallow (< 60 feet) groundwater flow across Area B (Sites 5, 6, and 7) is generally to the south, as shown in Figure 3-5, with a horizontal flow gradient of approximately 0.012. The potentiometric contours are dashed where inferred. Groundwater flowing to the southwest from the area near the eastern base boundary converges with groundwater flowing to the southeast from the base interior (Area B) near the southern edge of Area B.

Intermediate-depth (60 –110 feet) groundwater flow across Area B is to the south (Figure 3-6) and is similar to the shallow groundwater flow pattern. The horizontal flow gradient varies from north to south: it is slightly steeper to the north and lower to the south, which is consistent with the change in ground surface slope across the area. Overall, there is a horizontal flow gradient of approximately 0.02 to the south across Area B. Groundwater flowing to the southwest from the eastern base boundary converges with groundwater flowing to the southeast from Area B.

As with the shallow and intermediate-depth groundwater, deep (110 – 160 feet) groundwater flow across Area B is generally to the south at an approximate overall horizontal gradient of 0.02 (Figure 3-7). Groundwater flowing to the southwest from the area near the eastern base boundary converges with groundwater flowing to the southeast from Area B within the southern part of the study area.

The stream trace of one of the headwaters of Southampton Creek appears to exert some control over groundwater flow directions, as shown by the convergence of flow along the southern boundary of Area B and the accompanying change in flow direction parallel to the stream trace to the southwest. In general, groundwater flow directions within the upper portions of the Stockton Formation were observed to mimic the ground surface topography and are expected to be controlled by topography and the locations of streams in the area. Conversely, the flow direction across Area B is opposite the dip direction of the bedrock units. This flow direction of groundwater opposite the dip direction of the bedrock is confirmed by water-level data from wells screened within the same lithologic units. Wells HN36D, HN02D, and HN03I are screened across the same sandstone unit (cross section A-A', Figure 3-3). Well HN36D is the farthest well downdip, and the topographically highest, and also has the highest hydraulic head. HN03I is the farthest updip of the three wells, is located in the area of lowest topography of the three wells, and also has the lowest hydraulic head. This pattern of hydraulic heads indicates that groundwater moves with topography and against the dip of the rock in Area B. The same pattern of flow against the dip of the rock units can be seen by comparing water levels from shallow wells DG21 (HN-02S) and DG20 (HN-03S); and from wells HN36I2, HN02I, and MW05 (HN-38S).

Lateral groundwater flow gradients are generally steepest along the flank of the east-west-trending ridge upon which the runway is situated, along the northern edge of Area B. This is also the area of steepest

topographic relief within Area B. Across the ball field that is located adjacent to Site 5 and directly downgradient of Site 6, the groundwater flow gradient flattens out, as does the topography. Based on the intermediate groundwater flow map (Figure 3-6), the average flow gradient along the hillslope area is approximately 0.037. In the downgradient portion of Area B, the gradient flattens out to an average of approximately 0.02. Gradients in the shallow bedrock are slightly lower in the hillslope area and slightly higher in the downgradient area (Figure 3-5) than in the intermediate bedrock. In the deep bedrock (Figure 3-7), there is a gradual increase in flow gradient from the hillslope area to the downgradient area.

Based on groundwater-level measurements made in wells completed at different depths within well cluster locations, the overall vertical groundwater flow gradient is downward. Hydraulic heads within the shallow bedrock wells were generally higher than the water levels in the deeper wells, with a few exceptions. This pattern of vertical flow was expected and reflects that the source of water to the deeper groundwater flow zones within the bedrock is primarily leakage from overlying flow zones. The lowest groundwater elevations observed within Area B was at well HN-10D, where the June 3, 1998 water level of elevation 294.65 feet msl is similar to the base level of the tributary to Southampton Creek in the vicinity of this well cluster (based on USGS topographic map information). This further suggests that groundwater flow directions within the upper portion of the Stockton Formation in the vicinity of Area B are controlled by topography and stream locations.

3.5.2.3 Groundwater Elevation Trend Monitoring

A one-month groundwater-level monitoring program was conducted in selected Area B wells to investigate the duration and magnitude of short-term versus long-term water-level fluctuations, to determine the response of the aquifer to precipitation events, to determine the effects of nearby pumping wells on groundwater levels, and to provide data to be used for the design of the Area B pumping test. A detailed description of the program methods and evaluation of the results are presented in the Area B Hydrogeologic Report (Halliburton NUS Corporation, 1995). The water level data and daily precipitation records are presented in Appendix A of the same report.

All wells showed a marked response to precipitation. The individual well responses to the rainfall events appear to vary more by cluster location than by well depth within individual clusters. This is probably due to the marked lateral heterogeneity of the Stockton Formation, as described in many reports and studies. Some wells responded rapidly to the precipitation events, and the individual peaks in the water-level curves can be correlated to the individual precipitation events. Other wells exhibited a broader or more "averaged" response to the two main precipitation events that occurred during the program.

All wells exhibited a generally declining water-level trend over the 1 month period of investigation. After rising relatively sharply in response to a precipitation event, the water level in each well appears to decrease at a slower rate that is generally similar to the rate of decline (as measured by the slope of the curve) exhibited by the aquifer prior to the precipitation. Sloto and Schreffler (1994) noted that groundwater levels generally decline during the late spring when groundwater evapotranspiration and soil-moisture evapotranspiration are at a maximum and recharge is at a minimum.

The daily water-level fluctuations also vary by well cluster location from as little as 0.1 foot or less, to as much as 0.5 foot. The daily water-level fluctuations in some confined aquifer wells appear to be affected by earth tides. Earth tides are caused by the force of gravity exerted on the earth's crust by the moon (and to a lesser extent, the sun) and are characterized as semi-diurnal fluctuations that correspond to the moon's transit at upper and lower culmination (Sloto and Schreffler, 1994; Todd, 1980). The results of the study also indicated that the effects of off-base well pumping were negligible during the investigation.

3.5.2.4 Bedrock Aquifer Hydraulic Characteristics

The hydraulic characteristics of the shallow portion of the Stockton Formation in Area B were investigated through a 72-hour pumping test, performed as part of the Area B Hydrogeologic Investigation. The results of the pumping test are presented in this report to provide a comprehensive description of the hydrogeologic conditions within and around Area B. Interim Remedy extraction well installation included performance and analysis of 12-hour yield tests to establish the optimum placement of the next well. Following the extraction well installation, a 72-hour pumping test was performed to provide additional information regarding long term effects of storage on well yield, to induce greater drawdown in pumping and observation wells for more reliable aquifer evaluation, and to collect more representative groundwater samples after pumping for an extended period of time.

Area B Hydrogeologic Investigation Pumping Test

The Area B pumping test was performed during the week of August 7, 1994. For the long term pumping test, well HN-02I was pumped at a constant rate of 9 gpm (with <5 percent variation) for a period of 72 hours, beginning on August 8 and ending on August 11. Prior to the start-up of the test, trend measurements were obtained, starting on August 5 and ending immediately prior to starting the pumping test on August 8. After the completion of pumping activities, recovery measurements were made in the pumping and observation wells for a minimum of 12 hours and up to 72 hours for selected wells. The Area B Pumping Test Plan (Halliburton NUS, 1994) describes in detail the technical approach followed and the procedures used. There were no notable deviations from the planned approach.

The pumped well is screened primarily within a sandstone unit located at a depth of 80 to 110 feet below ground at the pumping well location. The unit is bounded on top and bottom by mudstones. Observation wells were screened within, above, and below the geologic unit pumped by HN-02I, as shown in geologic cross sections A-A' and B-B' (Figures 3-3 and 3-4).

Significant drawdowns were observed in wells located up to 580 feet from the pumping well. Drawdown data from observation wells HN-03I, HN-35I, HN-36I1, HN-36I2, HN-37I, HN-38, and MW-06 showed sufficient responses for pumping test evaluation purposes. Based on trend water-level data, background fluctuations in water levels were insignificant during the test and the drawdown data did not require any corrections.

The water-level data were evaluated using several analysis techniques. Log-log plots of the time-drawdown data were evaluated using manual type curve matching techniques, using type curves developed by Hantush (1960) for leaky aquifers with storage in the confining layer. This analysis technique likely provides the best true estimate of the aquifer transmissivity because leakage effects are filtered out of the transmissivity determination. Storativity was also determined using the log-log data plots.

A second analysis method employed for the time-drawdown data was a semilog inflection point analysis technique developed by Hantush (1956) for semiconfined aquifers. This method assumes no change in storage in the confining layer(s) and was employed as a supplement to the curve matching results.

Finally, a semilog distance-drawdown analysis was performed (Cooper-Jacob, 1946) using drawdown data from all the wells showing a drawdown response during the test. This method was developed for confined aquifers; thus, it ignores the leakage effects that occur in a semiconfined aquifer. It was considered, however, to be useful as an evaluation tool to evaluate directional-dependent trends in drawdowns and for an approximate transmissivity determination that employs all the well responses in one analysis. Drawdowns from each well at t = 4,000 minutes into the test were plotted along with the radial distance of each well from the pumping well. In theory, for an aquifer with an equivalent porous medium (EPM) response to pumping, the data points should all fall along a straight line; however, the data plot showed some scatter of the points plotted. It appears that two parallel lines can be extrapolated through the points present, as shown in Figure 3-10 of the Area B Hydrogeologic Report. No obvious directional, depth-related, or yield-related trends were identified within the distance-drawdown data subsets; i.e., there were no obvious features within each drawdown set that appeared consistent within the sets and unique to the sets. The distance-drawdown line slope, which was the same for both lines, was used to estimate transmissivity.

An analysis technique was also applied to the drawdown data from wells installed within, above, and below the strata being pumped, to evaluate the vertical permeability of the confining layers (Neuman and Witherspoon, 1972).

The results of the data analysis are presented in Table 3-1. From the leaky confined test evaluation methods, an average transmissivity of 139 ft^2/day was obtained. This value for T is considered to be the most accurate of the estimates generated. The semilog distance-drawdown estimation of transmissivity was 106 ft^2/day. Assuming an average thickness of the sandstone unit being pumped of about 25 feet, this yields an average bulk hydraulic conductivity (K) value of about 5 to 6 feet per day. In reality, most of the groundwater flow is through discrete fractures that typically occur at a frequency of two to four fractures per borehole; thus, the true K of these fractures is much higher than the bulk K value and the K of the rock matrix is much less. An average storativity in the 10^{-5} range was calculated. Based on the Neuman-Witherspoon analysis, an average vertical hydraulic conductivity for the underlying and overlying aquitards of 0.003 ft/day was obtained. Drawdown graphs and calculations are presented in Appendix A.

Drawdown responses in the observation wells indicated that pumping effects are projected laterally, along bedding, out much more so than vertically, across bedding. For the observation well clusters surrounding the pumping well, drawdowns in the wells screened across the same lithologic interval as the pumping well had much higher drawdowns than wells screened above and below the interval being pumped. This effect was most pronounced in wells located near the pumping well, with the effects being dampened farther out in the updip and strike-parallel directions. Downdip, few or no drawdowns were observed in the shallow wells at any distance, due to the increased vertical separation between the shallow bedrock wells and the stratigraphic interval being pumped. There was no apparent preferential drawdown observed along bedrock strike versus in the dip direction, within the strata being pumped.

Within the test area, the fine-grained mudstone units appeared to function as aquitards, as expected. A three-order-of-magnitude difference between the bulk K of the unit being pumped and the bulk vertical K of the adjacent aquitards is indicative of the relative resistance to flow through the finer-grained rock units (although some flow does undoubtedly occur through them).

TABLE 3-1
REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER
AREA B PUMPING TEST SUMMARY OF RESULTS
NAWC WARMINSTER, PENNSYLVANIA

Well	Distance from Pumping Well (feet)	Transmissivity		Storativity		Vertical Hydraulic Conductivity, K[1] (ft/day)
		Curve Matching (ft^2/day)	Semilog Analysis (ft^2/day)	Curve Matching	Semilog Analysis	
HN 35I	32.5	106	104	6.0×10^{-6}	2.8×10^{-5}	7.2×10^{-3}
HN 36I1	122	131	148	2.0×10^{-5}	2.4×10^{-5}	2.3×10^{-3}
HN 36I2	122	115	---	2.1×10^{-5}	---	---
HN 03I	250	144	193	1.3×10^{-5}	1.0×10^{-5}	4.0×10^{-4}
HN 37I	317	98	198	1.9×10^{-5}	1.3×10^{-4}	---
HN 38	520	134	135	1.1×10^{-4}	1.1×10^{-4}	---
MW 06	480	144	---	1.0×10^{-5}	---	---

Average T, Time-Drawdown Analysis - 139 ft^2/day (Average of each average T per cluster).
Average S, Time-Drawdown Analysis - 2.7×10^{-5}.
T, Distance-Drawdown Analysis - 106 ft^2/day.

Interim Remedial Action Pumping Tests

In addition to the pumping test described above, 12-hour yield tests were performed on extraction wells EW-12 and EW-14 and a 72-hour pumping test was performed on extraction well EW-12 in January 1995 by OHM Remediation Corporation, Inc. as part of the interim remedial action for Area B groundwater. The procedures, data, analyses, and results of the yield tests and the pumping test for the Area B extraction wells are included in the Final Yield Test Reports for wells EW-12 and EW-14 (OHM, 1995, 1995a, and 1995b).

The EW-12 12-hour yield test was performed on January 4, 1995. The test ran for a duration of 12 hours and included three separate steps or pumping rates of 7 gallons per minute (GPM) for 1 hour, 15.5 GPM for the following 2 hours, and 30 GPM for the remaining 9 hours. The EW-14 12-hour yield test was performed on January 12, 1995. The test ran for a duration of 12 hours and included two separate steps or pumping rates of 8.5 GPM for 2 hours and 13.5 GPM for the remaining 9 hours. The EW-12 72-hour yield test was performed from January 17 to 20, 1995. The test ran for a duration of 73 hours and included two separate pumping rates of 55 GPM for 48 hours and 15 GPM for the remaining 25 hours.

During each pumping test, water level data were collected from the pumping well, from the other extraction well, if present, from observation wells OB-5 through OB-10 and from 11 surrounding monitoring wells in clusters HN-02, HN-03, HN-37 and HN-38. Static water levels were measured before each pumping test, water level drawdowns were measured at prescribed intervals during each test and water level recovery data was measured upon completion of each test. Water level data were recorded automatically using pressure transducers and data loggers in some wells and were measured manually with water level indicators from the remaining wells.

The data collection and pumping test procedures from the interim remedy aquifer testing differed in several respects from those of the Area B Hydrogeologic Investigation. Water level trend measurements during the 12-hour yield tests were limited to one round of measurements the day before the test, however, these water level conditions were considered to be potentially unstable due to well development pumping the day before the test. Water level trend measurements were not obtained prior to the 72-hour test. The interim remedy 72-hour pumping test only provided 48 hours of constant rate pumping data for analysis due to reduction of the pumping rate partway through the test. Water level recovery data form the interim remedy 72-hour test are of poor quality due to the decreased pumping rate during the latter portion of the test and poor execution of the test shutdown and recovery measurements due to inclement weather. Recovery data were not recorded following the 12-hour yield tests.

Both extraction wells EW-12 and EW-14 are open over depth intervals (20 to 100 feet and 10 to 100 feet, respectively) that are much larger and which include multiple water-yielding sandstone units compared to the more restricted open interval of HN-02I (85 to 104 feet). Therefore, the discrepancy in transmissivity values obtained in the interim remedy tests versus the Hydrogeologic Investigation test are probably a function of the vertical extent of the aquifer pumped rather than local variations in hydraulic characteristics.

The pumped extraction wells, EW-12 and EW-14, are completed as 10-inch diameter, open boreholes within the alternating sandstone and mudstone units of the Stockton Formation at Area B. EW-12 is open from subsurface depths of 20 to 100 feet and EW-14 is open from subsurface depths of 10 to 100 feet. Approximate stratigraphic correlation between EW-12, EW-14 and the surrounding Area B monitoring wells and geologic cross sections indicate that each extraction well includes the screened sandstone unit of the Hydrogeologic Investigation pumping well HN-02I and one or more of the overlying and underlying mudstone and sandstone units.

Significant drawdowns were observed in most of the observation wells monitored during the pumping tests, particularly during the 72-hour test. Drawdowns were observed at distances up to 350 feet from pumping well EW-12, however, the maximum areal extent of the induced drawdown is unknown due to the limited number and distribution of monitored wells. Background fluctuations in water levels and the need for any drawdown data corrections are unknown due to the lack of trend water level data for these tests.

Transmissivity values for all of the pumping tests were calculated using the Cooper-Jacob time/drawdown and distance/drawdown solutions and the Walton specific capacity solution. The Geraghty & Miller AQTESOLV program was also used to estimate transmissivity using the Moench and Hantush solutions for leaky-confined aquifers for the 72-hour test in EW-12 and the 12-hour test in EW-14. These results are shown in Table 3-2. Values of aquifer storativity and vertical hydraulic conductivity were not calculated for these test results.

Data from the EW-12 12-hour yield test show a projected drawdown of 14 feet after 30 days of pumping at 30 GPM and suggest that a sustained yield of over 50 GPM could be achieved. More conservative pumping rates of 10 and 30 GPM were used for preliminary capture zone calculations. Data from the EW-14 12-hour yield test indicate that the pumping rate of 13.5 GPM should be sustainable over time based on the observed drawdown trend and this rate was used for preliminary capture zone calculations. During the EW-12 72-hour yield test, pumping levels in EW-12 did not stabilize at 55 GPM during 48 hours of pumping. The observed trend data show a projected drawdown of 39.5 feet (43 percent of available drawdown) after 30 days of pumping at 55 GPM and suggest that this rate is too high for design purposes. Therefore, a more conservative pumping rate of 30 GPM was used for capture zone calculations. The capture zone calculation results are shown in Table 3-3.

TABLE 3-2

REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER

AREA B INTERIM REMEDY YIELD TESTS

SUMMARY OF TRANSMISSIVITY CALCULATIONS

NAWC WARMINSTER, PENNSYLVANIA

Pumping Test	Avg. Transmissivity Cooper-Jacob time/drawdown (ft^2/day)	Avg. Transmissivity Cooper-Jacob distance/drawdown (ft^2/day)	Est. Transmissivity Walton specific capacity (ft^2/day)	Avg. Transmissivity AQTESOLV Moench & Hantush (ft^2/day)
EW-12, 12-Hour	309	1294	500	- N.A. -
EW-14, 12-Hour	342	162	259	499
EW-12, 72 Hour	178	1190	644	406

TABLE 3-3

REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER

AREA B INTERIM REMEDY YIELD TESTS

LATERAL CAPTURE ZONE RADIUS ESTIMATES

NAWC WARMINSTER, PENNSYLVANIA

Extraction Well Pumping Test	Extraction Well Pumping Rate (gallons per minute)	Transmissivity (ft^2/day)	Lateral Capture Zone Radius (feet)
EW-12, 12-Hour	10	309	1036
	10	1294	248
	30	309	3112
	30	1294	743
EW-14, 12-Hour	13.5	162	2673
	13.5	499	868
EW-12, 72-Hour	30	178	5404
	30	1190	807
	30	406	2370

Drawdown responses in the observation wells during the interim remedy pumping tests were similar to those observed during the Hydrogeologic Investigation pumping test for well HN-02I. Pumping effects are projected laterally, along bedding, out much more so than vertically, across bedding. Observation wells screened across one of the same lithologic intervals that comprise the open borehole in the pumping wells had much higher drawdowns than wells screened above the intervals being pumped. Only one of the monitored observation wells was completed in an interval below those that were pumped and it showed drawdowns similar to those of the pumped intervals. Downdip, only very small drawdowns were observed in the shallow wells, due to the increased vertical separation between the shallow bedrock wells and the stratigraphic intervals being pumped. There was no apparent preferential drawdown observed along bedrock strike versus in the dip direction, within the strata being pumped.

3.6 GEOLOGIC CONTROLS ON CONTAMINANT MIGRATION

The migration of contaminants in groundwater across Area B is influenced by several factors. Groundwater primarily moves through interconnected networks of fractures within the bedrock. Lateral groundwater (and contaminant) migration directions are to the south across Area B and are controlled by topography and by the presence of the tributary of Southampton Creek south of Area B. Groundwater flow follows the slope of the ground surface topography across Area B, flowing against the dip direction of the bedrock units. It is expected that groundwater from Area B will eventually discharge to streams within the Southampton Creek drainage.

Fine-grained mudstone beds act as semiconfining layers to groundwater flow, restricting but not preventing the vertical movement of groundwater across bedding. The hydraulic heads within the bedrock generally were observed to decrease with increasing depth, indicating that vertical flow potential is downward. Based on sampling results, however, contamination appears to be limited to the top 100 to 150 feet of the bedrock aquifer.

No known groundwater users influence groundwater flow directions within Area B. Historic domestic well usage in the residential area to the east may have flattened groundwater flow gradients along the southeast boundary of the base in the past; however, these wells are no longer in operation. Based on the results of the long-term water-level study, the historic usage of these wells did not significantly impact on-base groundwater levels. The Northampton municipal wells located along Bristol Road also do not appear to have a significant effect on on-base groundwater levels, based on the long-term water-level study.

3.7 GROUNDWATER USE

Residents near Area B rely entirely on groundwater sources for their water supply. The majority of these people are served by the Warminster Township or Northampton Township municipal water authorities, and the remainder depend on private domestic wells. The nearest residential supply wells are located approximately 1/2 mile southwest of Area B. These wells are not considered to be receptors of groundwater from Area B because they are not located downgradient from the area. The nearest active municipal supply wells are located over 1/2 mile south, southeast and east of Area B and are also not considered to be receptors of groundwater from Area B. None of these municipal wells are located directly downgradient from Area B and groundwater flow from Area B is expected to follow, or discharge to tributaries of Southampton Creek before migrating this distance from the site. Also, the results of the long-term water level monitoring program indicate that groundwater migration from Area B is not being caused by the drawdown of nearby pumping wells.

4.0 NATURE AND EXTENT OF CONTAMINATION

This section of the RI report discusses the nature and extent of contamination for Area B groundwater. As described in Section 2 of this report, Area B groundwater has been extensively studied over a sixteen year period from 1982 through 1998. The groundwater investigations in the area have primarily focused on the potential source areas, Sites 5, 6, and 7. In addition to these focused investigations the Navy has conducted area-wide comprehensive sampling and analysis programs that included the sampling of wells within and adjacent to Area B. The early investigations, prior to 1993, identified the presence of low-level groundwater contamination within Area B and the Navy and EPA, based on that data, selected an interim remedial action to address that contamination. As part of that interim remedy, the Navy installed extraction wells within Area B and conducted additional groundwater studies.

This section of the RI presents the analytical results and findings of the groundwater investigations conducted since 1982 and discusses the nature and extent of the contamination identified in Area B groundwater. The discussion is presented in five major subheadings segregated by time period followed by a presentation of contaminant trend data for wells within Area B. The five major subdivisions, based on time period, are; Pre-Interim ROD Investigations; Area B Hydrogeologic Investigation; Interim Remedial Action; Additional Groundwater Investigations; and Perimeter Monitoring Program. As presented in Sections 2 and 3 of this report, the investigations consisted of installing and sampling monitoring wells that targeted specific depth ranges. The ranges consisted of; Shallow - overburden and bedrock wells less than 60 feet deep; Intermediate – bedrock wells ranging from 60 to 110 feet deep; and Deep – bedrock wells greater than 110 feet deep. The initial studies conducted in Area B focused on the shallow groundwater and as investigations proceeded the deeper water-bearing zones were investigated. Contaminant detections have primarily occurred within the shallow monitoring zones. For consistency and to provide a focus on contaminant distribution, the nature and extent of contamination discussion is presented according to these depth ranges where appropriate to a specific investigation.

All analytical data, unless noted otherwise, were subjected to validation. The data validation was performed in accordance with the functional guidelines established by the U.S. EPA as modified for use in U.S. EPA Region III. Data that were noted to be compromised because of analytical or matrix considerations were qualified as prescribed by the guidance documents.

4.1 PRE-INTERIM ROD INVESTIGATIONS

Three separate major groundwater sampling investigations were conducted in Area B from 1982 through 1992. These investigations have been identified as the Pre-Remedial Investigation, the Phase I RI, and the Phase II RI. Based on the findings from these investigations, it was determined that an interim remedial action was warranted for Area B groundwater.

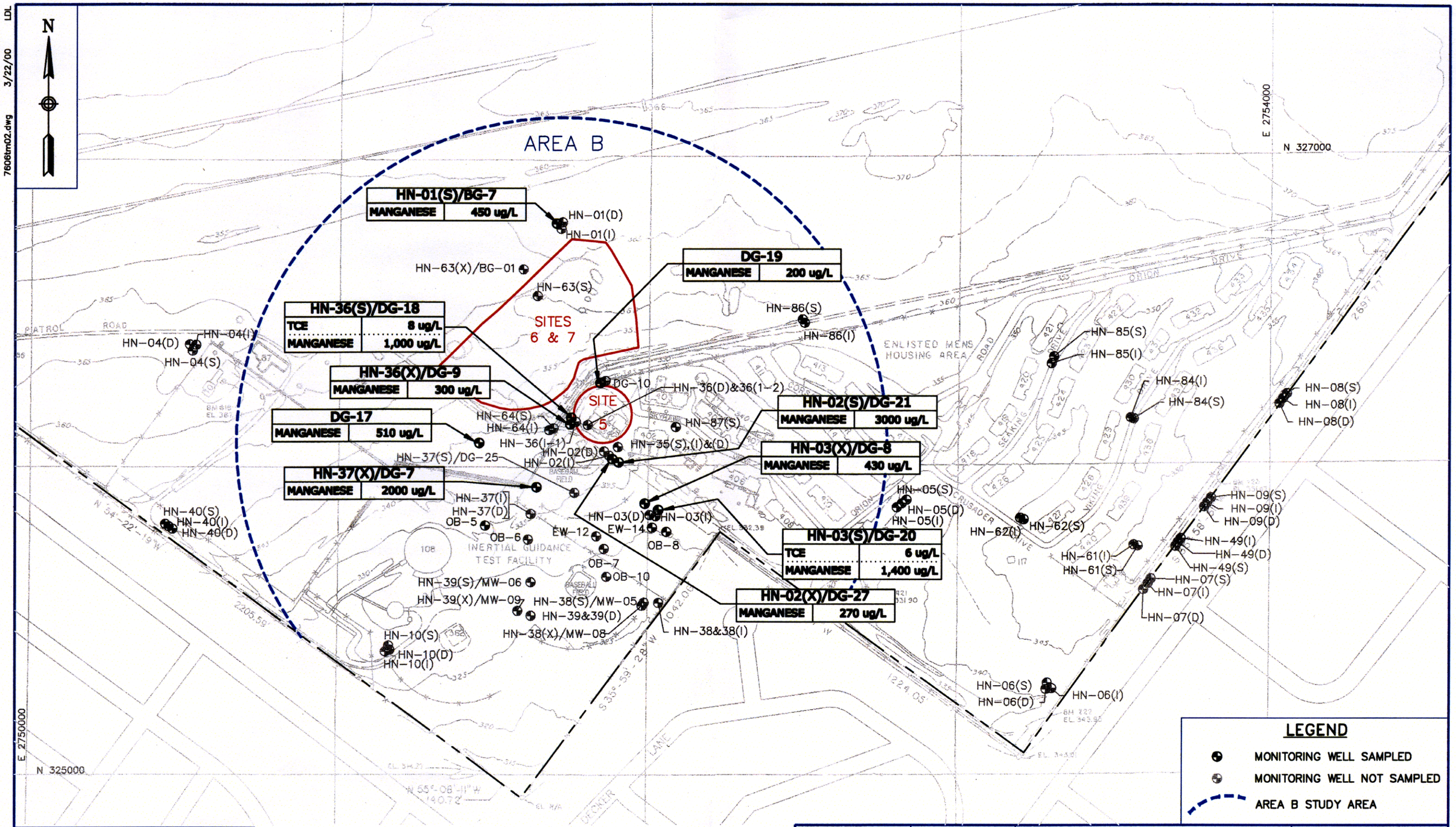
4.1.1 Pre-Remedial Investigation Sampling and Analysis

Samples were collected from 4 shallow overburden monitoring wells (DG-8/HN-03X, DG-9/HN-36X, DG-7/HN-37X, and DG-10) located within Area B during July and September 1982. The fifth well drilled during this investigation (BG-01) was completed as a dry well. Samples collected during the July sampling effort were analyzed for full range Target Compound List (TCL) organics and Target Analyte List (TAL) inorganics. Filtered samples were not collected. The analytical results were not subjected to a full data validation but were evaluated by reviewing the results of blank analysis and specific method requirements. The evaluation of the analytical results determined that the Volatile Organic Compound (VOC) analytical results were not valid and the wells were resampled in September 1982. The September samples were analyzed for VOCs only.

No VOCs were identified in Area B wells. The only contaminants that were reported as positively identified were copper, chromium, nickel, and zinc (JRB Associates, 1983). Concentrations were below EPA Maximum Concentration Limits (MCLs) for drinking water. The Pre-Remedial investigation compared the analytical results to a single overburden well background sample collected from NAWC Warminster and concluded that although elevated metals concentrations were not consistent among wells and the levels of contamination did not present a threat to human health or the environment, further study was needed to determine if the levels were related to disposal activities.

4.1.2 Phase I Remedial Investigation Sampling and Analysis

The Phase I remedial investigation included collecting samples from 12 Area B monitoring wells.



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NOTES: MCL for TCE = 5 ug/L
SMCL for Manganese = 50 ug/L

DRAWN BY LDL	DATE 3/24/00	
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REVISED BY	DATE	
SCALE AS NOTED		

Tetra Tech NUS, Inc.

AREA B
PHASE I RI GROUNDWATER
CONCENTRATION > MCL's & SMCL's
NAWC WARMINSTER, PA

CONTRACT NO. 7606
OWNER NO. 0102
APPROVED BY DATE
DRAWING NO. FIGURE 4-1
REV.

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All samples were analyzed for full TCL organics and TAL inorganics (unfiltered). Figure 4-1 depicts the wells that were sampled and presents the analytical results for contaminants that were identified at concentrations in excess of MCLs, (SMC Environmental Services Inc., 1991). Trichloroethene (TCE) was the only organic compound identified at concentrations in excess of the MCL (5 ug/l for TCE). TCE was identified at 6 ug/l and 8 ug/l in monitoring wells DG-20/HN-03S and DG-18/HN-36S, respectively. Both of these wells are shallow wells that monitor the upper portion of the bedrock. TCE was also identified in shallow wells DG-19 and DG-21/HN-02S at estimated trace-levels below the quantitation limit. Few other organic compounds were identified in any of the monitoring wells and where present, the concentrations were at trace- to low-levels, well below MCLs.

Inorganic analysis of the monitoring well samples identified the presence of two metals at concentrations in excess of Secondary MCLs (SMCLs). SMCLs are non-enforceable standards established for drinking water quality "based on taste, odor, color, and certain other non-aesthetic effects". Manganese was identified in all wells, including background wells, at levels in excess of the SMCL (50 ug/l) with the exception of wells DG-10 and DG-25 /HN-37S. Similarly, iron was found at levels in excess of the SMCL (300 ug/l) in all wells. Because iron is a common element in the environment and is not considered a significant in evaluating human health risks, individual sample results are not shown on Figure 4-1. Sample results are presented in the Phase I RI Report (SMC Environmental Services Inc., 1991). It was noted in the phase I RI that manganese and iron concentrations may be related to natural levels occurring in Area B groundwater and weathered bedrock. It was also noted that the concentrations identified in the samples may be in influenced by the presence of suspended solids in the unfiltered groundwater samples.

4.1.3 Phase II Remedial Investigation Sampling and Analysis

The Phase II remedial investigation included collecting samples from 14 Area B monitoring wells. All samples were analyzed for full TCL organics and TAL inorganics. In addition, one set of samples were also field filtered and analyzed for dissolved metals. Analytical results are included in Volume III Appendix K of the Phase II RI Report (HNUS, 1993).

TCE was the only organic compound identified at concentrations in excess of the MCL. TCE was identified at 6 ug/l in well DG-25/HN-37S, 8 ug/l in well DG-20/HN-03S, and at 13 ug/l in well DG-18/HN-36S. TCE was identified in DG-21/HN-02S and DG-19 at 1 ug/l and 4 ug/l, respectively. Figure 4-2 depicts the wells that were sampled and shows the TCE concentrations that exceed

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N

AREA B

SITES 6 & 7

SITE 5

HN-01(S)/BG-7	
MANGANESE	1,680/8 ug/L

DG-19	
MANGANESE	72/5 ug/L

DG-10	
MANGANESE	123/30 ug/L

HN-36(S)/DG-18	
TCE	13 ug/L
MANGANESE	326/38 ug/L

HN-36(X)/DG-9	
MANGANESE	467/391 ug/L

DG-17	
MANGANESE	1,080/8 ug/L

HN-37(S)/DG-25	
TCE	6 ug/L
MANGANESE	642/ND ug/L

HN-39(S)/MW-06	
MANGANESE	4090/17 ug/L

HN-38(S)/MW-05	
MANGANESE	68/24 ug/L

HN-39(X)/MW-09	
MANGANESE	699/753 ug/L

HN-02(S)/DG-21	
MANGANESE	536/8 ug/L

HN-03(X)/DG-8	
MANGANESE	160/64 ug/L

HN-03(S)/DG-20	
TCE	8 ug/L
MANGANESE	15,000/810 ug/L

HN-02(X)/DG-27	
MANGANESE	145/ND ug/L

HN-01(D) HN-01(I) HN-63(X)/BG-01 HN-63(S) HN-86(S) HN-86(I) HN-04(D) HN-04(I) HN-04(S) HN-36(D)&36(1-2) HN-64(S) HN-64(I) HN-36(I-1) HN-02(D) HN-02(I) HN-87(S) HN-35(S),(I)&(D) HN-37(X)/DG-7 HN-37(I) HN-37(D) OB-5 OB-6 HN-03(D) HN-03(I) EW-12 EW-14 OB-8 OB-7 OB-10 HN-40(S) HN-40(I) HN-40(D) HN-39&39(D) HN-38(X)/MW-08 HN-38&38(I) HN-10(S) HN-10(D) HN-10(I) HN-05(S) HN-05(D) HN-05(I) HN-85(S) HN-85(I) HN-84(I) HN-84(S) HN-08(S) HN-08(I) HN-08(D) HN-09(S) HN-09(I) HN-09(D) HN-62(I) HN-62(S) HN-61(I) HN-61(S) HN-49(I) HN-49(D) HN-49(S) HN-07(S) HN-07(I) HN-07(D) HN-06(S) HN-06(D) HN-06(I)

PATROL ROAD
ENLISTED MENS HOUSING AREA
ORION DRIVE
SEAKING ROAD
INERTIAL GUIDANCE TEST FACILITY
BASEBALL FIELD
DECKER LANE
N 56° 08'-11" W 14072'
S 33° 59' 29" W 1042.0'
N 54° 22' 19" W 2205.59'
1224.05'
EL. 314.27
EL. N/A
E 2754000
N 327000
E 2750000
N 325000

LEGEND

- MONITORING WELL SAMPLED
- MONITORING WELL NOT SAMPLED
- AREA B STUDY AREA
- MANGANESE – TOTAL / DISSOLVED
- TCE – LEVELS > MCL
- ND – NO DETECTS

0 300 600
SCALE IN FEET

DRAWN BY	DATE
LDL	3/29/00
CHECKED BY	DATE
REVISED BY	DATE
SCALE	
AS NOTED	

Tetra Tech NUS, Inc.

PHASE II RI
AREA B GROUNDWATER
TCE AND MANGANESE RESULTS
NAWC WARMINSTER, PA

CONTRACT NO. 7606
OWNER NO. 0102
APPROVED BY DATE
DRAWING NO. FIGURE 4-2 REV.

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the MCL (5 ug/l). Few other organic compounds were identified above the analytical quantitation limits. Positive detections included carbon tetrachloride, cis-1,2-dichloroethene (cis-1,2-DCE), tetrachloroethene (PCE), chloroform and toluene. These low-level detections were scattered throughout the area and not indicative any contaminant pattern.

Inorganic analysis of the unfiltered samples (total metals) identified the presence of numerous elements. A comparison to background results and health-based screening criteria was conducted and arsenic, cadmium, barium, and manganese levels were identified as potential contaminants of concern for Area B groundwater. Manganese concentrations were noted to be particularly high in all but one well. It was also noted in the Phase II RI Report that significant amounts of suspended materials in the samples may result in overestimation of the metals contamination present in Area B groundwater. Further review and comparison of filtered (dissolved) groundwater sample results was conducted. This comparison and evaluation of the filtered or dissolved concentrations found that arsenic and cadmium were not detected in filtered samples and that barium and manganese levels were significantly lower in the filtered samples. In fact the levels present were similar to or below the levels identified in filtered background or upgradient samples. As part of the Phase II RI, fifteen background wells located upgradient of NAWC study areas and sites were sampled to establish regional or base-wide background metals concentrations. Total manganese levels detected in these wells ranged from 80 ug/l to 4,830 ug/l and the representative concentration was 2,200 ug/l. Filtered or dissolved manganese levels in these same wells ranged from 4 ug/l to 4,220 ug/l with the representative concentration for dissolved manganese of 420 ug/l. Figure 4-2 shows the unfiltered (total) and filtered (dissolved) concentrations of manganese identified in Area B wells.

A human health risk assessment was performed as part of the Phase II RI. The risk assessment for Area B groundwater was conducted using the analytical results from both the Phase I and Phase II investigations. Potential risks were calculated for future residents assuming that Area B groundwater would be used for household water supplies. The risk assessment estimated a future potential lifetime resident carcinogenic risk of 1×10^{-4} (adult plus child risks) and a noncarcinogenic risk (Hazard Index or HI) of 12 for an adult and 28 for a child (HNUS, 1993). Arsenic, PCE, and carbon tetrachloride were identified as the major contributors to the carcinogenic risks and arsenic, barium, cadmium, and manganese as major contributors to the noncarcinogenic risks.

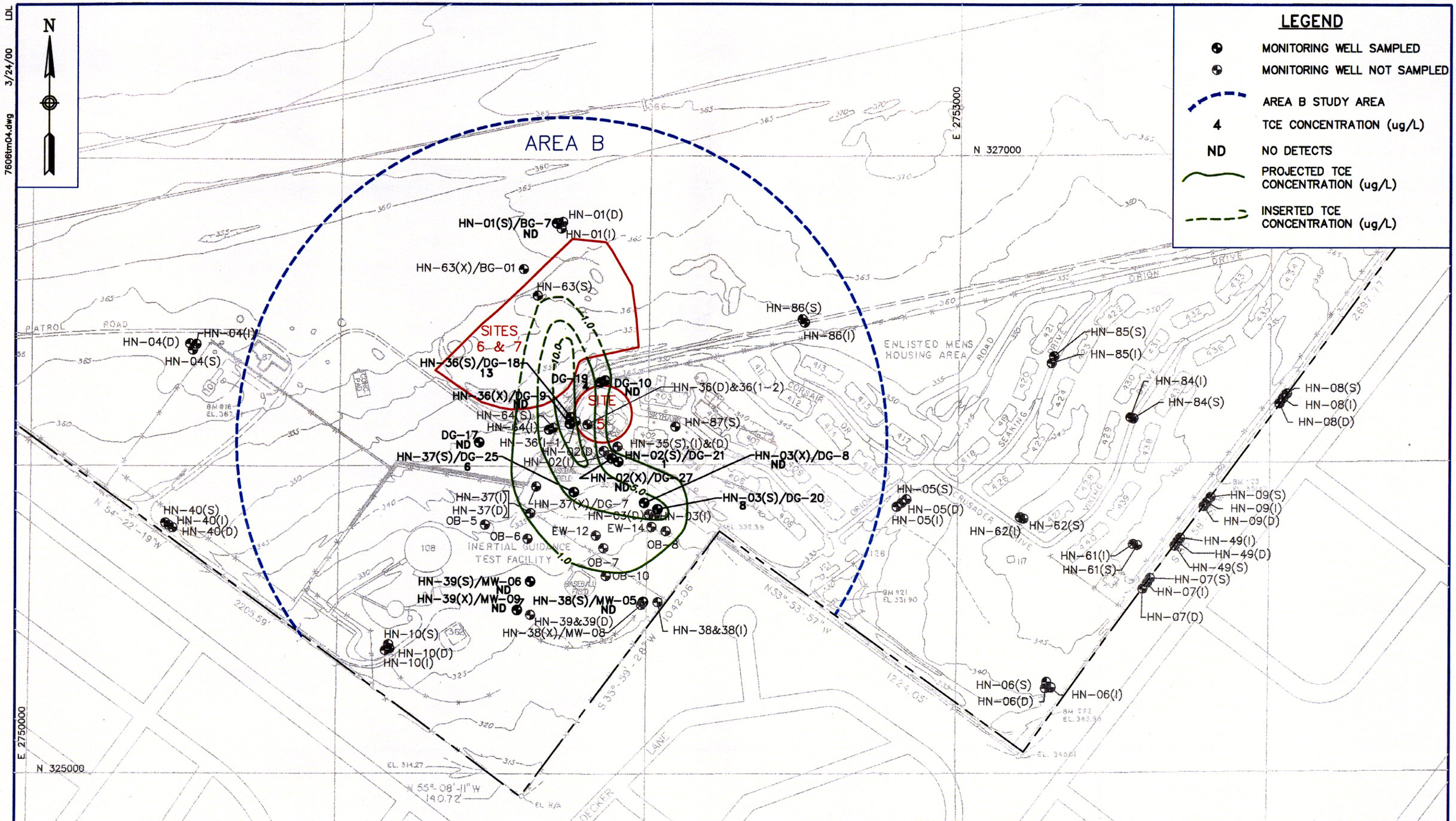
These risks were estimated based on total metals (unfiltered) analytical results. The Phase II RI report indicated that although filtered or dissolved metal concentrations were more likely to be representative of actual groundwater conditions, these results were not used for the base-line

assessment. The potential future residential risks based on dissolved metal concentrations were estimated as 1 $X10^{-5}$ for the lifetime cancer risk and 0.6 and 1.6 for the adult and child noncarcinogenic risks, respectively. Arsenic, barium, cadmium, and manganese were not identified as significant contributors to these risks. PCE and carbon tetrachloride were the main contributors to the carcinogenic risks. These compounds were identified during the Phase II sampling to be present in only one sample each (PCE - 3 ug/l in DG-20/HN-03S and carbon tetrachloride – 2 ug/l in DG-19). Thallium, which was identified in only one filtered sample (2 ug/l in DG-8/HN-03X) and in no unfiltered samples, was identified as the main contributor to the noncarcinogenic risks.

Based on the risk assessment and the presence of TCE at levels above the MCL in three wells, the Phase II RI concluded that shallow groundwater associated with Area B presented an unacceptable risk to human health and the environment. Based on available TCE data it was projected or hypothesized that a TCE contaminant plume may exist in Area B. Figure 4-3 depicts the TCE plume projected to exist in the shallow bedrock at the time of the Phase II RI. The projected TCE plume is consistent with inferred groundwater flow direction within Area B. These findings and conclusions lead to the issuance of the interim ROD for Area B groundwater.

4.2 HYDROGEOLOGIC INVESTIGATION

As required by the interim ROD for OU-1, the Navy conducted additional investigations in Area B during 1994 and into 1995. These investigations included the installation and sampling of additional monitoring wells. New and existing monitoring wells were sampled during an initial sampling effort in January 1994 and supplemented with additional sampling rounds conducted as new wells were installed from August 1994 through January 1995. These sampling efforts included some wells outside of Area B and not associated with the study area. The data from these wells are not presented or discussed in this RI report. The complete set of analytical results is presented in the Area B Hydrogeologic Report issued in April 1995 (HNUS, 1995). In addition to these monitoring events, samples were also collected and analyzed during a 1994 72-hour pumping test. The sampling and analysis events conducted under the hydrogeologic investigation are presented and discussed below according to the following sampling events; 1994 Sampling and Analysis; 1995 Sampling and Analysis; and 1994 72-Hour Pumping Test Sampling and Analysis.



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Tetra Tech NUS, Inc.

1993 PROJECTED TCE ISO CONCENTRATIONS IN AREA B SHALLOW GROUNDWATER

NAWC WARMINSTER, PA

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4.2.1 1994 Sampling and Analysis

The 1994 sampling and analysis event included collecting samples from 36 monitoring wells in and around Area B. All samples were analyzed for low-concentration volatile organic compounds (VOCs). Six of the samples were analyzed for TCL semi-volatile compounds, pesticides, and PCBs and 15 samples were collected for total and dissolved TAL inorganic analysis.

No semi-volatile or pesticide/PCB compounds were positively identified in any of the Area B wells above background and/or detection limits. Several VOCs were identified in the Area B wells. TCE was the only organic contaminant identified at levels above an MCL (TCE - 5 ug/l). TCE was identified at 12 ug/l in well HN-36S/DG-18 and at 7 ug/l in well HN-03S/DG-20. Eight other well samples contained low levels of TCE, see Figure 4-4. These TCE results are similar to those found during the Phase II RI and are consistent with the TCE plume projected to exist in 1993.

Other organic contaminants identified included cis-1,2-DCE, PCE, toluene, chloroform, and carbon tetrachloride. These were all identified at low to trace-levels below MCLs and did not present any significant pattern of contamination. Toluene was detected in 6 of the 36 wells sampled and was present in only intermediate and deep wells (HN-01D, HN-02I, HN-03D, HN-05I and D, and HN-10I). Concentrations ranged from 3 ug/l to 8 ug/l, well below the MCL of 1,000 ug/l. The upgradient background well (HN-01D) contained toluene at 4 ug/l.

Cis-1,2-DCE was identified in only 4 wells (HN-02I, HN-36S/DG-18, HN-03S/DG-20, and HN-37S/DG-25) at concentrations ranging from 1 ug/l to 6 ug/l (the MCL for DCE is 70 ug/l). These wells are all located in the central portion of Area B but no other wells in and around these wells contained Cis-1,2-DCE. PCE was identified at trace levels (1 ug/l to 2 ug/l) in 4 wells (HN-02I, HN-03I, HN-39D, and HN-03S/DG-20). These wells are scattered across the study area. The sporadic nature and low-level detection of this compound during this sampling event does not suggest a pattern of contamination associated with Area B. Carbon tetrachloride was identified in only 2 wells (HN-05D and DG-19) and chloroform in only a single well (DG-19). Concentrations were at trace-levels (1 ug/l and 2 ug/l) for these compounds.

Inorganic analysis of unfiltered (total metals) and filtered (dissolved metals) samples revealed the presence of metals in all samples but no significant pattern of contamination was noted. At least one metal in either the dissolved or total sample analysis from Area B wells exceeded background

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N

AREA B

SITES 6 & 7

SITE 5

HN-01(S)/BG-7
HN-01(D)
HN-01(I)
HN-63(X)/BG-01
HN-63(S)
HN-86(S)
HN-86(I)
HN-04(D)
HN-04(I)
HN-04(S)
HN-36(X)/DG-9
DG-10
HN-36(D)&36(1-2)
HN-64(S)
HN-64(I)
HN-36(I-1)
HN-87(S)
DG-17
HN-35(S),(I)&(D)
HN-37(X)/DG-7
HN-37(I)
HN-37(D)
HN-02(X)/DG-27
HN-03(X)/DG-8
OB-5
OB-6
EW-12
EW-14
OB-8
OB-7
OB-10
HN-39(S)/MW-06
HN-39(X)/MW-09
HN-38(S)/MW-05
HN-39&39(D)
HN-38(X)/MW-08
HN-38&38(I)
HN-40(S)
HN-40(I)
HN-10(S)
HN-10(D)
HN-10(I)
HN-05(S)
HN-05(D)
HN-05(I)
HN-62(I)
HN-62(S)
HN-61(I)
HN-61(S)
HN-85(S)
HN-85(I)
HN-84(I)
HN-84(S)
HN-08(S)
HN-08(I)
HN-08(D)
HN-09(S)
HN-09(I)
HN-09(D)
HN-49(I)
HN-49(D)
HN-49(S)
HN-07(S)
HN-07(I)
HN-07(D)
HN-06(S)
HN-06(D)
HN-06(I)

DG-19	
TCE	4 ug/L

HN-36(S)/DG-18	
TCE	12 ug/L

HN-02(D)	
TCE	2 ug/L

HN-02(I)	
TCE	3 ug/L

HN-37(S)/DG-25	
TCE	4 ug/L

HN-02(S)/DG-21	
TCE	3 ug/L

HN-03(S)/DG-20	
TCE	7 ug/L

HN-40(D)	
TCE	1 ug/L

HN-03(I)	
TCE	3 ug/L

HN-03(D)	
TCE	2 ug/L

PATROL ROAD
ENLISTED MENS HOUSING AREA
ORION DRIVE
CORSAIR DR
SEAKING
VIKING
CRUSADER DRIVE
BASEBALL FIELD
INERTIAL GUIDANCE TEST FACILITY
DECKER LANE
N 54°-22'-19"W
2205.58'
S 35°-59'-28"W
1041.05'
N 53°-53'-57"
1224.05'
N 55°-08'-11"W
140.72'
2697.77'
E 2754000
N 327000
E 2750000
N 325000

LEGEND

- MONITORING WELL SAMPLED
- MONITORING WELL NOT SAMPLED
- AREA B STUDY AREA
- TCE BOLDED RESULTS EXCEED MCL

0 300 600
SCALE IN FEET

NOTE:
SAMPLED MONITORING WELLS WITHOUT TAG BOXES, HAVE NO TCE DETECTION.

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1994 TCE CONCENTRATIONS IN AREA B GROUNDWATER

NAWC WARMINSTER, PA

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concentrations. However, the exceedances were not consistent for individual wells, well clusters, or grouping of wells. The analytical results are presented in the Area B Hydrogeologic Report (HNUS, 1995). It was concluded in the hydrogeologic report that the metals identified were indicative or characteristic of the normal levels and variation in metals result expected in groundwater for the area. The average manganese concentration reported for site samples, 223 ug/l total and 146 ug/l dissolved, was less than the average Area B background concentration, 322 ug/l total and 160 ug/l dissolved.

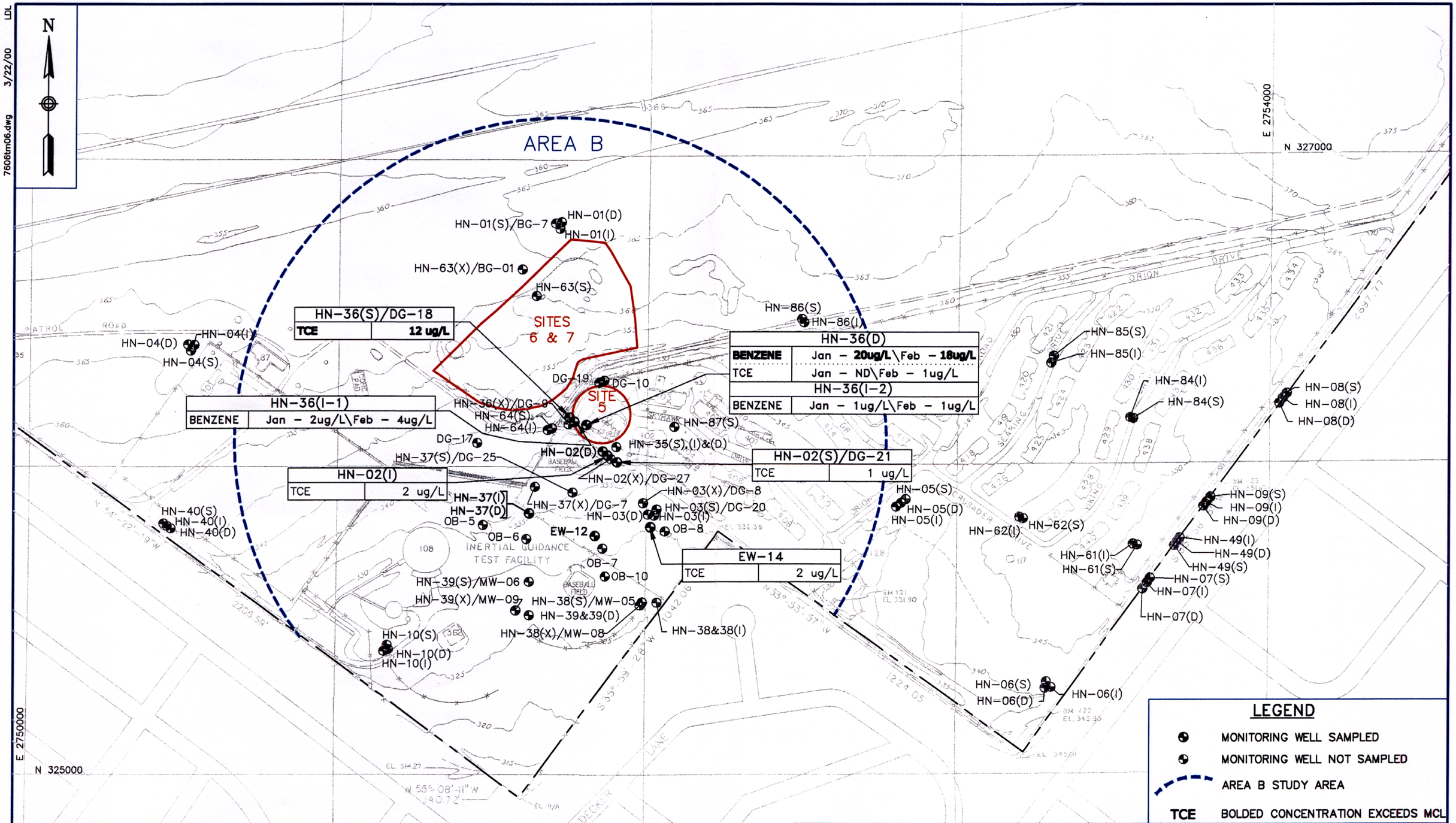
4.2.2 1995 Sampling and Analysis

Two sampling events were conducted in January and February 1995 for monitoring wells in cluster HN-36 (both events), cluster HN-37 (January only), and for monitoring wells HN-02I, HN-02D, HN36S/DG-18, and HN-02S/DG-21 and extraction wells EW-12 and EW-14 (for February only). These groundwater samples were analyzed for TCL volatile organics (low concentration) and arsenic. The analytical results were not subjected to data validation. Common laboratory contaminants methylene chloride and acetone were identified in most samples and in quality control, laboratory, and field blanks. Positive detections of these compounds in monitoring well samples are assumed to be artifacts and are not presented or discussed in this RI report.

TCE and benzene concentrations were identified at levels above their respective MCLs (5 ug/l for each). This was the first time benzene was positively detected in Area B groundwater. It was present in only well cluster HN-36 but was positively identified in both the January and February sampling events. Concentrations exceeded the MCL only in the deep bedrock well, see Figure 4-5. Only trace levels were identified in the intermediate depth (80 to 115 feet) wells. Benzene was not detected in the shallow well in this cluster or in any other Area B well.

TCE exceeded the MCL in only well HN-36S/DG-18, see Figure 4-5. TCE was detected in 4 other Area B wells at low to trace-levels similar to previous sampling results. TCE was reported at an estimated concentration of 1 ug/l in HN-36D during the February sampling event but was not detected in this well in the January sample.

Other organic compounds identified included toluene, 1,2-DCE (total), and carbon disulfide. Toluene was present in only well (HN-36D) in one sampling event and was reported as present at the detection limit (1 ug/l). Similarly, 1,2-DCE (total) was reported at an estimated concentration in well



NOTE:
SAMPLED MONITORING WELLS WITHOUT TAG BOXES, HAVE NO TCE DETECTION.

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Tetra Tech NUS, Inc.

1995 TCE AND BENZENE CONCENTRATIONS IN AREA B GROUNDWATER

NAWC WARMINSTER, PA

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HN-02I (1 ug/l) and HN-36S/DG-18 (5 ug/l). Carbon disulfide was detected in the February sampling of HN-36I1 and HN-36S/DG-18 at 1 ug/l and 46 ug/l respectively. This compound was also reported present in the trip blank for this sampling event.

Arsenic, an analytical parameter in the February 1995 sampling, was not detected in any of the monitoring wells. Analysis for this metal was not performed in the January 1995 sampling event.

4.2.3 1994 72-Hour Pumping Test Sampling and Analysis

A 72-hour pumping test was conducted in Area B in August 1994 (HNUS 1995). Monitoring well HN02I was used as the pumping well. This well is located near the center of the TCE plume projected to exist in 1993. Samples were collected from a sampling port in the pump discharge piping at approximately 10, 100, 1,000, and 4,300 minutes into the test. Samples were analyzed for TCL VOCs.

TCE and PCE were the only compounds detected in the samples. Concentrations of both of these compounds were below their respective MCLs (5 ug/l for each) in all samples. TCE was detected at 4 ug/l in the 10 and 100 minute samples and at 3 ug/l in the 1,000 and 4,300 minute samples. PCE was detected at 1 ug/l, 1 ug/l, 2 ug/l, and 1 ug/l in the 10, 100, 1,000, and 4,300 minute samples respectively.

4.3 OHM EXTRACTION WELL SAMPLING RESULTS

As presented in Sections 2 and 3 of this report, the Navy installed two extraction wells (EW-12 and EW-14) in the downgradient portion of the projected TCE plume identified in the Phase II RI. Extraction wells EW-12 and EW-14 were sampled in January 1995 while pumping tests of varying duration were performed to measure aquifer characteristics. Analysis was limited to low concentration TCL VOCs and was not subjected to data validation. No contamination above the MCL was identified in either extraction well after several hours of pump operation. Methylene chloride was reported in samples as well as in the blank. This is a common laboratory contaminant and such the sample results for this compound are not presented or discussed in this report. All sample results are presented in the OHM Remedial Services yield test reports (OHM 1995, 1995a, and 1995b).

Samples were collected during initial yield tests performed for each extraction well and during a 72-hour yield test performed on EW-12. Field analysis , using a headspace technique, was performed

on samples collected throughout the tests. This field analysis did not detect the presence of any VOC contamination. One laboratory sample was collected during each of the initial 12-hour yield tests and 4 samples were collected for laboratory analysis during the 72-hour test performed on EW-12.

The sample collected and analyzed during the 12-hour yield test for EW-12 was collected about 7 hours into the 12 hour test. The only compound detected in the sample was dibromomethane (1.4 ug/l). This compound had not been previous identified in Area B groundwater and no MCL has been established for this compound. The reported detection is at the analytical method detection limit.

The sample collected and analyzed during the 12-hour yield test for EW-14 was collected about 10.5 hours into the 12 hour test. Two compounds were detected in the sample. TCE was detected close to the detection limit at 1.5 ug/l, well below the MCL of 5 ug/l. Trichlorofluoromethane was also detected at 3.1 ug/l. No MCL has been established for this compound and it was not detected in previous analysis of Area B groundwater.

Four samples were collected from EW-12 during a 72-hour yield test performed in 1995. The only compound detected during this test was 1,2-dichloropropane. The MCL for this compound is 5 ug/l. Two samples were collected 24 hours into the test, one from a sampling port (tap) on the pump piping and one using a bailer. The tap sample did not contain any VOCs while the bailer sample contained 1,2-dichloropropaneat 2 ug/l. Additional samples were collected from the sampling port at 48 and 72 hours into the test. These samples contained 1,2-dichloropropane at estimated concentrations below the detection limit of 0.9 ug/l and 0.7 ug/l, respectively. 1,2-dichloropropane had not been previously detected in Area B groundwater.

After completion of the extraction well yield tests, the Navy, EPA, PADEP evaluated current and historical groundwater data from Area B and specifically reviewed the data available for the projected TCE plume area. Contaminant trends over time were evaluated and it was concluded that TCE concentrations in HN36S/DG-18 appeared to be stable while TCE levels were either not detected or were present at levels consistently below the MCL in downgradient monitoring wells (HNUS 1995a). Considering this contaminant trend along with the results from the extraction well results, a consensus decision was reached to discontinue the plan to actively pump groundwater from Area B. It was also agreed that this decision was consistent with the objectives stated in the interim ROD which was to minimize migration of contaminants within Area B groundwater. Contaminant trend data is further discussed in Section 4.6 of this report.

4.4 ADDITIONAL GROUNDWATER INVESTIGATIONS

Two additional groundwater sampling events have been performed in and around Area B. One sampling effort was a focused sampling effort that concentrated on obtaining water quality data specific to the Navy enlisted housing area to the east of Area B. The second study included a comprehensive round of water levels and sampling of all available monitoring wells in the general area. This sampling effort included all Area B monitoring wells.

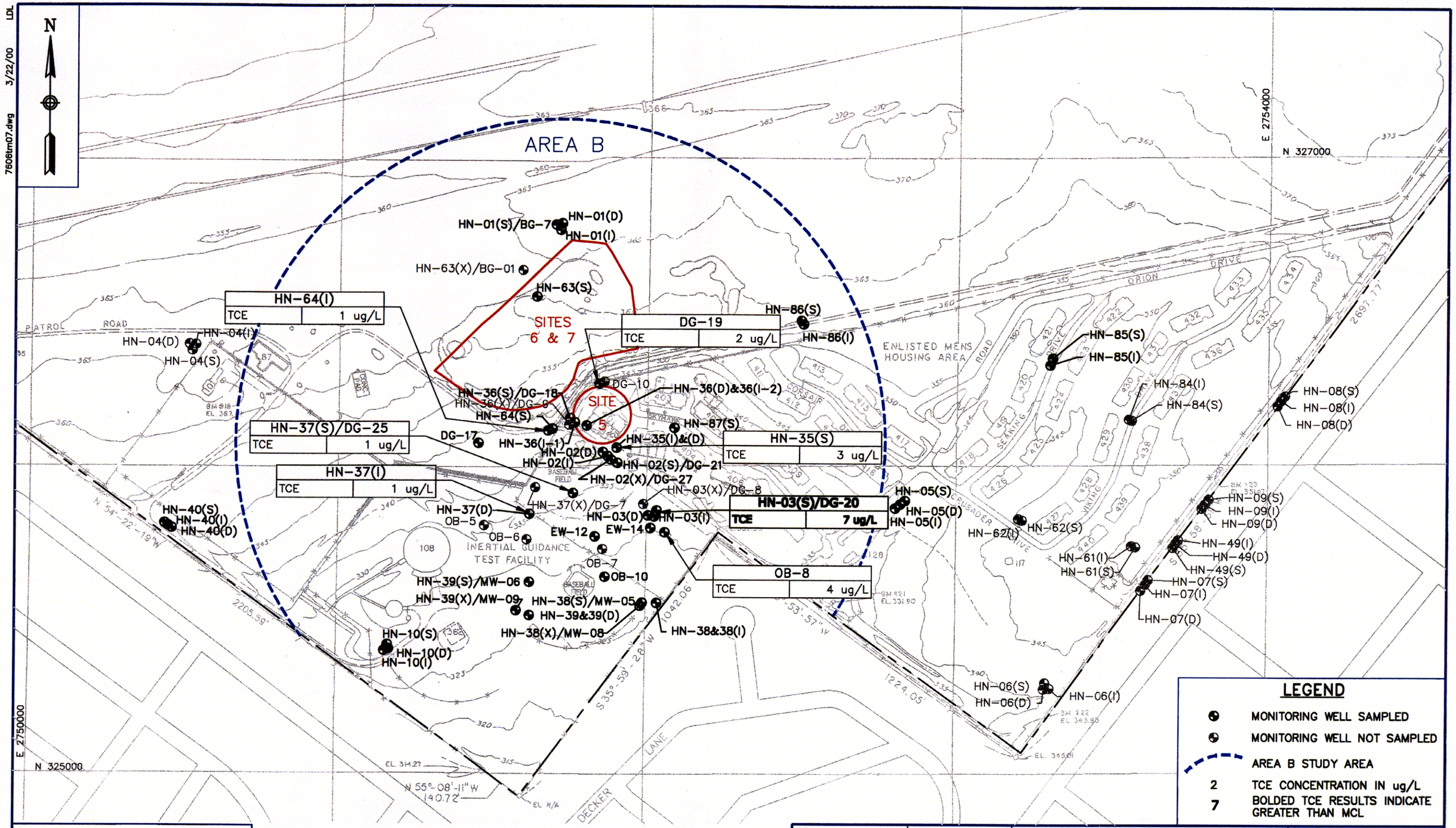
4.4.1 Navy Enlisted Housing Area Sampling and Analysis

Seven newly installed monitoring wells in the Navy enlisted housing area were sampled in 1998. The samples were analyzed for low detection TCL VOCs but the results were not subjected to data validation. The wells sampled included HN-87S, HN-86S and I, HN-85S and I, and HN-84S and I. Several of these wells are outside of Area B, see Figure 4-5 for well locations. The only compound detected during this sampling effort was carbon disulfide. There is no MCL established for carbon disulfide but EPA Region 3 has established a risk-based screening level of 1,000 ug/l for drinking water. Carbon disulfide was detected at low levels in four of the wells including two of the Area B wells (HN-87S 8 ug/l, HN-86S 2 ug/l, HN-85I 2 ug/l, and HN-84S 0.7 ug/l). As indicated above, these levels are well below the health-based screening criteria.

4.4.2 1998 Area B Groundwater Monitoring Sampling and Analysis

During June and July 1998 samples were collected from all available monitoring wells within and around Area B. The sampling effort and analytical results, which includes monitoring wells beyond Area B, are presented in the Summary Report for Area B Monitoring (TtNUS, 1998). The analytical results for monitoring wells within and around Area B are discussed and presented in this report. A total of 53 bedrock monitoring, extraction, and observation wells were sampled. All samples were analyzed for TCL low concentration VOCs, 10 were analyzed for TAL total metals, one was analyzed for TAL dissolved metals, and two were analyzed for TCL semi-volatiles, pesticides and PCBs. The analytical results were subjected to a full data validation.

VOC analysis identified the presence of six compounds in Area B groundwater. TCE was the only contaminant detected above MCLs. Well HN-03S contained TCE at 7 ug/l. No other well contained TCE at concentrations greater than the MCL. TCE was detected at low-levels in six other wells within Area B; DG-19 at 2 ug/l, HN-37S/DG25 at 1 ug/l, HN-37I at 1 ug/l, OB-08 at 4 ug/l, HN-35S at 3 ug/l, and HN-64I at 1 ug/l. Figure 4-6 shows the TCE concentrations detected during this sampling



NOTE:
SAMPLED MONITORING WELLS WITHOUT TAG BOXES, HAVE NO TCE DETECTION.

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JULY/1998 TCE CONCENTRATIONS IN AREA B GROUNDWATER

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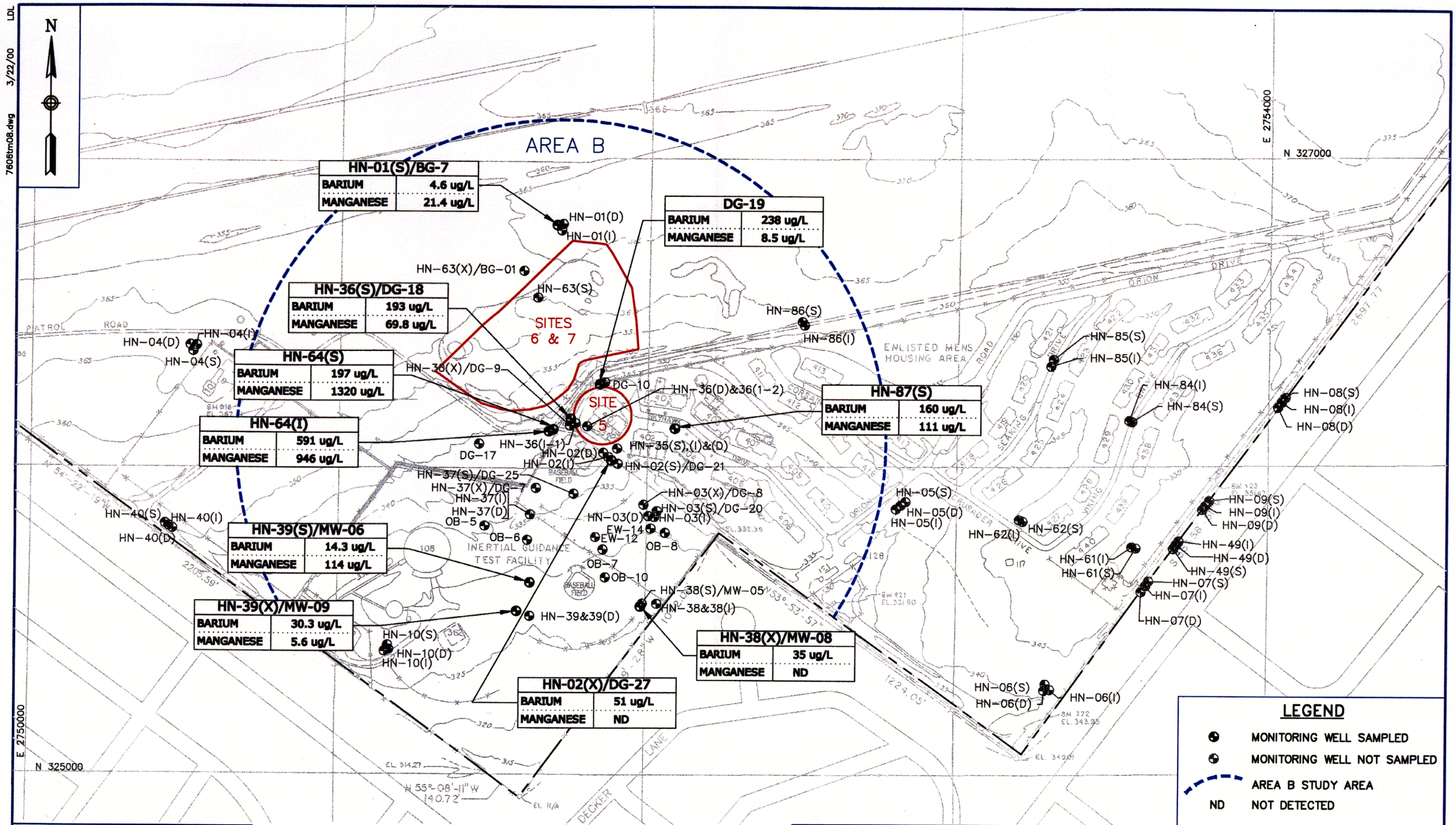
event. The distribution of TCE is similar to that identified in previous sampling events, including the Phase II RI; however, the levels of contamination are lower than identified in those investigations.

Other VOCs detected were Cis-1,2-DCE, benzene, carbon disulfide, chloroform, and PCE. Cis-1,2-DCE was detected at low to trace-levels, well below the MCL of 70 ug/l, in five monitoring wells; HN03S at 2 ug/l, HN-35S at 1 ug/l, HN-64S at 5 ug/l, HN-36S at 2 ug/l, and HN-64I at 3 ug/l. Carbon disulfide was found at similar levels in five different wells. Concentrations ranged from 2 ug/l to 3 ug/l (HN-05I – 2 ug/l, HN-05D – 2 ug/l, HN-35D – 3 ug/l, HN-36I – 2 ug/l, and HN-87S – 2 ug/l) which is well below the Region 3 screening criteria of 1,000 ug/l. PCE was detected at levels below the MCL in three wells (HN-03S - 2 ug/l, HN-35S – 3 ug/l, and OB-08 – 2 ug/l). Benzene and chloroform were each detected in a single well at estimated concentrations at or below the detection limit. Benzene was detected at 0.9 ug/l in well HN-36I and chloroform was detected at 1 ug/l in DG-19. This low-level benzene detection, along with the lack of benzene detections in previous well sampling events, indicates that the 1995 benzene levels were an isolated occurrence and may be an anomaly.

No semi-volatile or pesticide/PCB contamination was detected in any well within Area B.

Ten samples were analyzed for total metals and only one sample was analyzed for dissolved metals. Maximum site detections for samples from wells within Area B were compared to upgradient levels and Region 3 health-based bench marks (see Section 6 for details). This comparison indicated that barium and manganese levels in Area B groundwater may be elevated. Analytical results for barium and manganese are shown on Figure 4-7. As indicated above, these results are for total metals and may be effected the presence of suspended solids in the well samples. Similar levels were found in unfiltered samples during the previous investigations but filtered or dissolved metals concentrations were found to be significantly lower (see 4.1 and 4.2). Metals results for individual wells have not shown a strong consistency of results. HN-01S, the Area B upgardient well, has shown manganese levels ranging from 21.4 ug/l (July 1998) to 1,680 ug/l (1992). Dissolved manganese analysis during this same 1992 sampling event for HN01S detected only 8 ug/l. Metals concentrations in the wells appears to be related to suspended particles which can be related to sampling techniques.

Table 4-1 presents the occurrence and distribution statistics for compounds and elements identified in the 1998 Area B groundwater sampling round. The table provides a listing of all substances Figure 4-6 identified, the frequency and range of detection, the mean concentration, and the location of the maximum result. Because this data set is the most complete and recent set of analytical results for Area B groundwater, this data is used for assessing potential risks associated with Area B groundwater in Section 6 of this report.



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Tetra Tech NUS, Inc.

JULY 1998
BARIUM AND MANGANESE CONCENTRATIONS
AREA B GROUNDWATER
NAWC WARMINSTER, PA

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REMEDIAL INVESTIGATION REPORT FOR AREA B GROUNDWATER
OCCURANCE AND DISTRIBUTION OF ANALYTICAL RESULTS
1998 COMPREHENIVE SAMPLING ROUND

	SITE DATA			
Substance	Frequency of Detection	Range of Positive Detection	Mean of All Data	Location of Maximum
Aluminum	4/11	340 K - 502	159	W-HN-87S
Arsenic	1/11	2.4 - 2.4	1.2	W-DG-19
Barium	11/11	4.6 - 591	148	W-HN-64I
Beryllium	1/11	0.21 - 0.21	0.11	W-HN-39X
Cadmium	1/11	0.55 - 0.55	0.186	W-HN-87S
Calcium	11/11	3750 - 78200	33500	W-HN-64I
Chromium	10/11	1 - 6.7	2.11	W-HN-640-DUP
Cobalt	5/11	0.44 - 10.7	1.3	W-HN-640-DUP
Iron	7/11	23.5 L - 696	223	W-HN-87S
Lead	5/11	2.1 - 16.6	3.51	W-HN-87S
Magnesium	11/11	1460 - 24600	11500	W-HN-640-DUP
Manganese	8/11	5.6 - 1320	218	W-HN-640-DUP
Nickel	8/11	0.8 - 9.2	2.88	W-HN-640-DUP
Potassium	10/11	799 J - 2660	1310	W-HN-39X
Selenium	1/11	1.6 J - 1.6 J	1.05	W-HN-640-DUP
Sodium	11/11	6300 - 32300	13700	W-HN-39X
1,2-Dichloroethene (cis)	5/53	1 - 5	0.67	W-HN-640-DUP
Benzene	1/53	0.9 J - 0.9 J	0.508	W-HN-36I1
Carbon Disulfide	5/53	2 - 3	0.66	W-HN-35D
Chloroform	1/53	1 - 1	0.509	W-DG-19
Tetrachloroethene	3/53	2 - 3	0.604	W-HN-35S
Trichloroethene	7/53	1 - 7	0.858	W-HN-03S

Notes:

NA = Not Applicable.

Units are ug/L.

Number of samples may vary based on the number of usable results. Rejected or blank-qualified results were not considered valid samples. Duplicates are consolidated into one result.

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

Frequency of detection refers to number of times substance was detected among all samples versus total number of samples (minus number of unusable results).

4.5 PERIMETER MONITORING SAMPLING RESULTS

Twelve rounds of perimeter well sampling were conducted in Area B during the period from September 1994 through June 1999. Perimeter well clusters HN-10, HN-38 and HN-40 were sampled during most rounds and additional perimeter well cluster HN-39 was sampled during several rounds. Analytical results for the perimeter monitoring program are presented in the Summary Report for the Twelfth Round of Perimeter Monitoring (TtNUS, 1999). No VOC contamination above any MCL was detected in these wells during that 15 year period.

TCE was not detected in any of the twelve rounds of sampling at well cluster HN-10. It was detected on a sporadic intermittent bases in 5 samples from well cluster HN-38 at estimated concentrations ranging from 0.6 ug/l to 0.8 ug/l. TCE was detected at 1 ug/l in one sample collected in 1994 from well cluster HN-40. It has not been detected in this well cluster since that time. Well cluster HN-39 has been sampled five times during the twelve year perimeter monitoring program and TCE has not been detected in any of those sampling rounds.

Several wells at Area B interior locations HN-36, HN-37, HN-64, and DG-19 were sampled on one or more occasion. These wells have not been sampled on regular bases as part of the perimeter monitoring program. The analytical results from this periodic sampling are discussed in the following section addressing contaminant trends for specific Area B wells.

4.6 CONTAMINANT TRENDS OVER TIME

TCE is the major contaminant of interest for Area B groundwater. TCE is the only contaminant that consistently was found at concentrations above MCLs throughout the 17 years of groundwater investigations. MCL exceedances have largely been limited to low-level detections within the shallow groundwater (HN03S/DG-20, HN36S/DG-18, and HN37S/DG25). TCE contamination does not appear to have migrated at significant levels beyond these wells and the TCE concentration appears to be stable or decreasing over time. Table 4-2 presents historical TCE concentrations for the three wells that have repeatedly contained TCE concentrations in excess of the MCL. Data from these three wells was used in projecting the TCE plume in 1993.

TCE concentrations in HN36S, which historically contained the highest levels reported for Area B groundwater, have decreased over time. The levels in downgradient wells appear to be either

TABLE 4-2

REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER HISTORICAL TCE CONCENTRATIONS IN MONITORING WELLS HN03S/DG20, HN36S/GD-18, AND HN37S/DG-25

HNO3S/DG-20					
Date	1990	1992	1994	1998	1999
TCE ug/l	**6**	**8**	**7**	**7**	**8.4**

HN36S/DG-18						
Date	1990	1992	1994	1995	1998	1999
TCE ug/l.	**8**	**13**	**12**	**12**	ND	**6.2**

HN37S/DG-25					
Date	1990	1992	1994	1997	1998
TCE ug/l	ND	**6**	4	4	1

Bolded results exceed the MCL for TCE (5 ug/l).
ND - not detected in analysis.

remaining constant or also decreasing. Concentrations in HN03S, located downgradient and within the plume area projected in 1993, have remained slightly over the MCL. A decreasing trend in TCE concentrations is seen in monitoring well HN37S. This well, also located downgradient of HN36S, contained TCE at levels slightly above the MCL in 1992 (6 ug/l) and has shown a consistent decrease in levels since that time. TCE concentrations in these three wells, which have historically been used to define the plume area, appear to be approaching or are at levels below the MCL.

Other monitoring wells located within or downgradient of the projected plume area have not contained TCE levels above the MCL at anytime. Concentrations of TCE detected in these wells indicate that contamination noted in 1993 within Area B has not migrated and that a concentrated source of TCE within Area B groundwater is not likely to exist. Table 4-3 presents TCE concentrations over time for monitoring wells located within or downgradient of the historical area of concern.

Monitoring well HN02S, located between HN36S and HN03S and upgradient of HN37S, has shown only trace levels (estimated concentrations of 1 ug/l to 3 ug/l) of TCE between 1990 and 1998. The most recent sampling did not detect TCE in this well. TCE concentrations in DG-19, projected to be within the TCE plume area in 1993, have remained at concentrations below the MCL and close to the detection limit (estimated concentration of 2 ug/l to 4 ug/l). Monitoring wells HN38S and HN39S, both located at the downgradient edge of the are of concern, have never contained TCE concentrations above the analytical quantitation limit of 1 ug/l.

Well cluster HN64 was installed immediately within and/or downgradient of the suspected TCE source area in 1996. The well location was selected based on the projected TCE plume identified in the 1993 interim ROD and based on the detection of low levels of VOCs in the soil and soil gas during the Phase III RI (RI report for OU-7, TtNUS 1999). It should be noted that in 1997, the Navy conducted a removal action of the suspected source area immediately upgradient of well cluster HN64. The removal action consisted of the excavation and offsite disposal of soils down to bedrock. TCE concentrations in the shallow well (HN64S) have consistently been below the MCL. The intermediate depth well at this location (HN64I) has consistently contained TCE levels at or below the analytical quantitation limit. Concentrations have ranged from 0.6 ug/l to 1.6 ug/l (TtNUS1999).

As indicated in earlier sections, TCE contamination has largely been limited to the shallow bedrock. Intermediate depth wells have not shown TCE contamination related to the levels

TABLE 4-3

REMEDIAL INVESTIGATION FOR AREA B GROUNDWATER HISTORICAL TCE CONCENTRATIONS IN MONITORING WELLS WITHIN AND DOWNGRADIENT OF AREA OF CONCERN

HN02S/DG-21					
Date	1990	1992	1994	1995	1998
TCE ug/l	1J	1	3	1J	ND

DG-19					
Date	1990	1992	1994	1998	1999
TCE ug/l	2J	4	4	2	3

HN38S/MW-05												
Date	9/92	2/94	12/94	4/95	7/95	9/95	1/96	3/97	9/97	6/98	12/98	6/99
TCE ug/l	ND	ND	ND	ND	0.7J	ND	ND	0.6J	0.8J	ND	0.7J	0.6J

HN39S/MW-06							
Date	6/92	9/92	2/94	12/94	4/95	7/95	6/98
TCE ug/l	ND	ND	ND	ND	ND	ND	ND

HN64S				
Date	1996	1997	1998	1999
TCE ug/l	2.8	5	ND	3.8

J – Indicates estimated concentration at or below detection limit.
ND - not detected in analysis.

identified in the shallow bedrock zone. Intermediate depth bedrock wells in the same well clusters that contained TCE at levels that lead to the interim remedial action have not contained TCE at levels of concern. Monitoring wells HN36I1 and HN36I2 did not contain any TCE when they were sampled in 1995 and 1998. TCE was detected at an estimated concentration of 2 ug/l in HN02I in 1994 and 1995 but was not detected in 1998. Similarly, HN03I contained 3 ug/l of TCE in 1994 but none was detected during the 1998 sampling of this well. Downgradient well HN38I was sampled eleven times from 1994 to 1999. TCE was not detected in any of these sampling rounds (TtNUS 1999).

During the most recent comprehensive round of groundwater sampling conducted in Area B, TCE levels in excess of the MCL were identified in only one well, HN03S at 7 ug/l. As indicated above, TCE levels and the area of contamination appeared to be stable in 1993. Data collected since that time indicates that the concentration and extent of TCE has decreased and TCE has not migrated from the original area of concern. In addition, the data indicates that the overall concentration of TCE in Area B groundwater is at low-levels at or below the MCL. The current data indicates that a TCE contaminant plume does not exist within Area B.

5.0 CONTAMINANT FATE AND TRANSPORT

The fate of chemicals in the environment is determined by observable physical, chemical, and biological factors. However, observing the transformation of chemical contamination in the environment is often difficult, if not impossible, due to the inaccessibility, heterogeneity, or sheer size of the reaction site. Chemical and biologically-mediated transformation processes in any environmental matrix are controlled by factors such as availability of dissolved oxygen, light intensity, temperature, media surface bonding effects, pH, and a host of other location-specific conditions. The role that physical properties, such as specific gravity, solubility, and vapor pressure, play in determining what processes take place for a particular chemical is often variable and can vary considerably from location to location (due to the heterogeneous conditions), even within the same contaminant regime.

This section of the report provides a summary of the physical and chemical transport properties for the chemicals detected in Area B groundwater at NAWC Warminster. No distinction of location or magnitude of chemicals will be made in this section. The information presented in the second subsection will discuss chemical persistence and transport phenomena for the general classes of compounds detected in the groundwater at Area B. Finally, the last section will address probable contaminant migration routes and qualitatively identify the likely routes of human exposure.

5.1 PHYSICAL AND CHEMICAL PROPERTIES

Various physical and chemical properties of the detected chemicals are presented and discussed in this section. These properties are used to estimate the environmental behavior of site chemicals. Typical values for specific gravity, vapor pressure, solubility, octanol/water partition coefficient (K_{ow}), organic carbon partition coefficient (K_{oc}), soil-water partitioning coefficient, and Henry's Law constant are presented from scientific literature sources. Calculated values for these properties are presented if scientific literature values are not available. A discussion of the environmental significance of each of these parameters follows.

A summary of the physical and chemical transport properties for positively detected organic chemicals is provided in Table 5-1. Partitioning coefficient ranges for detected metals are presented in Table 5-2. These data are used to evaluate chemical migration and assess exposures in the risk assessment.

TABLE 5-1

SUMMARY OF PHYSICAL AND CHEMICAL PROPERTIES FOR DETECTED ORGANIC CHEMICALS
AREA B GROUNDWATER
NAWC WARMINSTER, PENNSYLVANIA

Chemical	Molecular Weight (g/mol)	Specific Gravity	Solubility (mg/L)	Vapor Pressure (mmHg)	Henry's Law Constant (atm-L/mol)	Log K_{ow}	Log K_{oc}	Bioconcentration Factor (L/Kg)
Chloroform	50.49	0.92	$6.4x10^3$	$3.8x10^3$	$8.8x10^{-3}$	$9.10x10^{-1}$	$6.30x10^1$	$3.2x10^0$
Carbon disulfide	76.13	1.26	$2.9x10^3$	$3.0x10^2$	$1.9x10^{-2}$	$2.16x10^0$	$2.15x10^0$	$1.1x10^1$
cis-1,2-Dichloroethene	96.94	1.3	$8x10^2$	$2.0x10^2$	$4.1x10^{-3}$	NA	NA	$1.6x10^0$
Trichloroethene	131.39	1.5	$1.1x10^3$	$7.7x10^1$	$1.2x10^{-2}$	$2.53x10^0$	$2.11x10^0$	$10.6x10^0$
Tetrachloroethene	165.83	1.6	$1.5x10^2$	$1.9x10^1$	$2.7x10^{-2}$	$2.53x10^0$	$2.56x10^0$	$3.1x10^1$
Benzene	78.11	0.88	$1.8x10^3$	$9.5x10^1$	$5.6x10^{-3}$	$2.13x10^0$	$1.81x10^0$	$5.2x10^0$

K_{ow} - Octanol-Water Partitioning Coefficient
K_{oc} - Organic Carbon Partitioning Coefficient

TABLE 5-2

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR SELECTED INORGANIC CHEMICALS AREA B GROUNDWATER NAWC WARMINSTER, PENNSYLVANIA

Analyte	Molecular Weight (g/mole)	Soil/Water Distribution Coefficient (K_d) Range[1] (L/kg)	Bioconcentration Factor[2] (L/kg)
Aluminum	26.98	NR	NA
Arsenic (III)	74.92	1.0-8.3	44
Barium	137.34	NR	NA
Beryllium	9.01	NR	19
Cadmium	112.40	1.3-27	64
Chromium (III)	51.99	470-150,000	16
Chromium (VI)	51.99	1.2-1,800	16
Copper	63.54	1.4-333	36
Lead	207.19	4.5-7,640	NA
Manganese	54.94	0.2-10,000	NA
Nickel	58.71	NR	47

NA Not available.
NR Not reported.
K_d Distribution Coefficient
g gram
kg kilogram
(1) Dragun, 1988.
(2) U.S. EPA, 1991. Draft Guidance on BCFs, Assessment and Control of Bioconcentratable Contaminants in Surface Water, Office of Water.

5.1.1 Specific Gravity

Specific gravity is the ratio of the weight of a given volume of pure liquid chemical, at a specified temperature, to the weight of the same volume of water at the same temperature. Specific gravity is used to determine whether a chemical will have a tendency to float or sink in water if it is present as a pure compound or at very high concentrations. Chemicals with a specific gravity less than 1 tend to float, whereas chemicals with a specific gravity greater than 1 tend to sink. At NAWC Warminster Area B, benzene and chloroform have specific gravities less than 1.

5.1.2 Vapor Pressure

Vapor pressure provides an indication of the rate at which a chemical volatilizes from both soil and water. It is of primary significance at environmental interfaces, such as surface soil/air and surface water/air. Volatilization is not as important when evaluating contaminated groundwater. Chemicals with high vapor pressures (e.g., volatile organic compounds) are expected to enter the atmosphere more readily than chemicals with low vapor pressures.

5.1.3 Solubility

The rate at which a chemical is leached from a waste deposit by infiltrating precipitation is directly proportional to its solubility in water. Several of the volatile organic compounds detected at Area B have relatively high water solubility's (e.g., chloroform, and benzene).

Organic chemicals detected in groundwater at concentrations that exceed one percent of their solubility are considered to have the potential to be present as a non-aqueous phase liquid (NAPL). None of the organic chemical positive detections in Area B groundwater were at concentrations of 1 percent or higher of their respective solubility limits.

The solubility of inorganic chemicals is strongly influenced by their electronic valence (ionic state) and the form they take in combination with other chemicals (e.g., hydroxides, oxides, carbonates, etc.). The solubility is also strongly dependent on pH, Eh, and the presence of other ionic species in solution (the Debye-Hückel theory). Solubility products reported in the literature vary with the type of complex formed.

5.1.4 Octanol-Water Partitioning Coefficient (K_{ow})

The octanol/water coefficient is a measure of the equilibrium partitioning of chemicals between the pure organic chemical octanol, and pure water. A linear relationship between the K_{ow} and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor) has been determined (Lyman et al., 1990). The K_{ow} is useful in characterizing the sorption of compounds by organic soils where experimental values are not available. Relatively simple organic chemical molecules have low K_{ow} values.

5.1.5 Organic Carbon Partitioning Coefficient (K_{oc})

The soil/sediment partition (organic carbon partition) coefficient indicates the tendency of a chemical to bind to soil particles containing organic carbon. Chemicals with high K_{oc}s generally have low water solubilities and vice versa. This parameter may be used to infer the relative rates at which more mobile chemicals are transported in groundwater. Complex organic chemicals are often relatively immobile and are preferentially bound to the soil phase. Complex organic chemical compounds are generally not subject to rapid groundwater transport. However, immobile chemicals adhered to soil are easily transported by erosional processes when they are present in surface soils.

5.1.6 Distribution Coefficient (K_d)

The soil-water partitioning (distribution) coefficient is a measure of the equilibrium distribution of a chemical or ion in soil/water systems. The distribution of organic chemicals is a function of both the K_{oc} and the amount of organic carbon in the soil.

5.1.7 Henry's Law Constant (H)

Both vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and groundwater. The ratio of these two parameters (the Henry's Law constant) is used to calculate the equilibrium contaminant concentrations in the vapor versus the liquid phases for dilute solutions. In general, chemicals with a Henry's Law constant less than 5e-6 atm-m^3/mole should volatilize very little and be present only in minute amounts in the atmosphere or in soil gas. Henry's Law constants are used to calculate the equilibrium soil gas vapor concentration for volatile organic compounds.

5.1.8 Bioconcentration Factor (BCF)

The Bioconcentration Factor (BCF) provides a measure of the accumulation tendency for chemicals in biological and ecological systems. BCFs represent the ratio of aquatic animal tissue concentration to the water concentration of a chemical. The ratio is both contaminant- and species-specific. When site-specific values are not measured, literature values are used or the BCF is derived from the octanol/water partition coefficient. All of the chemicals detected during the RI are bioaccumulative to some extent.

5.1.9 Summary

Tables 5-1 and 5-2 present a summary of the fate and transport data that are used in discussions of the contaminant fate and transport, and in the baseline risk assessment sections.

5.2 CONTAMINANT PERSISTENCE

The persistence of the classes of organic contaminants is discussed in this section. The text addresses general classes of the detected chemicals because the fate of chemicals in the environment is usually similar for chemicals within a particular chemical family.

5.2.1 Chlorinated Aliphatics

Research shows that aerobic bacteria predominantly degrade organic compounds containing zero, one, or two halogens, whereas anaerobic bacteria predominate when more halogens are present. As a result, highly chlorinated aliphatic hydrocarbons, such as tetrachloroethene, are subject to reductive dehalogenation via the action of anaerobic bacteria. It does not appear that appreciable degradation of highly halogenated aliphatics occurs in aerobic aquatic systems or unsaturated soils (Lyman et al., 1990).

The transformation pathways for chlorinated aliphatic hydrocarbons in soil systems have been documented by Dragun et al. (1988). Tetrachloroethene and trichloroethene are transformed via reductive dechlorination to 1,1-dichloroethene and 1,2-dichloroethene isomers. The terminal product of the transformation series is vinyl chloride, the chlorinated ethene with highest toxicity.

5.2.3 Monocyclic Aromatic Hydrocarbons

Monocyclic aromatic compounds, such as benzene, toluene, ethylbenzene, and xylenes, are not considered to be persistent environmental contaminants in comparison to PAHs, phthalate esters, and metals. Monocyclic aromatics are subject to degradation in both soil and water via the action of microorganisms. The biodegradation of these compounds in the soil matrix is dependent on the abundance of microflora, macronutrient availability, soil reaction (pH), temperature, oxygen, etc.

Although these compounds are amenable to microbial degradation, the rate of degradation cannot be predicted without information of the availability of nutrients and the type of bacteria present. If these contaminants discharge to a surface water body, volatilization and biodegradation may occur relatively rapidly. For example, a reported first-order biodegradation rate constant for benzene is 0.11 day^{-1} in aquatic systems (Lyman et al., 1990). This corresponds to an aquatic half-life of approximately 6 days. Other monocyclic aromatics are subject to similar degradation processes in aquatic environments (EPA, December 1982).

Additional degradation processes, such as hydrolysis and photolysis, are considered to be insignificant fate mechanisms for monocyclic aromatics (EPA, December 1982). However, some monocyclic aromatic compounds, such as benzene and toluene, have been shown to undergo clay-, mineral-, and soil-catalyzed oxidation (Dragun, 1988).

5.2.4 Metals

The transport and fate of metals in the environment are primarily controlled by sorption to soil/sediment material. The metal-organic relationships, both in soil and water, increase in importance as the organic carbon content increases. Some metals, such as arsenic, are extremely soluble and mobile in the environment. Many other metals, such as nickel, selenium, zinc, and copper, have an affinity for hydrous iron and manganese oxides, as well as for organic materials, and are therefore preferentially adsorbed to soil. The mobility of most metals increases as the soil pH decreases.

5.3 CONTAMINANT MIGRATION ROUTES

Based on the positively detected chemicals and associated analytical results for Area B, general statements can be made with respect to contaminant fate and transport and the possible exposure endpoints.

Groundwater chemical contaminants can migrate from the original source of the release. The most common transport mechanism is water infiltration through a contaminated zone, where partitioning from solid to aqueous phase can occur. The potential amount of chemical dissolving into infiltrating water is determined by a number of factors, including residence time, solubility, partitioning factor, and pH of the water. The dissolved chemicals continue downward migration and are able to interact with stationary (soil) particles in the saturated and/or unsaturated zones.

After percolation through the capillary zone, dissolved contaminants are then able to enter groundwater, where transport can occur in bulk (advection). The chemical concentrations in groundwater increase significantly shortly after initial groundwater impact to a maximum level. The longer-term effects at the source are a gradual decrease in the concentrations over time as chemical removal from the source area occurs. Short-term variations in release rate and impact to groundwater can occur, but long-term trends of decreased levels are usually observed. Chemical diffusion and dispersion throughout the groundwater flow regime occurs as the groundwater flows.

As materials are transported by the groundwater, a number of processes can reduce the concentration of the chemicals. Diffusion and attenuation effects are nontransformational mechanisms that result in a direct decrease in chemical concentration. Chemical and biological reactions with dissolved chemicals can also result in decreases in chemical concentration. Products of chemical transformation may have significantly different chemical, transport, and toxicological properties from the parent compounds.

Groundwater chemical contamination can vary over periods of time as climatic and meteorological conditions change. Also, as materials from the release (source) area are depleted, lower concentrations of contaminant are released into the groundwater. Eventually, the source area impacts to groundwater cease, and residual chemicals are subjected to dilution and to degradation via natural mechanisms.

Potential exposure endpoints for Area B groundwater include downgradient residential, municipal, and commercial water supply wells.

6.0 HUMAN HEALTH RISK ASSESSMENT

This section provides a description of the risk assessment methods employed for Warminster Area B, as well as a summary of the risk assessment results. The general objectives of the risk assessment were to estimate the actual or potential risks to human health resulting from the presence of contamination in groundwater.

6.1 INTRODUCTION

The specific objectives of the risk assessment were as follows:

- To estimate the actual or potential risks to human health resulting from the presence of contamination in groundwater.
- To provide a basis for attainment of concentrations that are protective of potential human receptors under residential exposure scenarios.
- To determine the need for remedial measures (if applicable) for these media.

Three major aspects of chemical contamination must be considered when assessing public health risks: (1) contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; (2) 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 (3) 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.

In order to estimate the potential for human health risk attributable to groundwater, 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 were combined. The risk assessment processes were performed in accordance with current EPA risk assessment guidance.

The baseline risk assessment (BLRA) for Warminster Area B groundwater consists of five sections: Data Evaluation, Exposure Assessment, Toxicity Assessment, Risk Characterization, and Uncertainty Analysis. Each section is briefly discussed below.

Data Evaluation (Section 6.1) is primarily concerned with data quality assessment, identification of chemicals of potential concern (COPCs), distributional analysis of the data, and calculation of exposure

point concentrations. The media/area-specific data are analyzed and COPCs are selected that are representative of the type expected for potential human health exposure. Distributional analysis of the data is the basis for calculating an exposure point concentration, which provides the chemical input into each of the exposure pathways.

Exposure Assessment (Section 6.2) 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.

Toxicity Assessment (Section 6.3) presents available reference doses, cancer slope factors, EPA weight of evidence and adjustment of the dose-response parameters. Quantitative toxicity indices, where available, are presented in this section, including any applicable regulatory standards and criteria.

Risk Characterization (Section 6.4) 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.

Uncertainty Analysis (Section 6.5) is a discussion of the general and site-specific uncertainties associated with the BLRA.

6.2 DATA EVALUATION

This section presents the approaches for data quality assessment, identification of contaminants of potential concern (COPCs), background comparison tests, distributional analysis of the data, and exposure point concentrations. Groundwater is the only environmental medium considered in this risk assessment for Warminster Area B.

6.2.1 Data Quality Assessment

Data quality is assessed using a data usability spreadsheet (Appendix E, Part 1) that summarizes important data quality issues and potential impacts on the quantitative BLRA. Data usability issues are summarized below and consist of impacts from rejected data, blank-affected results that were treated as non-detects, and the comparison of detection limits to risk-based screening values:

- Rejected results occurred for acetone, 2-butanone, and 2-hexanone. Omission of these data points are not expected to impact the risk assessment because previous rounds of groundwater sampling in Area B have not revealed these substances to be present at levels significant from a risk-based screening perspective.

- The treatment of blank-affected results as non-detects is also not expected to impact the risk assessment. This is because the maximum positive sample result was much greater than the maximum blank-affected result for substances that were confidently detected and, in other cases, the maximum blank-affected result was normally of a magnitude less than risk-based screening levels. For arsenic, this was not strictly true, but this substance was only confidently detected in one sample and blank-qualified in one other sample, and it was eliminated as a COPC because it was not present at concentrations above background.

- The comparison of detection limits to risk-based screening levels did not reveal problems with data usability. In general, detection limits were below Region 3 EPA risk based screening concentrations (RBCs – EPA, 1999a) except in a handful of cases where the analytical methodology has method quantitation limits above the RBC and no or very few positives occurred for the substance of concern. In particular, arsenic has a detection limit of 2.1 ug/L, which is above the RBC of 0.045 ug/L. Also, certain carcinogenic semivolatile compounds, such as benzo(a)pyrene, have detection limits of 10 ug/L, which is above the RBC. However, only three semivolatile samples were collected for the comprehensive sampling round used in the data set and historical sampling of Area B groundwater has shown that semivolatiles are generally not prevalent in groundwater.

6.2.2 Special Note Concerning Filtered Groundwater Samples

Most monitoring well samples were collected using low-flow pumps to minimize the occurrence of suspended solids associated with conventional purging and sampling techniques (see section 2.3). A filtered sample was collected from monitoring well W-HN-38X, according to the decision criteria and procedures described in the work plan. Metals data for the filtered and unfiltered aliquots were compared using EPA technical guidance to pick the most representative data to use for risk assessment. Elevated aluminum, iron, and manganese levels in the unfiltered sample relative to the filtered sample were considered evidence that filtered results are more representative of dissolved groundwater conditions and were the basis for the decision to select the filtered metals data from well W-HN-38X for use in the risk assessment. For other wells, only unfiltered results were available for use in the risk assessment.

6.2.3 Identification of COPCs

The selection of contaminants of potential concern (COPCs) was based on chemical-specific concentrations, comparison to background for metals, occurrence, distribution, and toxicity. COPC selection was based on comparing the maximum detected concentration for each substance to the applicable risk based screening criterion, consisting of the EPA Region 3 residential tap water RBC screening criteria set at cancer risk levels of 1×10^{-6} and Hazard Quotients of 0.1. Substances that are degradation products of COPCs were also retained and metals were eliminated from consideration if concentrations were not above background, based on statistical tests. Data presentation tables showing the occurrence and distribution of inorganic and/or organic constituents detected in groundwater were presented in Section 4. Results of selection of COPCs for Warminster Area B groundwater are presented in Table 6-1 (RAGS D Table 2).

6.2.3.1 Background Comparison Tests

To determine if results of samples for metals were elevated relative to background sample results, an array of statistical tests were performed in accordance with current Navy and EPA guidance (U.S. Navy, 1999, 1998; U.S. EPA, 1989b, 1992b, 1996c). 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 presented in Table 6-2. 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:

TABLE 6-1 (RAGS D TABLE 2)
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
WARMINSTER AREA B GROUNDWATER

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water

CAS Number	Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Contaminant Deletion or Selection (4)
7429-90-5	Aluminum	340	K	502		ug/L	W-HN-87S	4/11	13-209	502	588000 N	3700 N	-	MCL	N	BKG
7440-38-2	Arsenic	2.4		2.4		ug/L	W-DG-19	1/11	2.1-2.6	2.4	N/A N	0.045 C	50	MCL	N	BKG
7440-39-3	Barium	4.6		591		ug/L	W-HN-64I	11/11	N/A	591	345 Y	260 N	2000	MCL	Y	ASL
7440-41-7	Beryllium	0.21		0.21		ug/L	W-HN-39X	1/11	0.2-0.2	0.21	N/A N	7.3 N	4	MCL	N	BKG
7440-43-9	Cadmium	0.55		0.55		ug/L	W-HN-87S	1/11	0.3-0.3	0.55	N/A N	1.8 N	5	MCL	N	BKG
7440-70-2	Calcium	3750		78200		ug/L	W-HN-64I	11/11	N/A	78200	27300 Y		-	MCL	N	NUT
7440-47-3	Chromium	1		6.7		ug/L	W-HN-640-DUP	10/11	0.8-0.8	6.7	N/A NA	11 N	100	MCL	N	BKG
7440-48-4	Cobalt	0.44		10.7		ug/L	W-HN-640-DUP	5/11	0.4-0.4	10.7	N/A N	220 N	-	MCL	N	BKG
7439-89-6	Iron	23.5	L	696		ug/L	W-HN-87S	7/11	12.5-93.3	696	8880 N	1100 N	-	MCL	N	BKG
7439-92-1	Lead	2.1		16.6		ug/L	W-HN-87S	5/11	1.7-1.7	16.6	76.9 N	15 C	15	MCL	N	BKG
7439-95-4	Magnesium	1460		24600		ug/L	W-HN-640-DUP	11/11	N/A	24600	21000 Y		-	MCL	N	NUT
7439-96-5	Manganese	5.6		1320		ug/L	W-HN-640-DUP	8/11	1-2.9	1320	725 Y	73 N	-	MCL	Y	ASL
7440-02-0	Nickel	0.8		9.2		ug/L	W-HN-640-DUP	8/11	1.6-2.3	9.2	N/A NA	73 N	100	MCL	N	BKG
7440-09-7	Potassium	799	J	2660		ug/L	W-HN-39X	10/11	708-708	2660	3540 N		-	MCL	N	NUT
7782-49-2	Selenium	1.6	J	1.6	J	ug/L	W-HN-640-DUP	1/11	1.6-2.2	1.6	N/A N	18 N	50	MCL	N	BKG
7440-23-5	Sodium	6300		32300		ug/L	W-HN-39X	11/11	N/A	32300	18200 Y		-	MCL	N	NUT
156-59-4	1,2-Dichloroethene (cis	1		5		ug/L	W-HN-640-DUP	5/53	1-4	5	N/A NA	6.1 N	70	MCL	Y	DEG
71-43-2	Benzene	0.9	J	0.9	J	ug/L	W-HN-36I1	1/53	1-1	0.9	N/A NA	0.36 C	5	MCL	Y	ASL
75-15-0	Carbon Disulfide	2		3		ug/L	W-HN-35D	5/53	1-1	3	N/A NA	100 N	-	MCL	N	BSL
67-66-3	Chloroform	1		1		ug/L	W-DG-19	1/53	1-1	1	N/A NA	0.15 C	100	MCL	Y	ASL
127-18-4	Tetrachloroethene	2		3		ug/L	W-HN-35S	3/53	1-1	3	N/A NA	1.1 C	5	MCL	Y	ASL
79-01-6	Trichloroethene	1		7		ug/L	W-HN-03S	7/53	1-5	7	N/A NA	1.6 C	5	MCL	Y	ASL

(1) Minimum/maximum detected concentration.
(2) *N/A - Refer to supporting information for background discussion.*
Background values derived from statistical analysis. Follow Regional guidance and provide supporting information.
(3) Provide reference for screening toxicity value.
(4) Rationale Codes Selection Reason: Infrequent Detection but Associated Historically (HIST)
Frequent Detection (FD)
Toxicity Information Available (TX)
Above Screening Levels (ASL)
Deletion Reason: Infrequent Detection (IFD)
Background Levels (BKG)
No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)

Definitions: N/A = Not Applicable
SQL = Sample Quantitation Limit
COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered
MCL = Federal Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
J = Estimated Value
C = Carcinogenic
N = Non-Carcinogenic

Table 6-2
Background Comparison Tests for Metals - Groundwater Area B (Shallow, Intermediate, and Deep Monitoring Wells)
NAWC, Warminster, PA

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	3/4	4/11	0.9744	N	6.06	2.75	2.3534	L	588000	502	N	6	4	0.8571	N	0.9289	Gehan	Test	N	2400	159			NA	lognor.	nonpar.					NA
Arsenic	N	1/4	1/11	0.9429	N	2.6					2.4	NA				NA	0.9429	Gehan	Test	N	2.6	1.2			NA	nonpar.	nonpar.					NA
Barium	Y	4/4	11/11		NA	138	78.8	2.3534	N	345	591	Y	2	2	0.5238	N	0.6806			N	4.75	4.37	-0.5371	1.7709	N	lognor.	lognor.	0.75	1.34	1.1032	3.8852	Y
Beryllium	N	1/4	1/11		NA	0.75					0.21	NA				NA	0.9429	Gehan	Test	N	0.75	0.11			NA	nonpar.	nonpar.					NA
Cadmium	N	1/4	1/11		NA	2.08					0.55	NA				NA	0.9429	Gehan	Test	N	2.08	0.186			NA	nonpar.	nonpar.					NA
Calcium	Y	4/4	11/11		NA	16700	4030	2.3534	N	27300	78200	Y	7	7	0.0513	N	0.2330			N	16700	33500	2.0158	1.7959	Y	normal	normal	4030	26900	7.4303	3.8852	N
Chromium	NA	0/4	10/11		NA						6.7	NA				NA				NA		2.11			NA							NA
Cobalt	N	1/4	5/11		NA	2.55					10.7	NA	1	1	0.7333	N	0.7187	Gehan	Test	N	2.55	1.3			NA	nonpar.	nonpar.					NA
Iron	N	3/4	7/11		NA	2650	2370	2.3534	N	8880	696	N	9	6	0.9077	N	0.9685	Gehan	Test	N	2650	223			NA	normal	lognor.					NA
Lead	N	2/4	5/11	0.7692	N	0.405	1.5	2.3534	L	76.9	16.6	N	6	5	0.4615	N	0.3846	Gehan	Test	N	3.65	3.51			NA	lognor.	nonpar.					NA
Magnesium	Y	4/4	11/11		NA	8.86	0.414	2.3534	L	21000	24600	Y	6	6	0.0923	N	0.2755			N	7570	11500	0.9353	1.7709	N	normal	normal	3520	7940	1.9942	3.8852	Y
Manganese	Y	3/4	8/11		NA	203	199	2.3534	N	725	1320	Y	2	2	0.5238	N	0.7861	Gehan	Test	N	203	218			NA	normal	lognor.					NA
Nickel	NA	0/4	8/11		NA						9.2	NA				NA				NA		2.88			NA							NA
Potassium	N	4/4	10/11	1.0000	N	7.26	0.345	2.3534	L	3540	2660	N	5	4	0.5934	N	0.7495			N	7.26	7.05	-0.6998	1.7709	N	lognor.	lognor.	0.345	0.552	0.7594	3.8852	Y
Selenium	N	0/4	1/11	0.7333	N						1.6	NA				NA				NA		1.05			NA							NA
Sodium	Y	4/4	11/11		NA	9480	3300	2.3534	N	18200	32300	Y	4	4	0.2418	N	0.1810			N	9.1	9.41	1.0876	1.7709	N	lognor.	lognor.	0.388	0.503	0.2515	3.8852	Y

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

Table 6-2
Background Comparison Tests for Metals - Groundwater Area B (Shallow, Intermediate, and Deep Monitoring Wells)
NAWC, Warminster, PA

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	

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.

- 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.

- Nonparametric 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 nondetected 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, 1992b) 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; whereas, 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 be comprised of 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, 1992b, 1996c) 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 is comprised chiefly of 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 are comprised of 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 comprised of k samples from the area of interest.

- If none of the above quantitative statistical tests yielded a definite "yes" or "no" decision, a test of proportions is available 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, 1996c, 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.

- As recommended (EPA, 1996c, 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 combined routine and low detection limits mercury data comparisons due to different proportions of low detection limit data among the site and background populations.

6.2.3.2 Inorganic Substances Selected as COPCs

As shown in Table 6-1, the metals barium and manganese were the only inorganic substances detected at levels above RBCs and also above background concentrations. These metals were detected in the

majority or all groundwater samples and exhibited maximum detected concentrations and also Exposure Point Concentrations (EPCs) that exceeded their associated RBCs. The arithmetic mean also exceeded the RBC for manganese. Concentrations of barium and manganese in Area B groundwater were noted to be greater than background levels based on their maximum detected concentrations exceeding the 95 percent Upper Tolerance Limits (UTL) of the background data. UTLs and background comparison statistics for all metals are presented in Table 6-2.

6.2.3.3 Organic Substances Selected as COPCs

As shown in Table 6-1, benzene and chloroform were rarely detected (in only 1 out of 53 samples) and exhibited maximum detected concentrations, EPCs, and arithmetic mean concentrations that exceeded their respective RBCs. Tetrachloroethene (PCE) and trichloroethene (TCE) were detected at low frequencies (3 out of 53 and 7 out of 53 samples, respectively) and exhibited maximum detected concentrations and EPCs that exceeded their respective RBCs. Background comparisons were not utilized in the elimination of organic COPCs because organic analytes are not naturally occurring. 1,2-dichloroethene was selected as a COPC because it is a degradation product of both TCE and PCE, although it should be noted that the maximum detected concentration was slightly below the RBC.

6.2.4 Distributional Analysis of the Data

This section presents the approaches taken for distributional analysis of the Warminster Area B groundwater analytical data. Distributional analysis of the sampling data is important in determining the exposure point concentration (EPC) used to quantitatively estimate risks at the site. Statistical analyses discussed in this section adhere to the guidance referenced in several EPA and related publications (EPA, 1989a, 1989b, 1992b, 1992c, and 1996c). Before EPCs were estimated for each COPC, the underlying statistical distribution of data was determined for each COPC. The Shapiro-Wilk W test or the Shapiro-Francia Test (EPA, 1992a) were performed to determine if the data set of chemical concentrations matched the shape of a normal or lognormal distribution. [The latter test is required if there are greater than 50 samples (EPA, 1992a, 1996a).] Normally distributed data exhibit a characteristic "bell-shape" curve that is symmetrical, whereas lognormal data have a skewed shape with a longer tail at the high-concentration end. For each COPC, the W test was performed once using the original data and once after data were converted to their logarithms. A 5% level of significance was used to determine if the data deviated 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 confidence limit on the mean, as discussed in the next section) was based upon a normal distribution and standard deviation. If taking the natural logarithms (base e) of the data provided a better match than a normal distribution, a lognormal transformation of data was performed before the upper 95th percentile confidence limit on the mean

concentrations was computed. If neither distribution matched the data set of interest, the distribution having the better apparent fit was selected.

The distributional analysis results for COPCs in groundwater are shown in Appendix E (Part 2).

6.2.5 Exposure Point Concentrations

In this BLRA, an exposure point concentration (EPC) represents an estimated chemical concentration to which a receptor is assumed to be continuously exposed while in contact with an environmental medium. Using all of the analytical results for related samples, an EPC was calculated for each COPC identified at NAWC Area B. The EPC was calculated using the latest risk assessment guidance from EPA (1985, 1989a, 1991a, 1991b, 1997a) and Gilbert (1987).

6.2.5.1 Reasonable Maximum and Central Tendency Exposure EPCs

Two types of EPCs are possible for use in this risk assessment, reasonable maximum exposure (RME) EPCs and central tendency exposure (CTE) EPCs. RME is the exposure that is expected to represent a high end, but not worst case, exposure in a given media of concern. RME EPCs are selected from the maximum value, 95% upper confidence limit on the mean of normally distributed data (95% UCL-N), or the 95% upper confidence limit on log transformed data (95% UCL-T), that is, a conservative estimate of the mean. CTE is the exposure that is expected to represent an average exposure in a given medium of concern. CTE EPCs are selected from the mean of normally distributed data (Mean-N or arithmetic mean) or log-transformed data (Mean-T or minimum variance unbiased estimate of the mean for a lognormal distribution), that is, a best estimate of the mean (It should be noted that many risk assessors believe the UCL should be used for both RME and CTE analysis. This viewpoint considers that the uncertainty of the mean estimate is best reflected in the UCL, albeit the UCL is a conservative estimate of the average). CTE analysis not only involves a modified EPC, but also involves changes to input parameters for each exposure pathway.

6.2.5.2 Treatment of Data in EPC Calculations

Validated laboratory data were used to calculate EPCs. Estimated values (J qualified) and biased values (L and K qualified) were used as the reported value. Blank-contamination (B qualified) values were considered as non-detected results having detection limits equal to the reported value. Rejected results (R qualified) were eliminated from further consideration.

For chemicals with at least one positive detection in each data set, a value of one-half the sample quantitation limit was assumed for non-detect (U qualified) results when calculating EPCs.

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

6.2.5.3 RME EPC Calculation

The calculation of an RME EPC involves two steps. First, the distribution of the data was determined as discussed in the preceding section. Then, based on the distribution of the data, an EPC was either calculated or selected.

Several important assumptions were used to evaluate the distribution of the data:

- The distribution of a data set was determined using a Shapiro-Wilk test.
- The distributions were classified as lognormal, normal, or unknown.
- If the data were not determined to be either a lognormal or normal distribution, they were classified as the distribution having the better apparent fit.

If the data were considered to be lognormally distributed, then the standard deviation of the log-transformed sample set was determined, as follows:

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

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

The one-sided upper 95 percent confidence limit (UCL_{LOG}) was then calculated as follows:

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

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

The associated RME EPC was then selected as the lesser value of the one-sided 95 percent UCL and the maximum positive value in the data set.

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

First, the standard deviation of the sample set was 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}) was 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

The associated RME EPC was then selected as the lesser value of the one-sided 95 percent UCL and the maximum positive value in the data set.

For small sample sets or sample sets in which all positive results equal less than one-half the detection limit, the UCL can sometimes exceed the maximum detected concentration. In these cases, the maximum concentration was selected as the EPC.

6.2.5.4 CTE EPC Calculation

CTE EPCs are selected from the mean of normally distributed data (Mean-N or arithmetic mean) or log-transformed data (Mean-T or minimum variance unbiased estimate of the true mean). If the underlying distribution of the COPC is normal, the CTE EPC is selected as the arithmetic mean (Mean-N). If the underlying distribution of the COPC is lognormal, the CTE EPC is selected as the minimum variance unbiased estimate of the true mean (Mean-T).

The minimum variance unbiased estimate of the true mean (Mean-T) is calculated using an infinite series according to Gilbert, 1987:

$$\text{Mean-T} = \exp\{\mu_L\}\Psi_n(s_y^2/2)$$

Where: μ_L = arithmetic mean of log-transformed data

s_y = standard deviation of log-transformed data

$\Psi_n(t)$, with $t = s_y^2/2$, is the infinite series:

$$\Psi_n(t) = 1 + (n-1)t/n + (n-1)^3t^2/(2!n^2(n+1)) + (n-1)^5t^3/(3!n^3(n+1)(n+3)) + (n-1)^7t^4/(4!n^4(n+1)(n+3)(n+5)) + \ldots$$

6.2.5.5 EPCs for Area B Groundwater

Groundwater RME and CTE EPCs are shown on Table 6-3. Barium and manganese were determined to be lognormally distributed, while the organic COPCs did not meet the criteria for a lognormal distribution, but were assumed to be lognormally distributed based on better goodness of fit than a normal distribution. The RME EPCs for barium and manganese were estimated as the maximum detected concentration because this statistic was smaller than the 95 % Upper Confidence Limit for a log-transformed distribution (UCL-T). The EPCs for organic COPCs were estimated as the 95 % UCL-T. CTE EPCs were estimated as the minimum variance unbiased estimate of the mean for a lognormal distribution (Mean-T).

TABLE 6-3 (RAGS D TABLE 3)
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY
WARMINSTER AREA B GROUNDWATER

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water

Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL of Normal Data	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure			Central Tendency		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Barium	ug/L	148	919	591		ug/L	591	Max	Max < U95log	170	Mean-T	CTE uses LgAV
Manganese	ug/L	218	67600	1320		ug/L	1320	Max	Max < U95log	220	Mean-T	CTE uses LgAV
1,2-Dichloroethene (cis)	ug/L	0.67	0.709	5		ug/L	0.709	95%UCL-T	Wt >Wlg>=Wno	0.631	Mean-T	CTE uses LgAV
Benzene	ug/L	0.508	0.517	0.9	J	ug/L	0.517	95%UCL-T	Wt >Wlg>=Wno	0.507	Mean-T	CTE uses LgAV
Chloroform	ug/L	0.509	0.52	1		ug/L	0.52	95%UCL-T	Wt >Wlg>=Wno	0.509	Mean-T	CTE uses LgAV
Tetrachloroethene	ug/L	0.604	0.635	3		ug/L	0.635	95%UCL-T	Wt >Wlg>=Wno	0.58	Mean-T	CTE uses LgAV
Trichloroethene	ug/L	0.858	0.905	7		ug/L	0.905	95%UCL-T	Wt >Wlg>=Wno	0.765	Mean-T	CTE uses LgAV

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N).

6.3 EXPOSURE ASSESSMENT

The exposure assessment evaluates the potential for human exposure to the chemicals detected in Area B Groundwater. This section presents a characterization of the exposure setting, characterizes the exposed populations, identifies actual or potential exposure routes, and summarizes the methods used to generate exposure estimates. The nature and extent of contamination upon which exposures were based was presented in Section 4.0.

6.3.1 Potential Receptors

The potential receptors chosen for Warminster Area B groundwater are presented in this section. The on/off-site receptors were selected based on several criteria (i.e., current and anticipated future land use, hypothetical future land use, accessibility to the site, and media of concern sampled) and are listed as follows:

- Future Residential Child - This receptor is a child (age 1 - 6) who resides within or near Area B. This receptor is potentially exposed to COPCs in groundwater via ingestion of tap water and dermal absorption of COPCs while bathing.
- Future Residential Adult - This receptor is an adult (24 years exposure duration) who resides within or near Area B. This receptor is potentially exposed to COPCs in groundwater via ingestion of tap water, dermal absorption of COPCs while showering, and inhalation (volatile organic vapors during showering).
- Future Lifetime Resident - This receptor is a residential child (age 1 - 6) and a residential adult (24 years exposure duration) who resides within or near Area B. This receptor is potentially exposed to COPCs in groundwater via ingestion of tap water, dermal absorption of COPCs while bathing or showering, and inhalation (volatile organic vapors during showering - adult exposure duration only). [This additive residential exposure scenario is included to estimate the lifetime cancer risk under a residential land use scenario. The lifetime cancer risk is estimated by adding the cancer risk under a 24-year adult exposure to the cancer risk under a 6-year child exposure.].

6.3.2 Exposure Estimates

The estimation routes, methods, and models presented in this section are consistent with current EPA risk assessment guidance (EPA, 1989a, 1991b, 1996b, and 1999a). The exposure scenario incorporates RME and CTE EPCs in the estimation of intakes.

Noncarcinogenic risks were 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 were generally greater for children than for adults because of differences in body weight and intake. Carcinogenic risks, on the other hand, were estimated as an incremental lifetime risk and, therefore, incorporate terms to average the exposure duration (years) over the course of a lifetime (70 years).

Exposures via incidental groundwater ingestion, dermal contact, and inhalation of volatile organic vapors are estimated using the following equations (EPA, 1989a; EPA, 1992e; Foster and Chrostowski, 1987):

Ingestion:

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

Dermal Contact:

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

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

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

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 of COPCs in Volatile Organic Vapors:

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

Where:

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

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

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

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

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	=	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)

A sample calculation for dermal contact with groundwater is provided in Appendix E, Part 4. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Tables 6-4 and 6-5. The potential receptors for this scenario were current and 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 (1992e, 1998) or

TABLE 6-4 (RAGS D TABLE 4)
VALUES USED FOR DAILY INTAKE CALCULATIONS - CHILD RESIDENT TAP WATER CONTACT WITH GROUNDWATER
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact with Groundwater
Receptor Population: Resident
Receptor Age: Child Ages 0-6

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Groundwater	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Intake (mg/kg-day) =
	IR-W	Ingestion Rate of Groundwater	liters/day	1	EPA, 1997	1	EPA, 1997	CWS x IR-W x EF x ED x CF1 x 1/(BW x AT)
	EF	Exposure Frequency	days/year	350	EPA, 1994	234	EPA, 1994	
	ED	Exposure Duration	years	6	EPA, 1997	2	EPA, 1997	
	CF1	Conversion Factor 1	mg/ug	0.001	--	0.001	--	
	BW	Body Weight	kg	15	EPA, 1997	15	EPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	730	EPA, 1989	
Dermal	CW	Chemical Concentration in Groundwater	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Dermal Absorbed Dose (mg/kg-day) =
	SA-ADJ	Age-Adjusted Skin Surface Area/Body Wt. Ratio	cm2-years/kg	2682	EPA	2682	EPA	CW x SA-ADJ x KP x Function(ET) x EV x EF x CF1 x
	KP	Permeability Constant (Dermal for Liquids)	cm/hr	Chemical-Specific	EPA, 1992	Chemical-Specific	EPA, 1992	CF2 x 1/AT
	ET	Exposure Time	hr/event	0.25	EPA, 1997	0.167	EPA, 1997	Where: Function(ET) = ET for inorganics, or
	EV	Event Frequency	events/day	1	EPA, 1997	1	EPA, 1997	(24 x Tau x ET / PI)^0.5 for organics where ET < T*, or
	EF	Exposure Frequency	days/year	350	EPA, 1994	234	EPA, 1994	[ET/(1+B)] + Tau x (2+6B)/(1+B) for organics, ET > T*.
	ED	Exposure Duration	years	6	EPA, 1997	2	EPA, 1997	See EPA,1992 for chemical-specific constants Tau, B, T*
	CF1	Conversion Factor 1	mg/ug	0.001	--	0.001	--	
	CF2	Conversion Factor 2	l/cm3	0.001	--	0.001	--	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	730	EPA, 1989	

Sources:

EPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002. Office of Emergency and Remedial Response. Washington, DC.

EPA, 1992. Dermal Exposure Assessment: Principles and Applications. Interim Report. EPA 600/8-91/011/B. Office of Health and Environmental Assessment. Washington, DC. January.

EPA, 1997. Health Effects Assessment Summary Tables (HEAST). EPA/540/R-95-036. Office of Solid Waste and Emergency Response. May.

TABLE 6-5 (RAGS D TABLE 4)
VALUES USED FOR DAILY INTAKE CALCULATIONS - ADULT RESIDENT TAP WATER CONTACT WITH GROUNDWATER
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact and Inhalation During Showering with Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Groundwater	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Intake (mg/kg-day) =
	IR-W	Ingestion Rate of Groundwater	liters/day	2	EPA, 1997	1.4	EPA, 1997	CWS x IR-W x EF x ED x CF1 x 1/(BW x AT)
	EF	Exposure Frequency	days/year	350	EPA, 1994	234	EPA, 1994	
	ED	Exposure Duration	years	24	EPA, 1997	7	EPA, 1997	
	CF1	Conversion Factor 1	mg/ug	0.001	--	0.001	--	
	BW	Body Weight	kg	70	EPA, 1997	70	EPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	2555	EPA, 1989	
Dermal	CW	Chemical Concentration in Groundwater	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Dermal Absorbed Dose (mg/kg-day) =
	SA	Skin Surface Area Available for Contact	cm2	18150	EPA, 1997	18150	EPA, 1997	((CW-CWD) x SA x KP x Function(ET) x EV x EF x ED x CF1 x
	KP	Permeability Constant (Dermal for Liquids)	cm/hr	Chemical-Specific	EPA, 1992	Chemical-Specific	EPA, 1992	CF2 x 1/(BW x AT)
	ET	Exposure Time	hr/event	0.25	EPA, 1997	0.167	EPA, 1997	Where: Function(ET) = ET for inorganics, or
	EV	Event Frequency	events/day	1	EPA, 1997	1	EPA, 1997	(24 x Tau x ET / PI)^0.5 for organics where ET < T*, or
	EF	Exposure Frequency	days/year	350	EPA, 1994	234	EPA, 1994	[ET/(1+B)] + Tau x (2+6B)/(1+B) for organics, ET > T*.
	ED	Exposure Duration	years	24	EPA, 1997	7	EPA, 1997	See EPA,1992 for chemical-specific constants Tau, B, T*
	CF1	Conversion Factor 1	mg/ug	0.001	--	0.001	--	
	CF2	Conversion Factor 2	l/cm3	0.001	--	0.001	--	
	BW	Body Weight	kg	70	EPA, 1997	70	EPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	2555	EPA, 1989	
	CWD	VOC Water Conc. lost in Shower by Evaporation	ug/l	See Shower Model	Foster & Chros.,1987	See Shower Model	Foster & Chros.,1987	
Inhalation	CW	Chemical Concentration in Groundwater	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Intake (mg/kg-day) =
	IR-SH	Inhalation Rate in Shower	m3/hr	0.6	Prof Judge	0.6	Prof Judge	[IR-SH x (CWD x FR / SV) x Q x CF1 x CF4 /(BW x Ra)] x
	FR	Shower Flow Rate	l/min	20.0	Prof. Judgment	9.5	Prof. Judgment	EF x ED / AT
	SV	Shower Room Air Volume	m3	6.0	Prof. Judgment	6.0	Prof. Judgment	Where CWD = Function of Water Conc. & other parameters;
	CF1	Conversion Factor 1	mg/ug	0.001	--	0.001	--	Ra =Air Exchange Rate; Q =Function of Ra, Time in Shower
	CF4	Conversion Factor 4	m3/l	0.001	--	0.001	--	Shower Model Equations from Foster and Chrostowski, 1987
	BW	Body Weight	kg	70	EPA, 1997	70	EPA, 1997	
	EF	Exposure Frequency	days/year	350	EPA, 1994	234	EPA, 1994	
	ED	Exposure Duration	years	24	EPA, 1997	7	EPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	2555	EPA, 1989	
	DS	Duration of Shower	min	15	EPA, 1996a	10	EPA, 1996a	
	DT	Total Time in Shower Room	min	20	Prof Judge	15	Prof Judge	

Sources:

EPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002. Office of Emergency and Remedial Response. Washington, DC.

EPA, 1992. Dermal Exposure Assessment: Principles and Applications. Interim Report. EPA 600/8-91/011/B. Office of Health and Environmental Assessment. Washington, DC. January.

EPA, 1997. Health Effects Assessment Summary Tables (HEAST). EPA/540/R-95-036. Office of Solid Waste and Emergency Response. May.

derived from the molecular weight and Kow as demonstrated therein. Values of K_{pw} for organic chemicals were generally selected as the estimated as opposed to empirical values. (In the case of chloroform, tetrachloroethene, and trichloroethene, empirical values are more than 5-fold greater than estimated values, but may be biased high because EPA (1992e) noted that in-vivo studies of Guinea Pig skin yields greater permeabilities and tends to overpredict human K_{pw} values.) 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). The age-adjusted, body weight-normalized surface areas exposed while bathing for a resident child is 2728 cm^2-year/kg.

For bathing and showering, the dermal exposure point concentrations were based on the representative concentrations estimated for the source (tap) water. This is a protective approach that may slightly overestimate bathing or showering dermal exposures due to the continuous evaporation of VOCs from water during bathing/showering.

A sample calculation for inhalation of volatile COPCs during showering is provided in Appendix E, Part 4. The input parameters for this exposure route, along with the rationale for the selection of each value, are presented in Table 6-5. The potential receptors for this scenario were current and future adult (showering) residential receptors. 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). The volatile chemical generation rate was estimated using the Foster and Chrostowski mass transfer model, which is based on two-phase film theory. The model employs contaminant-specific mass transfer coefficients, Henry's Law constants, droplet drop time, viscosity, temperature, etc. Specific details regarding the application of the mass transfer model can be found in the source document (Foster and Chrostowski, 1987).

6.4 TOXICITY ASSESSMENT

Toxicity Assessment identifies 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 in Warminster Area B groundwater are presented in Tables 6-6 through 6-9 and Appendix E, Part 5 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

TABLE 6-6 (RAGS D TABLE 5.1)

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

WARMINSTER AREA B GROUNDWATER

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
Barium	Chronic	7.00E-02	mg/kg-day	1.00E+00	7.00E-02	mg/kg-day	Cardiovascular/Kidney	3	IRIS	12/08/99
Manganese	Chronic	2.40E-02	mg/kg-day	1.00E+00	2.40E-02	mg/kg-day	CNS	3	IRIS	12/08/99
1,2-Dichloroethene (cis)	Chronic	1.00E-02	mg/kg-day	1.00E+00	1.00E-02	mg/kg-day	Blood	3000	HEAST	1997
Benzene		3.00E-03	mg/kg-day	1.00E+00	3.00E-03	mg/kg-day	Blood/Immune	3000	EPA-NCEA	7/2/96
Chloroform	Chronic	1.00E-02	mg/kg-day	1.00E+00	1.00E-02	mg/kg-day	Liver	1000	IRIS	12/08/99
Tetrachloroethene	Chronic	1.00E-02	mg/kg-day	1.00E+00	1.00E-02	mg/kg-day	Liver	1000	IRIS	12/08/99
Trichloroethene	Chronic	6.00E-03	mg/kg-day	1.00E+00	6.00E-03	mg/kg-day	Liver/Kidney	3000	EPA-NCEA	3/5/92

N/A = Not Applicable

(1) Refer to RAGS, Part A

(2) Provide equation used for derivation.

(3) For IRIS values, provide the date IRIS was searched.

For HEAST values, provide the date of HEAST.

For NCEA values, provide the date of the article provided by NCEA.

TABLE 6-7 (RAGS D TABLE 5.2)

NON-CANCER TOXICITY DATA -- INHALATION

WARMINSTER AREA B GROUNDWATER

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD (1)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (2) (MM/DD/YY)
Barium		---	---	1.43E-04	mg/kg-day	Fetotoxicity	1000	HEAST Alternative	12/08/99
Manganese	Chronic	---	---	1.43E-05	mg/kg-day	CNS	1000	IRIS	12/08/99
1,2-Dichloroethene (cis)	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Benzene		---	---	1.70E-03	mg/kg-day	Blood	1000	EPA-NCEA	7/2/96
Chloroform		---	---	8.60E-05	mg/kg-day	Respiratory	1000	EPA-NCEA	12/1/97
Tetrachloroethene	Chronic	---	---	1.40E-01	mg/kg-day	Liver/Kidney	300	EPA-NCEA	6/20/97
Trichloroethene	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A

N/A = Not Applicable

(1) Provide equation used for derivation in text.

(2) For IRIS values, provide the date IRIS was searched.

For HEAST values, provide the date of HEAST.

For NCEA values, provide the date of the article provided by NCEA.

TABLE 6-8 (RAGS D TABLE 6.1)

CANCER TOXICITY DATA -- ORAL/DERMAL

WARMINSTER AREA B GROUNDWATER

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source Target Organ	Date (2) (MM/DD/YY)
Barium	N/A	N/A	N/A	N/A	D	N/A	N/A
Manganese	N/A	N/A	N/A	N/A	D	N/A	N/A
1,2-Dichloroethene (cis)	N/A	N/A	N/A	N/A	D	N/A	N/A
Benzene	2.90E-02	1.00E+00	2.90E-02	1/(mg/kg-day)	A	IRIS	12/08/99
Chloroform	6.10E-03	1.00E+00	6.10E-03	1/(mg/kg-day)	B2	IRIS	12/08/99
Tetrachloroethene	5.20E-02	1.00E+00	5.20E-02	1/(mg/kg-day)	C	EPA-NCEA	31868
Trichloroethene	1.10E-02	1.00E+00	1.10E-02	1/(mg/kg-day)	C	EPA-NCEA	32690

IRIS = Integrated Risk Information System

HEAST= Health Effects Assessment Summary Tables

(1) Provide equation for derivation in text.

(2) For IRIS values, provide the date IRIS was searched.

For HEAST values, provide the date of HEAST.

For NCEA values, provide the date of article provided by NCEA.

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

Weight of Evidence:

Known/Likely

Cannot be Determined

Not Likely

TABLE 6-9 (RAGS D TABLE 6.2)

CANCER TOXICITY DATA -- INHALATION

WARMINSTER AREA B GROUNDWATER

Chemical of Potential Concern	Unit Risk	Units	Adjustment	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (1) (MM/DD/YY)
Barium	---	---	---	N/A	N/A	D	N/A	N/A
Manganese	---	---	---	N/A	N/A	D	N/A	N/A
1,2-Dichloroethene (cis)	---	---	---	N/A	N/A	D	N/A	N/A
Benzene	---	---	---	2.90E-02	1/(mg/kg-day)	A	IRIS	12/08/99
Chloroform	---	---	---	8.10E-02	1/(mg/kg-day)	B2	IRIS	12/08/99
Tetrachloroethene	---	---	---	2.03E-03	1/(mg/kg-day)	B2 - C	EPA-NCEA	4/1/87
Trichloroethene	---	---	---	6.00E-03	1/(mg/kg-day)	B2 - C	EPA-NCEA	7/1/89

IRIS = Integrated Risk Information System

HEAST= Health Effects Assessment Summary Tables

Weight of Evidence:

Known/Likely

Cannot be Determined

Not Likely

(1) For IRIS values, provide the date IRIS was searched.

For HEAST values, provide the date of HEAST.

For NCEA values, provide the date of the article provided by NCEA.

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - indicates that limited human data are available

B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

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.

Dose-response values [reference doses (RfDs) and slope factors (SFs)] have been developed by EPA and other sources for many organics and inorganics. This section provides a brief description of these parameters.

6.4.1 Reference Doses

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. Subchronic RfDs are specifically developed to be protective for a portion of a lifetime exposure to a compound (as a Superfund program guideline, short term). Chronic RfDs are specifically developed to be protective for long-term exposure to a compound (as a Superfund program guideline, long term). 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 NOEL) or a Lowest-Observed-Adverse-Effect-Level (LOAEL) by an appropriate uncertainty factor. NOAELs, etc. are determined from laboratory or epidemiological toxicity studies. The uncertainty factor is based on the availability of toxicity data.

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), when test results from animals are extrapolated to humans (to account for interspecies variability), when a NOAEL derived from a subchronic study (instead of a chronic study) is used to develop the RfD, and when a LOAEL is used 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 data base not already accounted for. The default value of the modifying factor is 1.

The RfD incorporates the surety of the evidence for chronic human health effects. Even if applicable human data exist, the RfD (as diminished 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. Oral and dermal RfDs, primary target organs, uncertainty/modifying factors, and sources for selected COPCs in groundwater are provided in Table 6-6. Inhalation RfDs, primary target organs, uncertainty/modifying factors, and sources for selected COPCs in groundwater are provided in Table 6-7. Inhalation RfDs (mg/kg/day) were derived from inhalation reference concentrations (RfCs) (mg/m^3) by

dividing by 70 kg (an assumed human body weight), multiplying by 20 m^3/day (an assumed human inhalation rate), and adjusting by an appropriate absorption factor (EPA, 1997a).

Target organ data have been extracted from the Integrated Risk Information System (IRIS; EPA, 1999b), Health Effect Assessment Summary Tables (HEAST; EPA, 1997b), or other applicable sources. Only the target organs that are affected in the applicable study in which the RfD was derived have been included in Tables 6-6 and 6-7.

6.4.2 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.

Oral and dermal SFs, weight of evidence, and sources for selected COPCs in groundwater are provided in Table 6-8. Inhalation SFs, weight of evidence, and sources for selected COPCs in groundwater are provided in Table 6-9. Inhalation SFs $(mg/kg/day)^{-1}$ were derived from inhalation unit risks $(ug/m^3)^{=1}$ by multiplying by 70 kg (an assumed human body weight), dividing by 20 m^3/day (an assumed human inhalation rate), and multiplying by the appropriate conversion factor (1000 ug/mg) (EPA, 1997b).

6.4.3 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 as follows (EPA, 1992d):

WEIGHT OF EVIDENCE CATEGORY	DEFINITION
A	Known human carcinogen
B1	Probably human carcinogen, limited human data are available
B2	Probable human carcinogen, sufficient animal data are available but inadequate human data are available
C	Possible human carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity in humans

6.4.4 Adjustment of Dose-Response Parameters for Dermal Exposure

Risks associated with dermal exposures were evaluated using toxicity values that are specific to absorbed dermal doses. Most oral toxicity values are based on administered doses rather than absorbed doses. Therefore, in accordance with EPA Region III (1995) and EPA (1989a, Appendix A) guidance, the

toxicity values based on administered doses were adjusted before they were used for evaluating absorbed doses.

Dermal RfDs and SFs were obtained from oral RfDs and SFs via the following relationships:

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

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

where:

GI_{Oral}	=	Gastrointestinal (GI) Absorption Efficiency (EPA, 1995)
RfD_{Oral}	=	Oral Reference Dose (EPA, 1999a; EPA, 1999b; EPA, 1997a; or EPA-NCEA)
SF_{Oral}	=	Oral Slope Factor (EPA, 1999a; EPA, 1999b; EPA, 1997a; or EPA-NCEA)

Dermally adjusted RfDs and SFs for COPCs are presented in Tables 6-6 and 6-8, respectively.

6.5 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 were generated based on risk assessment methods outlined in current EPA guidance (EPA, 1989a).

Noncarcinogenic risk estimates were presented in the form of HQs and HIs that are determined through comparison of estimated intakes with published RfDs. Incremental cancer risk estimates were 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 noncarcinogenic and carcinogenic risks were summarized for each exposure route on a series of tables in this section.

6.5.1 Noncarcinogenic Risks

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

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

HIs were generated by summing the individual HQs for the COPCs. If the value of the HI exceeds unity (1.0), the potential for noncarcinogenic health risks associated with exposure to that particular chemical mixture cannot be ruled out (EPA, 1986b). In that case, 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 results (HIs) for different organs are not truly additive. The HI is not defined as a mathematical prediction of the severity of toxic effects; it is simply a numerical indicator of exceedence of the acceptable threshold for noncarcinogenic effects. Above an HI of 1, toxic effects would not necessarily occur, but can longer be ruled out.

6.5.2 Carcinogenic Risks

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

$$Risk = Intake * SF$$

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

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

The risk determined using these equations is defined as 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 a 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 defined as 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 10^{-4} to 10^{-6} as being acceptable for most hazardous waste facilities addressed under CERCLA. For CERCLA activities, residual risks on the order of 10^{-6} are the primary goal but are often modified by such regulatory requirements as MCLs or chemical-specific clean-up goals.

6.5.3 Comparison of Quantitative Risk Estimates to Benchmark Criteria

In order to interpret the quantitative risks and to aid risk managers in determining the need for remediation at a site, quantitative risk estimates are compared to typical benchmarks.

An HI exceeding unity (1) indicates that there may be potential noncarcinogenic health risks associated with exposure. If an HI exceeds unity, target organ effects from individual COPCs contributing to the risk are considered. Only those chemicals that impact the same target organ(s) or exhibit similar critical effect(s) will be regarded as truly additive. Thus, COPCs contributing to an HI greater than 1 on the basis of a single target organ/effect are considered to be COCs.

EPA has defined the range of 10^{-4} to 10^{-6} as the incremental cancer risk (ICR) "target range" for most hazardous waste facilities evaluated. Cumulative ICRs greater than 10^{-4} generally will indicate that some degree of remediation is required, and ICRs below 10^{-6} normally will not result in remedial efforts. Whenever ICRs fall between 10^{-4} to 10^{-6}, decisions for remediation will be made on a case-specific basis. Individual chemicals contributing significantly to risks above the target range are considered to be chemicals of concern (COCs).

Potential RME hazard indices and RME cancer risks were estimated for current and future potential receptors using the methodologies presented in Sections 6.2 and 6.3. The following sections present a summary of the results of the estimation of risk for exposure to Area B groundwater.

Receptor risks are presented for each receptor in the form of tables and summary text. 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 that are reported as "N/A" generally indicate that the chemical is not carcinogenic or that a SF has not yet been developed.

6.5.4 Site-Specific Noncarcinogenic Risks

Site specific noncarcinogenic risks were estimated for potential receptors exposed to Area B groundwater. These risks are discussed below and presented on Tables 6-10 through 6-14 (RAGS D Table 7's).

The estimated RME HI for a child resident exposed to Area B groundwater is 4.1 (Table 6-10), based on exposure pathways from ingestion and dermal absorption, which exceeds unity (1.0). The major contributors to the HI are manganese (target organ CNS, HQ = 3.5) and barium (target organs

TABLE 6-10 (RAGS D TABLE 7)
CALCULATION OF NON-CANCER HAZARDS - CHILD RESIDENT TAP WATER CONTACT WITH GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact with Groundwater
Receptor Population: Resident
Receptor Age: Child Ages 0-6

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	3.78E-02	mg/kg-day	7.00E-02	mg/kg-day	N/A	N/A	5.40E-01
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	8.44E-02	mg/kg-day	2.40E-02	mg/kg-day	N/A	N/A	3.52E+00
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	4.53E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	4.53E-03
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	3.31E-05	mg/kg-day	3.00E-03	mg/kg-day	N/A	N/A	1.10E-02
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	3.32E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	3.32E-03
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	4.06E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	4.06E-03
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	5.79E-05	mg/kg-day	6.00E-03	mg/kg-day	N/A	N/A	9.64E-03
	(Total)												4.09E+00
Dermal	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	6.33E-05	mg/kg-day	7.00E-02	mg/kg-day	N/A	N/A	9.05E-04
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	1.41E-04	mg/kg-day	2.40E-02	mg/kg-day	N/A	N/A	5.89E-03
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	2.02E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	2.02E-04
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	3.28E-06	mg/kg-day	3.00E-03	mg/kg-day	N/A	N/A	1.09E-03
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	1.88E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	1.88E-04
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	1.06E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	1.06E-03
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	4.45E-06	mg/kg-day	6.00E-03	mg/kg-day	N/A	N/A	7.42E-04
	(Total)												1.01E-02
												Total of Routes	4.10E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

TABLE 6-11 (RAGS D TABLE 7)
CALCULATION OF NON-CANCER HAZARDS - CHILD RESIDENT TAP WATER CONTACT WITH GROUNDWATER
CENTRAL TENDENCY EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact with Groundwater
Receptor Population: Resident
Receptor Age: Child Ages 0-6

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Barium	1.70E+02	ug/l	1.70E+02	ug/l	M	7.27E-03	mg/kg-day	7.00E-02	mg/kg-day	N/A	N/A	1.04E-01
	Manganese	2.20E+02	ug/l	2.20E+02	ug/l	M	9.40E-03	mg/kg-day	2.40E-02	mg/kg-day	N/A	N/A	3.92E-01
	1,2-Dichloroethene (cis)	6.31E-01	ug/l	6.31E-01	ug/l	M	2.70E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	2.70E-03
	Benzene	5.07E-01	ug/l	5.07E-01	ug/l	M	2.17E-05	mg/kg-day	3.00E-03	mg/kg-day	N/A	N/A	7.22E-03
	Chloroform	5.09E-01	ug/l	5.09E-01	ug/l	M	2.18E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	2.18E-03
	Tetrachloroethene	5.80E-01	ug/l	5.80E-01	ug/l	M	2.48E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	2.48E-03
	Trichloroethene	7.65E-01	ug/l	7.65E-01	ug/l	M	3.27E-05	mg/kg-day	6.00E-03	mg/kg-day	N/A	N/A	5.45E-03
	(Total)												5.16E-01
Dermal	Barium	1.70E+02	ug/l	1.70E+02	ug/l	M	2.44E-05	mg/kg-day	7.00E-02	mg/kg-day	N/A	N/A	3.49E-04
	Manganese	2.20E+02	ug/l	2.20E+02	ug/l	M	3.16E-05	mg/kg-day	2.40E-02	mg/kg-day	N/A	N/A	1.32E-03
	1,2-Dichloroethene (cis)	6.31E-01	ug/l	6.31E-01	ug/l	M	2.94E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	2.94E-04
	Benzene	5.07E-01	ug/l	5.07E-01	ug/l	M	5.27E-06	mg/kg-day	3.00E-03	mg/kg-day	N/A	N/A	1.76E-03
	Chloroform	5.09E-01	ug/l	5.09E-01	ug/l	M	3.02E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	3.02E-04
	Tetrachloroethene	5.80E-01	ug/l	5.80E-01	ug/l	M	1.59E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	1.59E-03
	Trichloroethene	7.65E-01	ug/l	7.65E-01	ug/l	M	6.17E-06	mg/kg-day	6.00E-03	mg/kg-day	N/A	N/A	1.03E-03
	(Total)												6.64E-03
												Total of Routes	5.22E-01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

TABLE 6-12 (RAGS D TABLE 7)
CALCULATION OF NON-CANCER HAZARDS - ADULT RESIDENT TAP WATER CONTACT WITH GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact with Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	1.62E-02	mg/kg-day	7.00E-02	mg/kg-day	N/A	N/A	2.31E-01
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	3.62E-02	mg/kg-day	2.40E-02	mg/kg-day	N/A	N/A	1.51E+00
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	1.94E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	1.94E-03
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	1.42E-05	mg/kg-day	3.00E-03	mg/kg-day	N/A	N/A	4.72E-03
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	1.42E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	1.42E-03
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	1.74E-05	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	1.74E-03
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	2.48E-05	mg/kg-day	6.00E-03	mg/kg-day	N/A	N/A	4.13E-03
	(Total)												1.75E+00
Dermal	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	3.67E-05	mg/kg-day	7.00E-02	mg/kg-day	N/A	N/A	5.25E-04
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	8.20E-05	mg/kg-day	2.40E-02	mg/kg-day	N/A	N/A	3.42E-03
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	6.59E-07	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	6.59E-05
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	9.97E-07	mg/kg-day	3.00E-03	mg/kg-day	N/A	N/A	3.32E-04
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	6.52E-07	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	6.52E-05
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	3.91E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	3.91E-04
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	1.56E-06	mg/kg-day	6.00E-03	mg/kg-day	N/A	N/A	2.59E-04
	(Total)												5.06E-03
												Total of Routes	1.76E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

TABLE 6-13 (RAGS D TABLE 7)
CALCULATION OF NON-CANCER HAZARDS - ADULT RESIDENT INHALATION OF GROUNDWATER VAPORS DURING SHOWERING
REASONABLE MAXIMUM EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air
Exposure Point: Inhalation of Groundwater Vapors During Showering
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Inhalation	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	2.37E-05	mg/kg-day	--	--	--	mg/kg-day	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	1.88E-05	mg/kg-day	--	--	1.70E-03	mg/kg-day	1.11E-02
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	1.60E-05	mg/kg-day	--	--	8.60E-05	mg/kg-day	1.86E-01
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	1.78E-05	mg/kg-day	--	--	1.40E-01	mg/kg-day	1.27E-04
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	2.75E-05	mg/kg-day	--	--	--	mg/kg-day	--
	(Total)												1.97E-01
												Total Hazard Index Across All Exposure Routes/Pathways	1.97E-01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

TABLE 6-14 (RAGS D TABLE 7)
CALCULATION OF NON-CANCER HAZARDS - ADULT RESIDENT TAP WATER CONTACT WITH GROUNDWATER
CENTRAL TENDENCY EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact with Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Barium	1.70E+02	ug/l	1.70E+02	ug/l	M	2.18E-03	mg/kg-day	7.00E-02	mg/kg-day	N/A	N/A	3.11E-02
	Manganese	2.20E+02	ug/l	2.20E+02	ug/l	M	2.82E-03	mg/kg-day	2.40E-02	mg/kg-day	N/A	N/A	1.18E-01
	1,2-Dichloroethene (cis)	6.31E-01	ug/l	6.31E-01	ug/l	M	8.09E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	8.09E-04
	Benzene	5.07E-01	ug/l	5.07E-01	ug/l	M	6.50E-06	mg/kg-day	3.00E-03	mg/kg-day	N/A	N/A	2.17E-03
	Chloroform	5.09E-01	ug/l	5.09E-01	ug/l	M	6.53E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	6.53E-04
	Tetrachloroethene	5.80E-01	ug/l	5.80E-01	ug/l	M	7.44E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	7.44E-04
	Trichloroethene	7.65E-01	ug/l	7.65E-01	ug/l	M	9.81E-06	mg/kg-day	6.00E-03	mg/kg-day	N/A	N/A	1.63E-03
	(Total)												1.55E-01
Dermal	Barium	1.70E+02	ug/l	1.70E+02	ug/l	M	4.72E-06	mg/kg-day	7.00E-02	mg/kg-day	N/A	N/A	6.74E-05
	Manganese	2.20E+02	ug/l	2.20E+02	ug/l	M	6.11E-06	mg/kg-day	2.40E-02	mg/kg-day	N/A	N/A	2.54E-04
	1,2-Dichloroethene (cis)	6.31E-01	ug/l	6.31E-01	ug/l	M	3.20E-07	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	3.20E-05
	Benzene	5.07E-01	ug/l	5.07E-01	ug/l	M	5.34E-07	mg/kg-day	3.00E-03	mg/kg-day	N/A	N/A	1.78E-04
	Chloroform	5.09E-01	ug/l	5.09E-01	ug/l	M	3.49E-07	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	3.49E-05
	Tetrachloroethene	5.80E-01	ug/l	5.80E-01	ug/l	M	1.95E-06	mg/kg-day	1.00E-02	mg/kg-day	N/A	N/A	1.95E-04
	Trichloroethene	7.65E-01	ug/l	7.65E-01	ug/l	M	7.18E-07	mg/kg-day	6.00E-03	mg/kg-day	N/A	N/A	1.20E-04
	(Total)												8.82E-04
												Total of Routes	1.56E-01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

cardiovascular system and kidney, HQ = 0.5). Adverse effects cannot be ruled out when the HI exceeds 1.0 for a particular target organ.

The estimated CTE HI for a child resident exposed to Area B groundwater is 0.52 (Table 6-11), based on exposure pathways from ingestion and dermal absorption, which is less than 1.0, the cutoff level below which adverse effects are not expected.

The estimated RME HI for an adult resident exposed to Area B groundwater is 1.8 [Table 6-12 (Ingestion/Dermal) and Table 6-13 (Inhalation)], based on principal contributions to risk from ingestion and dermal absorption, which exceeds 1.0. The major contributors to the HI are manganese (target organ CNS, HQ = 1.5) and barium (target organs cardiovascular system and kidney, HQ = 0.2).

The estimated CTE HI for an adult resident exposed to Area B groundwater is 0.16 (Table 6-14), based on exposure pathways from ingestion and dermal absorption, which is less than 1.0, the cutoff level below which adverse effects are not expected.

6.5.5 Site-Specific Carcinogenic Risks

Site specific carcinogenic risks were estimated for potential receptors exposed to Area B groundwater. These risks are discussed below and presented on Tables 6-15 through 6-19 (RAGS D Table 8's).

The estimated RME incremental cancer risk (ICR) for a child resident exposed to Area B groundwater is 4.0×10^{-7}, based on a principal contribution to risk from ingestion, which is below EPA's target risk range of 10^{-4} to 10^{-6}.

The estimated RME ICR for an adult resident exposed to Area B groundwater is 1.4×10^{-6}, based on principal contributions to risk from ingestion and inhalation during showering, which is at the lower end of EPA's target risk range of 10^{-4} to 10^{-6}.

The estimated RME ICR for a lifetime resident (summation of child and adult residential exposure) exposed to Area B groundwater is 1.8×10^{-6}, based on principal contributions to risk from ingestion and inhalation during showering, which is near the lower end of EPA's target risk range of 10^{-4} to 10^{-6}. Chloroform (lifetime cancer risk 4.4×10^{-7} via inhalation), tetrachloroethene (lifetime cancer risk 4.9×10^{-7} via ingestion), and benzene (lifetime cancer risk 4.1×10^{-7} via ingestion and inhalation) are the principal contributors to risk.

TABLE 6-15 (RAGS D TABLE 8)
CALCULATION OF CANCER RISKS - CHILD RESIDENT TAP WATER CONTACT WITH GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact with Groundwater
Receptor Population: Resident
Receptor Age: Child Ages 0-6

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	3.24E-03	mg/kg-day	--	1/(mg/kg-day)	--
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	7.23E-03	mg/kg-day	--	1/(mg/kg-day)	--
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	3.88E-06	mg/kg-day	--	1/(mg/kg-day)	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	2.83E-06	mg/kg-day	2.90E-02	1/(mg/kg-day)	8.22E-08
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	2.85E-06	mg/kg-day	6.10E-03	1/(mg/kg-day)	1.74E-08
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	3.48E-06	mg/kg-day	5.20E-02	1/(mg/kg-day)	1.81E-07
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	4.96E-06	mg/kg-day	1.10E-02	1/(mg/kg-day)	5.45E-08
	(Total)										3.35E-07
Dermal	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	5.43E-06	mg/kg-day	--	1/(mg/kg-day)	--
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	1.21E-05	mg/kg-day	--	1/(mg/kg-day)	--
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	1.73E-07	mg/kg-day	--	1/(mg/kg-day)	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	2.81E-07	mg/kg-day	2.90E-02	1/(mg/kg-day)	8.15E-09
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	1.61E-07	mg/kg-day	6.10E-03	1/(mg/kg-day)	9.83E-10
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	9.12E-07	mg/kg-day	5.20E-02	1/(mg/kg-day)	4.74E-08
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	3.82E-07	mg/kg-day	1.10E-02	1/(mg/kg-day)	4.20E-09
	(Total)										6.08E-08
										Total of Routes	3.96E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

TABLE 6-16 (RAGS D TABLE 8)
CALCULATION OF CANCER RISKS - ADULT RESIDENT TAP WATER CONTACT WITH GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact with Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	5.55E-03	mg/kg-day	--	1/(mg/kg-day)	--
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	1.24E-02	mg/kg-day	--	1/(mg/kg-day)	--
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	6.66E-06	mg/kg-day	--	1/(mg/kg-day)	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	4.86E-06	mg/kg-day	2.90E-02	1/(mg/kg-day)	1.41E-07
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	4.88E-06	mg/kg-day	6.10E-03	1/(mg/kg-day)	2.98E-08
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	5.96E-06	mg/kg-day	5.20E-02	1/(mg/kg-day)	3.10E-07
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	8.50E-06	mg/kg-day	1.10E-02	1/(mg/kg-day)	9.35E-08
	(Total)										5.74E-07
Dermal	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	1.26E-05	mg/kg-day	--	1/(mg/kg-day)	--
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	2.81E-05	mg/kg-day	--	1/(mg/kg-day)	--
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	2.26E-07	mg/kg-day	--	1/(mg/kg-day)	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	3.42E-07	mg/kg-day	2.90E-02	1/(mg/kg-day)	9.91E-09
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	2.23E-07	mg/kg-day	6.10E-03	1/(mg/kg-day)	1.36E-09
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	1.34E-06	mg/kg-day	5.20E-02	1/(mg/kg-day)	6.98E-08
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	5.33E-07	mg/kg-day	1.10E-02	1/(mg/kg-day)	5.87E-09
	(Total)										8.69E-08
										Total of Routes	6.61E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

TABLE 6-17 (RAGS D TABLE 8)
CALCULATION OF CANCER RISKS - ADULT RESIDENT INHALATION OF GROUNDWATER VAPORS DURING SHOWERING
REASONABLE MAXIMUM EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air
Exposure Point: Inhalation of Groundwater Vapors During Showering
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Inhalation	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	8.12E-06	mg/kg-day	--	1/(mg/kg-day)	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	6.45E-06	mg/kg-day	2.90E-02	1/(mg/kg-day)	1.87E-07
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	5.48E-06	mg/kg-day	8.10E-02	1/(mg/kg-day)	4.44E-07
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	6.10E-06	mg/kg-day	2.03E-03	1/(mg/kg-day)	1.24E-08
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	9.43E-06	mg/kg-day	6.00E-03	1/(mg/kg-day)	5.66E-08
	(Total)										7.00E-07
										Total Risk Across All Exposure Routes/Pathways	7.00E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

TABLE 6-18 (RAGS D TABLE 8)
CALCULATION OF CANCER RISKS - LIFETIME RESIDENT TAP WATER CONTACT WITH GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Tap Water Contact with Groundwater
Receptor Population: Resident
Receptor Age: Child/Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	5.55E-03	mg/kg-day	--	1/(mg/kg-day)	--
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	1.24E-02	mg/kg-day	--	1/(mg/kg-day)	--
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	6.66E-06	mg/kg-day	--	1/(mg/kg-day)	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	7.69E-06	mg/kg-day	2.90E-02	1/(mg/kg-day)	2.23E-07
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	7.73E-06	mg/kg-day	6.10E-03	1/(mg/kg-day)	4.72E-08
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	9.44E-06	mg/kg-day	5.20E-02	1/(mg/kg-day)	4.91E-07
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	1.35E-05	mg/kg-day	1.10E-02	1/(mg/kg-day)	1.48E-07
	(Total)										9.09E-07
Dermal	Barium	5.91E+02	ug/l	5.91E+02	ug/l	M	1.26E-05	mg/kg-day	--	1/(mg/kg-day)	--
	Manganese	1.32E+03	ug/l	1.32E+03	ug/l	M	2.81E-05	mg/kg-day	--	1/(mg/kg-day)	--
	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	2.26E-07	mg/kg-day	--	1/(mg/kg-day)	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	6.23E-07	mg/kg-day	2.90E-02	1/(mg/kg-day)	1.81E-08
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	3.85E-07	mg/kg-day	6.10E-03	1/(mg/kg-day)	2.35E-09
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	2.25E-06	mg/kg-day	5.20E-02	1/(mg/kg-day)	1.17E-07
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	9.15E-07	mg/kg-day	1.10E-02	1/(mg/kg-day)	1.01E-08
	(Total)										1.48E-07
										Total of Routes	1.06E-06

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

TABLE 6-19 (RAGS D TABLE 8)
CALCULATION OF CANCER RISKS - LIFETIME RESIDENT INHALATION OF GROUNDWATER VAPORS DURING SHOWERING
REASONABLE MAXIMUM EXPOSURE
WARMINSTER AREA B RI

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air
Exposure Point: Inhalation of Groundwater Vapors During Showering
Receptor Population: Resident
Receptor Age: Child/Adult

Exposure Route	Chemical of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Inhalation	1,2-Dichloroethene (cis)	7.09E-01	ug/l	7.09E-01	ug/l	M	8.12E-06	mg/kg-day	--	1/(mg/kg-day)	--
	Benzene	5.17E-01	ug/l	5.17E-01	ug/l	M	6.45E-06	mg/kg-day	2.90E-02	1/(mg/kg-day)	1.87E-07
	Chloroform	5.20E-01	ug/l	5.20E-01	ug/l	M	5.48E-06	mg/kg-day	8.10E-02	1/(mg/kg-day)	4.44E-07
	Tetrachloroethene	6.35E-01	ug/l	6.35E-01	ug/l	M	6.10E-06	mg/kg-day	2.03E-03	1/(mg/kg-day)	1.24E-08
	Trichloroethene	9.05E-01	ug/l	9.05E-01	ug/l	M	9.43E-06	mg/kg-day	6.00E-03	1/(mg/kg-day)	5.66E-08
	(Total)										7.00E-07
										Total Risk Across All Exposure Routes/Pathways	7.00E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

6.6 UNCERTAINTY ANALYSIS

The goal of the uncertainty analysis is to identify important uncertainties and limitations associated with the BHRA. Uncertainties are related to each component of the assessment (i.e., data collection/evaluation, exposure assessment, toxicity assessment, and risk characterization). The effect of a particular uncertainty on the outcome of the assessment (i.e., risk estimates) is also indicated, where possible.

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 Warminster Area B groundwater are noted in the following sections.

6.6.1 Uncertainties Associated with Data Collection/Evaluation

The time period of groundwater monitoring and areal extent of sampling points (including the number, location, and depth of wells) can add uncertainties to a risk assessment and impact the representativeness of the data. At Warminster Area B, over a decade of groundwater monitoring has been performed, and long-term characterization has indicated that concentrations of the principal substances of concern (chlorinated VOCs) are in the low micrograms per liter range and have not been observed to increase or decrease rapidly over numerous quarters of groundwater monitoring. In addition, a total of 53 wells were included in the June 1998 sampling round that was exclusively used for this risk assessment. For these reasons, the degree of uncertainty related to estimation of future groundwater risk using this Area B groundwater data set is minor.

6.6.1.1 Uncertainties Regarding the Selection of the EPC

Uncertainties exist regarding selection of a concentration for input into the quantitative risk assessment. The use of the exposure point 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 exposure point 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 exposure point concentration may overestimate the actual risk present in an exposure pathway at a particular area of interest. To help avoid this problem, the maximum value was used in place of the upper 95 percent confidence limit when the latter was higher.

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. To help avoid potentially overestimating risk, the maximum value was used in place of the upper 95 percent limit when the latter was higher.

6.6.1.2 Uncertainties in Manganese EPC

For manganese, the primary contributor to risk in this assessment, the EPC used in the risk calculation was based on the maximum value. However, close examination of the metals data set indicates that the manganese HI for individual wells exceeds 1.0 only in one well cluster, represented by samples HN-64S (shallow) and HN-64I (intermediate). The remaining positive manganese results in the data set would not contribute to an HI greater than 1.0, so the human health risks attributable to manganese in Area B groundwater are estimated appropriately only for groundwater usage at this one geographic well cluster and not in general across the rest of Area B wells. Therefore, the estimated risks from manganese exposures are overly conservative since manganese levels above the health-based benchmark (HI 1.0) were found in only one well cluster.

In addition, the manganese concentrations reported for well cluster HN64 are total not dissolved manganese levels. As indicated in Section 4 of this report, total metals results for Area B groundwater have varied significantly from one sampling round to another and are impacted by suspended solids in the samples which may be naturally occurring and may be a function of the sampling techniques employed. The maximum manganese level identified in the 1998 sampling results for well cluster HN64 (1,320 ug/l) is less than the site-specific total manganese background sample result (HN01S at 1,680 ug/l) identified in the Phase II RI (HNUS 1993). The HN64 well cluster results are also consistent with the regional or base-wide background manganese levels established in 1992, background range of 80 ug/l to 4,830 ug/l and a representative background concentration of 2,200 ug/l. This regional background level for total manganese was established by sampling fifteen area wells upgradient of NAWC study areas (HNUS 1993).

The presence of suspended solids in samples from well cluster HN64 add further uncertainty regarding the nature of the risk estimates calculated using the total manganese results. The field sampling records for this well cluster indicate that although low-flow purging was used, HN64I was purged dry after removing less than two well volumes. The sample was obtained after the water level in the well recovered but the turbidity readings in the well were 22 NTU as opposed to 8 NTU in well HN01.

Considering base-wide background levels, the variability of total metals results from sample round to sample round and the presence of suspended solids, it does not appear that total manganese levels identified in the 1998 comprehensive sampling round are site related. The estimated risks from manganese exposures calculated for Area B groundwater are indicative of background risks and are associated with suspended solids in the groundwater samples.

6.6.1.3 Uncertainties in Analytical Database Usability

The results of the data usability evaluation for groundwater shows that data quality assessment problems are not generally associated with substances of concern in Area B groundwater. Two data usability issues for the quantitative BLRA are listed below:

1. Quantitation and/or method detection limits for several chemicals were elevated above applicable screening levels. However, the inclusion of these data in the quantitative BLRA were determined to have little to no impact on estimated risks.

2. Rejected results occurred for three chemicals that are not historically present above risk-based screening levels.

3. The treatment of blank-affected results as non-detects is also not expected to impact the risk assessment. This is because the maximum positive sample result was much greater than the maximum blank-affected result for substances that were confidently detected and, in other cases, the maximum blank-affected result was normally of a magnitude less than risk-based screening levels.

6.6.1.4 Uncertainties in Risk-Based Screening Levels

The use of single-route (ingestion) risk-based screening concentrations may lead to the underestimation of risks since these values do not account for the additive effects across various exposure pathways. However, the resultant effects on risks is not expected to be significant because conservative values, derived from a target Hazard Index of 0.1 for noncarcinogens and a target risk of 1 x 10-6 for carcinogens, were employed.

6.6.2 <u>Uncertainties Associated with Exposure Assessment</u>

Major uncertainties associated with Exposure Assessment are listed below.

6.6.2.1 Exposure Scenarios

The likelihood of the occurrence of the defined exposure scenarios is not always known. Identified land use and activity patterns at a site are limited to the observations made during the field investigation and known land uses in the surrounding area. The future anticipated land use at Warminster Area B is expected to be recreational or residential, since the surrounding area is already residential. The more conservative approach was taken to assume only residential exposures. Therefore, the uncertainty associated with the selection of exposure scenarios and potential receptors is not expected to be significant.

6.6.2.2 Exposure Equations

There are limitations to using various models and/or equations to estimate exposure doses or contaminant concentrations.

For estimation of dermal exposures to groundwater, 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 variability's 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.

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. The chemical-specific parameters such as vapor pressure and solubility were not always obtainable at the desired temperature. Most of the inputs into the models were considered conservative; therefore, the output may overestimate the exposure for this route.

Uncertainties associated with the use of a single round of groundwater sampling include the assumption that current conditions are indicative of future concentrations of contaminants. However, many rounds of quarterly monitoring data have shown that contaminants are not increasing (due to migration, sediment loading, or chemical transformation) and one at steady-state or decreasing (due to migration or transformation) over time.

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 data or professional judgment) were used in combination with average values.

In general, the underestimation of risks was prevented using conservative exposure assumptions and exposure concentrations. Although maximum concentrations are not a reasonable estimate of the concentration expected to be experienced by a receptor over time, the use of these values does provide a highly conservative estimate of risk to potential receptors. For highly skewed distributions, the maximum concentration could be less than the upper 95 percent confidence limit on the mean. In these cases, the maximum would be considered a reasonable estimate of the concentration expected to be experienced by the receptor over time because of the uncertainty associated with the highly skewed data set.

6.6.3 Uncertainties Associated With Toxicity Assessment

6.6.3.1 RfDs and SFs

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 RfD 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.

There are uncertainties regarding nonthreshold (carcinogenic) effects extrapolation from the high doses administered to laboratory animals to the low doses received under more common human exposure scenarios. Uncertainties due to short-time toxicological study predictions of long-term effects are also present. Additionally, there is considerable interspecies variation in toxicological endpoints used in characterizing potential health effects resulting from exposure to a chemical, and there is considerable variability in sensitivity among individuals of any particular species.

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.

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. In general, dermal exposures at Crater Resources did not drive the carcinogenic or noncarcinogenic risks, therefore, the effects of this uncertainty are expected to be minimal.

As discussed in Section 6.4.2, established RfDs have an inherent amount of uncertainty. Uncertainty factors for RfDs used in this BHRA are presented on Table 6-6 and Table 6-7. In addition, available data do not indicate the speciation of manganese, which is a primary risk driver for Area B groundwater. However, divalent manganese (2+) is about 2.5 to 3 times more toxic than is manganese (3+) and it has been shown that the anion of a manganese salt influences the overall manganese toxicity (Venugopal and Luckey, 1978).

6.6.4 Uncertainties Associated with Risk Characterization

Major uncertainties associated with Risk Characterization are listed below.

ICRs and HIs are summed for all potential COPCs and for all applicable routes of exposure. Summing the risks implies that no antagonistic or synergistic effects exist between chemicals that are not otherwise documented to affect the same target organ(s). It also assumes that similar mechanisms of action and metabolism are prevalent. Therefore, the use of this approach may either underestimate or overestimate the risks, depending on the chemical-specific interactions, which cannot be predicted. The direction of the uncertainty cannot be defined, but the methodology used is based on current EPA guidance.

Risks to any individual may also be overestimated by summing multiple assumed exposure pathway risks for any single receptor. Although every effort was made to develop reasonable scenarios, not all individual receptors may be exposed via all pathways considered (for example, inhalation risks may not be applicable for some individuals).

7.0 SUMMARY AND CONCLUSIONS

7.1 GROUNDWATER FLOW

Groundwater flow direction in the shallow, intermediate and deep aquifers identified in the vicinity of Area B sites 5, 6 and 7 is to the south and southeast. The overall vertical gradient is downward. The lowest groundwater elevation observed within Area B is similar to the base level of the closest tributary to Southampton Creek. Groundwater flow in the upper Stockton units is controlled by topography and stream locations.

7.2 GROUNDWATER USE

Residents near Area B rely entirely on groundwater sources for their water supply. The nearest residential supply wells, located approximately 1/2 mile southwest of Area B, are not considered to be potential receptors of groundwater from Area B because they are not downgradient. The nearest active municipal supply wells are located over 1/2 mile south and east of Area B and are also not considered to be receptors of groundwater from Area B. None of these supply wells are directly downgradient of Area B and groundwater flow from Area B is expected to follow and/or discharge to tributaries to Southampton Creek located between Area B and these wells. In addition, long-term water level monitoring indicates that the pumping of these wells has no effect on Area B groundwater levels.

7.3 GROUNDWATER QUALITY

Low-level VOC contamination has been identified in Area B groundwater. The VOC contamination has been extensively studied and monitoring over the last sixteen years. The most recent comprehensive sampling of Area B groundwater identified TCE levels above the MCL in one single well. No other VOC was detected above any MCL in any well.

A TCE contamination plume was projected in 1993 based on MCL exceedances in three wells, HN03S, HN36S, and HN37S. Sampling and analysis performed during a 72-hour pumping test conducted in 1994 in the central portion of the projected plume did not detect any VOC above MCLs. Initial implementation of an interim remedy pump and treatment system in the downgradient portion of the projected plume did not detect any significant contamination. TCE was found in one sample only at levels approaching the analytical detection limits. Subsequent sampling results from wells within the projected plume area do not indicate that a TCE plume

exists. In addition, results from long-term monitoring of wells immediately downgradient of the area indicate that TCE has not migrated from the area.

7.4 HUMAN HEALTH RISK SUMMARY

Area B groundwater does not pose an unacceptable risk due to site related contamination.

The estimated RME lifetime cancer risk associated with the potential residential use of Area B groundwater is 1.8×10^{-6} (child 4.0×10^{-7} and adult 1.4×10^{-6}). This estimated risk is at the lower end of the EPA target range (1×10^{-4} to 1×10^{-6}).

The estimated RME HI for a resident child using Area B groundwater is 4.1. The estimated adult RME HI was calculated as 1.8. An evaluation of the contaminants, and the potential risks presented by each, indicates that manganese is the only contaminant that presents a potential risk greater than 1.0.

Manganese concentrations responsible for the estimated noncancer risks are typical of regional and base-wide background levels. The estimated elevated risks are based on total manganese results from one well cluster. The groundwater sample collected from this well contained suspended particles that were related to the sampling technique used during the investigation. Similar and higher levels of manganese have been detected in site-specific and base-wide background samples. The estimated risk associated with manganese concentrations in Area B groundwater is considered to be a background risk for the area and not associated with Area B contamination.

7.5 CONCLUSIONS AND RECOMMENDATIONS

Area B groundwater does not pose a significant risk to human health or the environment. It is recommended that no further action be taken in regard to Area B groundwater.

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APPENDIX A

DRILLING LOGS AND MONITORING WELL DETAILS

NAWC WARMINSTER AREA B

MONITORING WELL BORING LOGS

SMC ENVIRONMENTAL SERVICES GROUP

DRILLING LOG

PROJECT NADC OWNER Navy

LOCATION Site 6 W.O. NUMBER 9710-40001

WELL NUMBER BG-7 (HN-01S) TOTAL DEPTH 37' DIAMETER 6"

SURFACE ELEV. / WAT. LEV.: INIT. 28.65' 11/13/90 ~~24 HRS~~ 24.40'

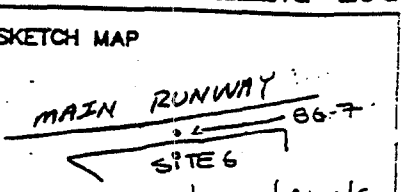
Open Hole: DIA. 6" LENGTH 18.15'-37' SLOT SIZE NA

CASING: DIA. 6" LENGTH 0-18.15' TYPE PVC

DRILLING COMPANY C.S. Garber DRILLING METHOD Air Rotary

DRILLER K. Levan LOG BY PDB DATE DRILLED 11/1/90 11/2/90

SKETCH MAP



-water levels were measured from top of inner casing.

NOTES

SHALLOW BEDROCK WELL

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	PID SAMPLE NUMBER	FID	DESCRIPTION / SOIL CLASSIFICATION (U.S.C.S) (COLOR, TEXTURE, STRUCTURES, MOISTURE, OVA READING)
			ND	ND	0-1' Brown organic silt (OL)
	SOIL				1-7' Orange-brown sandy silt. Dry
7					7-11' Light tan medium grained arkosic sandstone. Dry.
		18.15' CASING			11-13' Orange-tan fine grained arkosic sandstone. Dry. Came to surface as sand-granule sized particles
	BEDROCK	OPEN HOLE			13-16' Light tan medium grained quartzitic sandstone. Came to surface as sand-granule sized particles
					16-24' Light pink sandy shale. Dry. Friable.
					24-25' Grayish brown medium grained arkosic sandstone. Dry.
37					25-37' Brownish-red sandy siltstone. Came to surface as granule particle
		2' BENT. SEAL; B/C GROUT. PROTECT. CASING & LOCK. CAP SEE work plan for specs.			* Casing set at 18.15'

Hydrogeology

- No water detected at soil / bedrock interface
- Water hit at approximately 30'
- Yield is < ½ gpm
- Two feet of water collected in hole in three minutes

01 86001

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-01 I
PROJECT NO.: 0159 — DATE: 11-11-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					OR	CLAY		
	3					bN	SILTY CLAY		
	7					TN	f. gr. SS		ARKOSIC
	13			8" at 12 ft.		RD-BN	MUDSTONE		SOFT
1009	17								BEGIN ADDING H2O TO Borehole
	18					BN	SILTSTONE/f. gr. SS		
									CUTTINGS "CLUMPED"; NO H2O flow from hole
	21					RUST RD-BN	MUDSTONE		
									SOFT
	25						LITHOLOGY AS Above		
	33					RD-BN	SILTSTONE		
1025	38					LT. TO RD. BN	SILTSTONE + SS		HARDER DRILLING;
						& GY			PICK-UP 1-2 GPM
1030	42					PK. GY	f. gr. SS		
	45					LT. BN & GY	f. gr. SS		IRONOXIDE STAINING
1040	48								YIELD ~4 gpm

REMARKS

BORING HN-1

PAGE 1 OF 2

* See Legend on Back

PROJECT: _____ BORING NO.: HN01I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	51					RD, BN	SILTSTONE		large fragment
	52					LT. BN	f. gr. SS		
	55								
1049						TN	f. gr. SS		some coarse, angular, quartz
	58					TN	f. gr. SS		
	61					LT. BN	f. gr. SS		LIGNITIC FILM
	63					RD. BN	SILTSTONE		
	64					LT. BN + TN	f. gr. SS.		YIELD ~5 gpm. FRACTURE at 64.5
1057	68					RD. BN	SILTSTONE		
									~5 gpM TOTAL YIELD
1109	80					RD. BN	SILTSTONE		
	84					PK. GY	f - gr. SS		
	87								Pick up ~4 gpM
1124	89					RD. BN	SILTSTONE/f-gr. SS		
	93					RD. BN	SILTSTONE/f-gr. SS		
	97					RUST RD	MUDSTONE		
	103			TD					YIELD ~ 8-9 gp

REMARKS _____

BORING HN-01

PAGE 2 OF 2

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-01 D
PROJECT NO.: 0159 — DATE: 11-9-93 — DRILLER:
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					OR	SILTY CLAY		
	4					BN	SILTY CLAY		
	5					TN	f. gr. SS; arkosic		large fragments
	8								DRY
				8" at 12 ft					
1015	17					RD.BN	SILTSTONE		
	20					BN	SILTSTONE/f. gr. SS		
1020	22					RD.BN	SILTSTONE		
1029	36			*		RD.BN + GY	SILTSTONE		4-5 gpm
									NO HNU > BK
	42					RD.BN	SILTSTONE		
1043	45					LT.BN	f. gr. SS		
	48					PK-GY	f. gr. SS		
	50					TAN	f. gr. SS		

REMARKS

BORING HN 1

PAGE 1 OF 3

* See Legend on Back

BORING LOG HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN 01D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS (6" OR RQD (%))	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	52					LT. GY	F. gr. SS		
	56					TAN	F. gr. SS		
1105	59						Lithology as Above		
	61								Lignitic film
	63					GY	f. gr. SS		
	65					TN/GY	f. gr. SS		
1115									
	71					RD. BN	SiLTSTONE		
									Gain water TO
									~10 gpm
1124	77					RUST RED	SiLTSTONE		
1131	83					BN	SiLTSTONE		
	87					RD. GY + BN	F. gr. SS		
	88								YiELD ~15 gpm
1142	92					BN	SiLTSTONE / f. gr. SS		
1151	98					RUST RED	MUDSTONE		

REMARKS _____

BORING HN-01

PAGE 2 OF 3

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN01D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1324	112					RD	SILTSTONE		
1327	117					RD.BN	SILTSTONE		
1350	128								Pick up ~2 gpm
1357	132					PK-GY	f. gr. SS		No HNU > BK
	135					RD.BN	SILTSTONE		
					X	GY	f. gr. SS		
1406	138					PK-GY	f. gr. SS		
	141					RD.BN	SILTSTONE		
					X	GY	f. gr. SS		
	145					BN	SILTSTONE		
1425	152								YIELD ~ 18 gpm

REMARKS _____

BORING HN01D

PAGE 3 OF 3

* See Legend on Back

SMC ENVIRONMENTAL SERVICES GROUP

DRILLING LA

PROJECT NADC OWNER Navy

LOCATION Site 5 W.O. NUMBER 9710-40001

WELL NUMBER DG-27 (HN-02X) TOTAL DEPTH 13.8' DIAMETER 4"

SURFACE ELEV. / WAT. LEV.: INIT. 13.2' 24-HRS 9.75

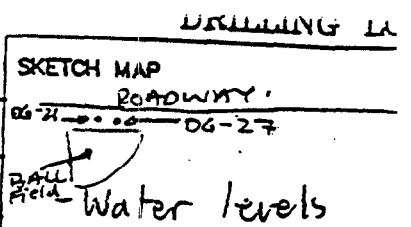
SCREEN: DIA. 4" LENGTH 8.2-13.2' SLOT SIZE 0.020

CASING: DIA. 4" LENGTH 0-8.2' TYPE PVC

DRILLING COMPANY C.S. Garber DRILLING METHOD Auger

DRILLER B. Stoudt LOG BY PDB DATE DRILLED 11/14/90

SKETCH MAP



Water levels measured from top of inner casing

NOTES

OVER BURDEN WELL

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	PID / SAMPLE NUMBER	BLOW COUNT/	DESCRIPTION / SOIL CLASSIFICATION (U.S.C.S) (COLOR, TEXTURE, STRUCTURES, MOISTURE, OVA READING)
1	OVERBURDEN		ND	10	0-0.5' Dark brown clayey silt loam
2				14	0.5-1.0' Orange-tan clay and silt, moist
3				15	1.0-2.9' Gleyed and mottled clayey silt Moist.
4.2				26	
5				9	2.9-4.0' Orange-tan silt. Compact, wi thin organic layers.
6.2				34	
7				50+	4.0-5.2' Dark brown quartz sand with silt matrix. Dry.
8.2				45	
9				50+	5.2-6.8' Dark purple micaceous sandy silt. Dry
10				26	
11				50+	6.8-9.0' Dull purple compact, dry arkosic sand.
12				50+	
13				Refusal	9.0-10.5' Brown medium-coarse grained weathered sandstone. Gravel also present. Wet.
13.2					
14					11.0-11.8' Dull purple coarse grained arkosic sand. Wet
					13.0-13.8' Semi-Lithified dull purple coarse grained arkosic sand. Dry

Grout, Bent, #1 SAND PACK

Hydrogeology

- Hit water at 9'
- Well yield = ½ gpm
- Well was developed with a 4" submersible pump.

013 9018 86001

SMC ENVIRONMENTAL SERVICES GROUP

DRILLING LOG

PROJECT NADC OWNER Navy

LOCATION Site 5 W.O. NUMBER 9710-40001

WELL NUMBER DG-21 (HN-025) TOTAL DEPTH 33' DIAMETER 6"

SURFACE ELEV. / WAT. LEV.: INIT. 11.51 11/13/90 ~~24 HRS~~ 10.47'

Open Hole: DIA. 6" LENGTH 15-33' SLOT SIZE NA

CASING: DIA. 6" LENGTH 0-15' TYPE PVC

DRILLING COMPANY C.S. Garber DRILLING METHOD Air Rotary

DRILLER E. Williams LOG BY PDB DATE DRILLED 11/6/90 11/7/90

SKETCH MAP

see DG-27 sketch map.

~Water levels were measured from top of inner casing.

NOTES

SHALLOW BEDROCK WELL

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE NUMBER	PID	FID	DESCRIPTION / SOIL CLASSIFICATION (U.S.C.S) (COLOR, TEXTURE, STRUCTURES, MOISTURE, OVA READING)
	SOIL 6	← 15' CASING	ND	ND		0-3' Brown organic silt (OL). Dry
						3-6' Maroon red sandy silt (ML). Dry
	BEDROCK					6-11' Saprolitic purple-brown arkosic Sandstone. Moist at 11'
						11-31' Purple-brown medium grained arkosic sandstone. Wet at 28'
33						31-33' Dark gray fine-medium grained arkosic sandstone. Dry
		OPEN HOLE				* Casing set at 15'
		2' BENT. SEAL W/ GROUT + WELL CELLAR PROTECT. CASING W/ LOCKING CAP. SEE WORK PLAN WELL S/DEG.				Hydrogeology
						- Water detected at saprolite / competent bedrock interface
						- Hit water at 28'
						- Well yield = < ½ gpm
						- 3' of water collected in 4 minutes
						- Water was run down the well during development to purge the well of sediment.

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-02I
PROJECT NO.: 0159 — DATE: 11-29-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: KC Kilmartin
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					LT. BN	SILTY CLAY		
	4					DK. BN	CLAYEY SILT		
	5					DK. BN	CLAYEY SILT / rock frags		Perched water ~8 ft
	9					RD. GY	SILTSTONE / f. gr. SS		moderately to highly fractured
	11					RD. GY	f. gr. SS		more competent
	14					RD. GY	SILTSTONE		
				8" at 14 ft.					
	20					DK. GY	V.f. gr. SS + SILTSTONE		DRY; HNU (BK) = 0.5
1001	25					LT. BN	V.f. gr. SS		No HNU > BK
	27			*			CUTTINGS DAMP; NO DUST		H2O zone
1004	28						No H2O flow from borehole		
1010	33					BN	SILTSTONE with CLAY		NO HNU > BK
							"TIGHT DRILLING"		DAMP
1015	35						Cuttings DRYING UP →		DUSTY
1020	38			*		LT. BN	CLAYEY SILTSTONE		~ 1 gpm
							grading TO ↓		
1025	43					LT. GY	f. gr. SS w/ QUARTZ		NO HNU > BK
1033	45						LITHOLOGY AS ABOVE. DRILLING SKIP = FRACTURE ?		~2 gpm TOTAL
	50			*		DK. GY	SILTSTONE TO V.f. gr. SS		DRILLER BEGINS ADD HGPM TO hole

REMARKS

BORING

PAGE ___ OF ___

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN02I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS (/6" OR RQD (%))	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1045	53								Blow ~10 gal after rod connection
1050	55								Yield ~4 gpm
1052	57						Driller notes fracture.		Decrease in borehole flow
1055	63					RD. BN	Claystone/mudstone		Very little H2O flow from borehole
1059	68						Bit chatter increases		Yield ~.1 gpm
1102	70						Siltstone to v.f.-gr. SS		Yield ~2 gpm
1106	75						harder drilling		Yield ~3 gpm
1112	78								Blow 5-10 gal after rod connection
1115	80						Yield steady at ~3 gpm		
1122	83						Slight increase in yield?		
1125	85			*					Noticeable increase in yield to 5-6 gpm
1131	88								Yield ~6-8 gpm
1131	90						Possible fracture		Decrease in yield to 2-3 gpm
1136	94						Bit chatter increases		Yield 4-5 gpm
1140	98						Q = grayish		Yield ~5 gpm
1142	100			*			Possible fractures		Yield ~5 gpm
1143	101						Sig. increase in yield		Yield ~6-8 gpm
1146	103			TD					

REMARKS Blow H2O from hole until 12:15. Driller feels yield may be decreasing slightly (losing H2O)

BORING HN-02I

PAGE 2 OF 2

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-02 D
PROJECT NO.: 0159 — DATE: 11-10-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. or USCS	REMARKS
	2					LT.BN	SILTY CLAY		
	4					BN	SILTY CLAY		channery
	9					RD.GY	SILTSTONE		Perched H_2O at 8.5
									BEDROCK = DRY
	13					RD.GY	SILTSTONE		
1016	18			8" at 14 ft.		BN	f. gr. SS/SILTSTONE		
	21					RD.BN	SILTSTONE		RUST STAINS on SOME FRAGMENTS
	26					LT.BN	f. gr. SS		
1025									
	31					REDDISH, GY-BN	f. gr. SS		
1033									
	34					LT.BN	f. gr. SS		
	39					RD.BN	f. gr. SS		
	41					REDDISH, GY-BN	f. gr. SS		
1046				*					
	46					TAN	f. gr. SS		SOME RUST STAINS, 1-2 gpm ?
1052	50					PK.GY	f. gr. SS		

REMARKS

BORING HN-02

PAGE 1 OF 3

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-02D
PROJECT NO.: 0159 — DATE: 11-10-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	51					RD.BN	Siltstone		
	55					RD-GY BN	Siltstone		
1100	58					PK.GY	f. gr. SS		Fracture? Quartz crystals
	60					RD.BN	Siltstone		
1107	66					RUST RD	Mudstone (some green + white clay)		2 gpm Total
1113	75					RD.BN	Siltstone		
1120	79					RD.GY	Siltstone/v.f.gr.SS		
	83					PK.GY	f. gr. SS		No HNU > BK
	87						Lithology as Above		
	89								Possible fracture
	92					RD, GY-BN	f. gr. SS		
1140									
	95						Lithology as Above		
	98			*		RD, GY-BN	f.gr.SS/some siltstone		Fracture, Large rock frags w/ calcite

REMARKS

BORING HN- 1

PAGE 2 OF 3

* See Legend on Back

BORING LOG

PROJECT: _____ BORING NO.: HN02D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	101					PK.GY	f. gr. SS		
1151	103								Yield ~ 6 gpm
	105					PK, GY, BN	f. gr. SS		large fragment
	109					RUST RD-BN	MUDSTONE		
1328	116					RD, GY-BN	f. gr. SS; whitish clay		
1331	121								Yield up to 10-12gf
									(gain 4-5 gpm
									Through the 120's
1335	128					LT.GY	f. gr. SS		large fragment
1344	135					RD.BN	SILTSTONE		
	143					RD.BN	SILTSTONE		
					X	PK. TO LT. GY	f. gr. SS		
									TOTAL YIELD ~12g
	149					RUST RD	MUDSTONE		NO HNU > BK
	153			TD					

REMARKS _____

BORING HN-02

PAGE 3 OF 3

* See Legend on Back

JRB ASSOCIATES, INC.
8400 Westpark Drive, McLean, Virginia 22102

WELL LOG

PROFILE	DESCRIPTION
0	TOPSOIL/VEGETATION
1	YELLOW TAN SANDY LOAM. STIFF. DRY. SOME SANDSTONE FRAGMENTS
2	
3	VERY HARD SANDSTONE LAYER
4	BROWN SANDY LOAM HARD DRY
5	SPLIT SPOON 5'-5.1' 50/.1'
6	
7	VERY HARD BROWN SANDSTONE. ALTERNATING HARD AND SOFT LAYERS. LARGE ROCK FRAGMENTS IN CUTTINGS.
8	WATER.
9	
10	AUGER REFUSAL.
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

PROJECT NADC WARMINSTER, PA

OWNER NAVAL AIR DEVELOPMENT CENTER

WELL NO. D6-8 (HN-03X)

LOCATION ACROSS FROM NAVAL HOUSING SOUTH OF BATTLEFIELD & NORTH OF DRAINAGE DITCH. DOWNGRADIENT SITE #5

	Date	Time
DRILLING STARTED	7/19/82	[illegible]
DRILLING COMPLETED	7/19/82	[illegible]

DRILLER [illegible] CISLER

GEOLOGIST ED TOKARSKI JRB

RIG TYPE MOBILE B-56.

REFERENCE POINT LAND SURFACE

R.P. ELEVATION 332.4

TOPO POSITION FLAT LANDS

PROFILE BY [illegible]

FIELD BOOK NO. 1 PAGES 44-45

WELL DATA

HOLE DIAMETER 6" O.D.

HOLE DEPTH 10'

CASING DIAMETER 2" I.D.

CASING LENGTH 5.28'

SCREEN DIAMETER 2" I.D.

SCREEN SETTING 9.87' - 5.6'

SCREEN SLOT/TYPE 10-SLOT/MICRONESH (2.15/2.15' STAINLESS STEEL - JOHNSON)

PUMP TEST DATA

STATIC DEPTH TO WATER 2.39 // 4.94

DATE MEASURED 7/25/82 // 9/9/82

PUMPING DEPTH TO WATER SAME

TEST DURATION —

PUMPING RATE —

TEST DATE 9/9/82

TEST TYPE RAPID TEST

PUMP SETTING —

SPECIFIC CAPACITY SEE REPORT.

REMARKS

UNABLE TO PENETRATE VERY HARD SS LAYER AT 10' WORN 2 AUGER TEETH. NO PENETRATION

SMC ENVIRONMENTAL SERVICES GROUP

DRILLING LO

PROJECT NADC OWNER Navy

LOCATION Site 5 W.O. NUMBER 9710-40001

WELL NUMBER DG-20 (HHU-035) TOTAL DEPTH 32' DIAMETER 6"

SURFACE ELEV. WAT. LEV.: INIT. 30.1' 11/13/90 ~~24 HRS~~ 7.13

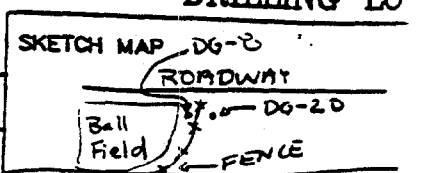
Open Hole: DIA. 6" LENGTH 17.6 - 32' SLOT SIZE NA

CASING: DIA. 6" LENGTH 0 - 17.6' TYPE PVC

DRILLING COMPANY C.S. Garber DRILLING METHOD Air Rotary

DRILLER E. Williams LOG BY PDB DATE DRILLED 11/6/90 11/7/90

SKETCH MAP



- Water levels were measured from top of inner casing

NOTES

SHALLOW BEDROCK WELL

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	PID SAMPLE NUMBER	FID	DESCRIPTION / SOIL CLASSIFICATION (U.S.C.S.) (COLOR, TEXTURE, STRUCTURES, MOISTURE, OVA READING)
	SOIL		ND	ND	0-3' Yellow-tan silty sand (SM)
4					3-4' Dark brown clayey silt (ML). Slight moist.
					4-8' Light brown fine to medium grained arkosic sandstone. Dry
		17.6' CASING	.5		8-13' Light brown medium to coarse grained arkosic sandstone. Dry
	BEDROCK		1.5		13-17' Olive-tan medium grained arkosic sandstone. Iron rich grains are oxidized. Dry
			ND		17-19' Grayish-white fine to medium grained arkosic sandstone. Dry
					19-28' Brownish-red micaceous siltstone. Wet at 27'.
					28-29' Buff medium grained quartzitic sandstone. Dry
					29-30' Dark red coarse grained arkosic sandstone.
32		OPEN HOLE			30-32' Dark red micaceous siltstone. Dry
		8 SEAL w/c GROUT BOT. CASING w/ locking CAP			* Casing set at 17.6'

Hydrogeology

- Soil / bedrock interface was moist
- Well yield = 1 gpm
- Water was hit at 27'

SEE work plan well specs.

01 8 86001

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-03I
PROJECT NO.: 0159 — DATE: 11-24-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					LT. BN	CLAYEY SILT		
	2					LT. BN			
	5					RD-BN	SILTSTONE		
	7					LT. BN ← GY	M. GR. SS		
0917	8			8" at 7 ft		TN	f. gr. SS		very weathered
	16					PK-GY	v. f. gr. SS		
	21					LT. BN	f. gr. SS		
	43					BN	v. f. gr. SS		
	48					PK-GY	f. gr. SS.		

REMARKS

BORING HN-1

PAGE 1 OF 2

* See Legend on Back

BORING LOG HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN03I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS (6" OR RQD (%))	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
0944	53					PK-GY	f. gr. SS		MICA
	58					PK-GY	f. gr. SS (slightly coarser-grained)		
0948	63								1 gpm ?
	65					RUST RD-BN	MUDSTONE / minor f. gr. SS		chlorite
	78					RUST RD	MUDSTONE		
					&	PRP	SILTSTONE		
1000	83								YIELD ~ 2 gpm
	85					GY	f. gr. SS		Gain 2-3 gpm
	98					RUST RD+BN	SILTSTONE		calcite + chlorit
1012	103					RUST RD+BN	SILTSTONE		Some calcite
									YIELD ~ 7 gp

REMARKS _____

BORING HN-0

PAGE 2 OF 2

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-03D
PROJECT NO.: 0159 — DATE: 11-23-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					LT. BN	SILTY CLAY		
	2					LT. BN	M.-C. GR. SS		
	6					LT. BN	M.-C. GR. SS		1ST H2O
				8" at 8 ft					
	16					RD-BN & PRP	SILTSTONE/f. gr. SS		
1102	18					BN	V. f. gr. SS		
	25								Gain ~1.5 gpm
	28					BN	V. f. gr. SS		
1112	33					BN	SILTSTONE/V.f. gr. SS		
1117	43					RD-BN	SILTSTONE		YIELD ~1.5-2 gpm
	46					RUST RD-BN	SILTSTONE		

REMARKS

BORING HN-1

PAGE 1 OF 4

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HW03D
PROJECT NO.: _____ DATE: _____ DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK SR. OR USCS	REMARKS
1127	51					GY	f. gr. SS		
1130	58					GY	f. gr. SS		
1133	63								Yield ~ 2-2.5 gpm
									No HNU > BK
	67					RUST RD-BN	Siltstone		
1143	73					GY	f. gr. SS		
	78					GY	f. gr. SS (coarser)		
1149	83					GY	f. gr. SS		
					X	RUST RED	Siltstone		
	85					GY	f. gr. SS		
	88					PK-GY	v.f. gr. SS		
1200	93					LT.GY	f. gr. SS		Gain 1-2 gpm ?
									No HNU > BK

REMARKS _____

BORING HW-03

PAGE 2 OF 4

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN03D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	103					RUST RD-BN	Mudstone with chlorite + kaolinite		Yield ~ 8 gpm
1213	108					RD-BN	Siltstone/v.f. gr. SS		
1217	113					RD-BN	Siltstone/v.f. gr. SS		"Sparkling" MICA
1221	123					RD-BN	Siltstone		Yield ~ 8-10 gpm
					&	PK-GY	f. gr. SS		
	128					RD-BN	Siltstone		Gain 3-4 gpm
1237	133					RD + GY-BN	V.f. gr. SS		
1250	143					PK + GY-BN	V.f. gr. SS		Yield ~ 12 gpm
							Some calcite + mica		
	146					RUST RD-BN	Siltstone		
							Some calcite + chlorite		

REMARKS _____

BORING HN-03

PAGE 3 OF 4

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN03D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, FT.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1309	158					PK-GY	f. gr. SS		
1311	163					PK-GY	f. gr-SS		YIELD ~ 12 gpm

REMARKS _____

BORING HN-03

PAGE 4 OF 4

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-04S
PROJECT NO.: 0159 — DATE: 12-2-93 — DRILLER:
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					OR	CLAY		
	7						Rock fragments		
	8					RUSTY BN	MUDSTONE		
1125	11					RUSTY BN	MUDSTONE		DRY
				8" at 12 ft					
	13					RD.BN	v.f. gr. sandstone/siltstone		
	15								DUSTY
1129	18					RD.BN	v.f. gr. SS		Damp; hard Dri[illegible]
	22								CUTTINGS We[illegible]
1135	23			*		BN	v.f. gr. SS (SILTY)		2 GPM at 22.5
	25					BN	f. gr. SS - rust staining		Fracture, Large fragment
	27					BN-GY	f. gr. SS		Yield ~ 12 gpm
1142									
	33					BN-GY	f. gr. SS w/rust staining		No HNU > BK
1158	35								Yield ~ 15 gpm

REMARKS

BORING HN-1

PAGE 1 OF 1

* See Legend on Back

BORING LOG — **HALLIBURTON NU.**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-04I
PROJECT NO.: 0159 — DATE: 11-24-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					OR	CLAY		MOIST
	4					RUSTY BROWN	CLAY		
	8					RUSTY BROWN	MUDSTONE		
	12					RUSTY BROWN	MUDSTONE		DRY
				8" at 12 ft					
	16					PK-GY	V. f. gr. SS		
1327									
	26					RD-PURP	f. gr. SS; SILTY		5 gpm
									Large fragment
	33					GY	f-gr. SS; SILTY		12 gpm
1336	38					LT. BN & GY	f. gr-SS		NO HNU > BK
1338	43					LT. BN	M.-C. gr. SS		
	48					RUST RD-BN	MUDSTONE		

REMARKS

BORING HN-01

PAGE 1 OF

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN04I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1345	53					RD.BN	MUDSTONE/f.gr.SS(SILTY)		
1347	58								
1348	63					RD.BN	V.f.gr.SS (SILTY)		
	66								Pick-up 2 gpm
	68					RD.BN	SILTSTONE/V.f.gr.SS		
1356	73					RD.BN	V.f. gr. SS		
									FAST, QUIET drilling
	78					BRIGHT RUST-RD	MUDSTONE		SOFT
									Possible H2O
									Zone
1400									
	85					RD.BN	V.f. gr. SS (SILTY)		
1407	88					RD.BN	V.f. gr. SS (SILTY)		Fracture
							with calcite		
1412	93					RD.BN	V.f.gr. SS (SILTY)		
	97								Possible water increase
	103						Vf - f. gr. SS		YIELD 20-25 GPM NO HNU > 3K

REMARKS _____

BORING HN-1

PAGE 2 OF 2

* See Legend on Back

PROJECT: NAWC WARMINSTER BORING NO.: HN-04D
PROJECT NO.: 0159 DATE: 11-16-93 DRILLER:
ELEVATION: FIELD GEOLOGIST:
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
						RUST BN	CLAY		
							↓		
							▽		
	7					RD	MUDSTONE		
									IRON-OXIDE STAINING FRACTURED
	11					RD	MUDSTONE		
908	12			8" at 12ft		RD-BN	SILTSTONE		
	21					TAN	f. gr. SS		
	23					LT. BN	SILTSTONE / f. gr. SS		
916	25								Fracture, 1-2 gpm
	29					LT. BN	f. gr. SS		
924	32					GY + LT BN	f.-m. gr. SS		
	35					GY & LT BN	f.-m. gr. SS		YIELD 5-6 gpm
929	38					GY & LT BN	M. gr. SS		Some QTZ pebbles
									39-48 fractured interva
933									
	48					RD BN	SILTSTONE		

REMARKS

BORING HN-04

PAGE 1 OF 4

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN04D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR ROD (ft.)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK QR OR USCS	REMARKS
937	53					RD.BN	f. gr. SS		YIELD 5 gpm
	55								ADD 1-2 gpm
943	56						SILTSTONE		
	59								~ 20 ppm
951	63					RD.BN	SILTSTONE		
954	68					RD.BN	SILTSTONE		
	70					PK-GY	f. GR. SS		
	72					RUST RD	MUDSTONE		
	81					RD.BN	SILTSTONE		
1019	83						SILTSTONE/ f. gr. SS		
	86					GY & RD-BN	SILTSTONE/ f. gr. SS		GAIN 1-2 gpm ?

REMARKS _____

BORING HN-1.D

PAGE 2 OF 4

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN04D
PROJECT NO.: _____ DATE: _____ DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1045	103					PK-GY	v. f. gr. SS		
	105						f. gr. SS		Pick-up 1-2 gpm
	108								Yield 10-12 gpm
	111					PK-GY	f. gr. SS (slightly coarser grained)		Pick-up 2-3 gpm
1107	115								Fracture
	122					BN	F. GR. SS		
	125								Pick up 2 gpm
1139	135					RD, BN	SILTSTONE + MUDSTONE		
1141	138						LITHOLOGY AS ABOVE		
1145	143						LITHOLOGY AS ABOVE.		
1150	148					RUST RD-BN	SILTSTONE		

REMARKS _____

BORING HN-04

PAGE 3 OF 4

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN04D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK SR. OR USCS	REMARKS
1155	153								YIELD ~ 20 gpm
↓									RIG MAINTENANCE
1447	158					RD.BN	SILTSTONE		
1457	165					RD.BN + GY	Siltstone/f.-v.f.-gr. SS		
	169					PK-GY	f.-m. gr. SS		Pick-up 2-7
1511									
	173					PK-GY	f.-m. gr. SS		
1519	178								TOTAL YIELD ~ 30 gpm

REMARKS _____

BORING HN 1

PAGE 4 OF 4

* See Legend on Back

PROJECT: NAWC WARMINSTER BORING NO.: HN-05S

PROJECT NO.: 0159 DATE: 11-22-93 DRILLER:

ELEVATION: FIELD GEOLOGIST: D. Whalen

WATER LEVEL DATA

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					BN	SILTY CLAY		
	4						SANDY SILT		
	6					RDBN	SILTY SAND		
	9					RDBN	f. gr. SS		
1124				8" at 13 ft.					
	15					LTBN	f.-M. gr. SS		low Yield
	20					GY & LT. BN	f.-M. gr. SS		
	24					TAN	M-gr. SS		
1139									Fx at 26.5
	29					TAN	M.-C. GR. SS		ANGULAR QTZ Pebbl
1152									Pick-up 1 GPM
	34						Lithology AS Above		
	38					RDBN	SILTSTONE		
	44					BN	f-M. gr. SS		
1207	48					LT BN	f-M. gr. SS		
	50					RD & GY-BN	f-M. gr. SS		Pick-up 2-3 GPM
	53					GY & RD-BN	f. gr. SS & Siltstone		TOTAL YIELD ~ 10 GPM NO HNU > BK
	54			TD					

REMARKS

BORING HN-05

PAGE 1 OF 1

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-05I

PROJECT NO.: 0159 — DATE: 11-8-93 — DRILLER: RAAB

ELEVATION: — FIELD GEOLOGIST: D. Whalen

WATER LEVEL DATA (Date, Time & Conditions):

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR 300 (Ft.)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	9					BN	f. gr. SS		
	12					RD.BN	f. gr. SS		Soft, wet
1000	15			8" at 14 ft		TN	f. gr. SS		
	20						Lithology as Above		
1009	26					TN	M.-C. gr. SS		Angular quartz pebbles
	31					YL-TN	f.-M. gr. SS		H_2O zone ?
1026	38					RD. BN	Siltstone		
	40					RD.GY	f. gr. SS		
	42					RD.BN	Siltstone/f. gr. SS		
	43					PK-GY	f. gr. SS		
1035	46					RD.BN	Siltstone		

REMARKS

BORING HN-05I

PAGE 1 OF 3

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN 05 I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. or USCS	REMARKS
1042	53					RD.BN	Siltstone/f. gr. SS		
1050	57					RD.BN	Siltstone		
1056	61					RD.BN	Siltstone		
	64					PK-GY	Siltstone/f. gr. SS		
	70					PK-GY, BN	f. gr. SS		
1114	73					RUST RD	Siltstone		
	78					RUST RD	Siltstone		
	83					RUST RD+BN	Siltstone		
	88					RUST RD+BN	Siltstone		
	93					RD.BN	Siltstone		
	94					PK-GY	f. gr. SS		
1144	97					PK-GY	f. gr. SS/red siltstone		
	98					RD-BN	Siltstone/ v.f. gr. SS		
	99					LT.GY	f. gr. SS.		

REMARKS _____

BORING HN-05

PAGE 2 OF _

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN05I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	102					PK-GY	f. gr. SS + red Siltstone		
1309									
	108					LIGY	f. gr. SS		
	111					PK.GY	f. gr. SS		
	113					RD. BN	Siltstone		
	118					RD.BN	Siltstone		
1320	123					RD.BN	Siltstone		
	128					GY — RD —	f. gr. SS Siltstone		
	133					RD.BN	Siltstone		
1338	136					RD.BN	Siltstone		
	138					RD.BN & GY	Siltstone / f. gr. SS		
	143					RD.BN & GY	Siltstone / f. gr. SS		
1351									
	148					RD.BN & GY	Siltstone / f. gr. SS		
1402	153					PK.GY	f. gr. SS		Yield ~ 10 gpm

TD=155

REMARKS _____

BORING HN 5

PAGE 3 OF 3

* See Legend on Back

PROJECT: NAWC WARMINSTER BORING NO.: HN-05D
PROJECT NO.: 0159 DATE: 11-18-93 DRILLER: RAAB
ELEVATION: FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					LT. BN	SILTY CLAY		
	5					BN	Channery Sand		
	9					BN	f. gr. SS		
	12								WET CUTTINGS
	14					LT. BN	f.-m. gr. SS		
	16					LT. BN + TN	f. gr. SS		
1254	17			8" at 14FT		BRGE + TN	f.-m. gr. SS		
	24					GY + TN	f.-m. gr. SS		
	35					RD. BN	SILTSTONE		
1315									
	40								2-3 gpm
	41				X	RD.BN PK.GY	SILTSTONE f. gr. SS		HNU 3-4 ppm
	45					RD. BN	SILTSTONE		
	47				X	RD.BN PK.GY	SILTSTONE f. gr. SS		
1330	50					RUST RD + BN	SILTSTONE		

REMARKS

BORING HN-05

PAGE 1 OF 1

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN05D
PROJECT NO.: _____ DATE: _____ DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	55					RUST RD + BN	Siltstone		Some white clay
	59					RD. BN.	Siltstone		Some white and Green clay
	62						Lithology AS Above		
1355	66					PK-GY	Siltstone/f. gr. SS		
1404	72					PK-GY	f. gr. SS		fast Drilling
									↓
1406	77					RUST RD+BN	Siltstone/Mudstone		
									Some white and Green clay
	83					RUST RD+BN	Siltstone/Mudstone		
	90					RUST RD+BN	Siltstone/Mudstone		
									5 PPM
1427	93					RD. BN	Siltstone		
	96					PK-GY	f. gr. SS		
	97						f. gr. SS/Siltstone		

REMARKS _____

BORING HN 5

PAGE 2 OF 4

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN05D
PROJECT NO.: _____ DATE: _____ DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	104					LT.GY	f. gr. SS		
							(Minor Red-brown Siltstone)		
1501	111						Lithology as Above		
	120					RUST RD + BN	Siltstone		some white and green clay
1517	128					RUST RD	Mudstone		~40 green shale
	130				X	RD.BN — PK-GY —	Siltstone f. gr. SS		
									15-20 gpm
1534	137					RD.BN	Siltstone		
	140				X	RD.BN — PK.GY —	Siltstone f. gr. SS		
1545	143					RD.BN + GY	Siltstone / f. gr. SS		
	150					RD.BN + GY	Siltstone / f. gr. SS		some red and green mudstone

REMARKS _____

BORING HN-05

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* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN05D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1625	155					PK.GY	f. gr. SS		
					X	RUST RD	MUDSTONE		
	160					PK-GY	f. gr. SS		
	163								
	165								
	168					RD.BN + GY	SILTSTONE		
	177					PK-GY	f. gr - SS		
1753	180						f. gr - SS		
1809	183					LT.GY	f. gr. SS		
					X	RD.BN	SILTSTONE		
1824	188					PK.GY	f. gr. SS		H_2O Increase NO HNU > BK
1838	192					PK.GY	f. gr. SS		FRACTURE — YIELD DECREASE
	194					RD.BN	SILTSTONE		
1902	198					RD.BN	SILTSTONE and some LT. GY. f. GR. SS		FRACTURE 196.5 — YIELD DECREASE
	200					RUST RD	MUDSTONE		
	203			TD		RUST RD	MUDSTONE & SILTSTONE, SOME LT. GY. SS		

REMARKS _____

BORING HN-05D

PAGE 4 OF 4

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-06S
PROJECT NO.: 0159 — DATE: 11-30-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: Kevin C. Kilmartin
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	9					GY-RD	M. GR. SS		ARKOSIC
	11						M-C. GR. SS		conglomeratic
	13								
1415	14			8" at 13 ft		GY	Vf. gr. SS		DRY
	20								DAMP CUTTINGS
1425	21								3-5 GPM
1428	28					RD BN	SILTSTONE		>10 gal at ROD connection
1434	33						Harder Drilling		
	37					DK GY	Vf. gr. SS.		Yield ↑ 8-10 gp
1440	40					RD BN	SILTSTONE		DRILL BREAK — Possible fracture
1443	45						Fractures?		Several drill brea
1446	50								Yield > 10 gpm
1448	53						Abd. pale whitish to YL-GY MINERAL; Fractures? FILL		Yield 10-12 g

REMARKS Blow formation water until 1509 TO clean borehole.

BORING HN-1

PAGE 1 OF

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-06 I
PROJECT NO.: 0159 — DATE: 11-30-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: Kevin C. Kilmartin
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	2					LT.BN	SILTY CLAY		
	6					BN/RD	Channery SAND		
	8					GY-RD	M.-C. GR SS		DRY
	11					GY-RD	M.-C. GR SS		ARKOSIC, DRY, Angular QUARTZ
				8" at 13'					
946	15					GY	f-M. GR. SS		DRY
950	20					LT.BN	f-M.GR.SS w/ pebbles		DAMP
952	23						HARDER DRILLING		Slightly DAMP STILL DUSTY
	25								Possible Fx
955	27					RD-BN	SILTSTONE		DRY cuttings
									±2 gal of connection H_2O
	33					DK RD BN	SILTSTONE TO V.f. gr. SS		DAMP
1005	35						RAPID Changes between hard & soft DRILLING		LOTS of DUST
1007	40					RD BN	SILTSTONE		
	43					GY	V.f. gr. SS		WET
1010	44			*					~1 gpm
1014	50						Soft Drilling TO 53'		Possible Fx

REMARKS

BORING HN 06

PAGE 1 OF 2

* See Legend on Back

BORING LOG HALLIBURTON NUS

PROJECT: BORING NO.: HN06I
PROJECT NO.: DATE: DRILLER:
ELEVATION: FIELD GEOLOGIST:
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
				50-78 does not appear to be a prospective screen interval; Monotonous lithology, no fractures, no increase in yield					
1025	55					DKGY	V. f. gr. SS		~1 gpm
	58						VERY HARD DRILLING		Yield ~ 3 gpm
1044	63						Slight water increase?		Yield ~ 3 gpm
1052	67						"MONOTONOUS" HARD DRILLING		YIELD ~ 3 gpm
1055	70					DKGY	f. gr. SS		
	74						SLIGHTLY easier drilling		YIELD ~ 3 gpm
	75					DKGY	f. gr. SS		
	78								DRILLER begins ADDIN ~4 GPM
1120	80					GY	f. gr. SS.		Apparent Yield 5-6 gp
	83						fracture ?		
1125	85					RDBN	SILTSTONE		Possible gain 1 gp
1132	96								Possible H2O Ga
	98						DRILLER NOTES fracture		H2O increase ?
1140	100-103					GY	F. gr. SS		FINAL Apparent Yi 6-8 gpm

REMARKS Blow formation water until 1220 To clean borehole. Hear cascading water inside borehole 1220 - 1300.

BORING HN-06

PAGE 2 OF 2

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-06 D
PROJECT NO.: 0159 — DATE: 11-4-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					BN	SILTY CLAY		MOIST
	4					BN, RD	Sandy SILT		
	9					RD-GY + TN	M-C. gr. SS		ARKOSIC
	11					RD-GY + TN	Sand + pebble conglom.		
	13			8" at 14 ft.		RD, BN	f. gr. SS		
1356									CLAY-RICH CUTTINGS
	23					RD	SILTSTONE/MUDSTONE		SOFT
1403									
	29					RD, BN	MUDSTONE		
1416									
	38					RG, GY + BN	SILTSTONE		
	43					RD, BN	SILTSTONE/f. gr. SS		
							MUDSTONE		CUTTINGS CLUMPING; NO H2O DISCHARGE
									SOFT
	49					RD, BN	MUDSTONE		

REMARKS

BORING HN-06D

PAGE 1 OF 3

* See Legend on Back

BORING LOG

PROJECT: _____ BORING NO.: HN06D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS PER 300 (ft)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	54					RD.BN	SILTSTONE		
1438	58					RD.GY + BN	SILTSTONE/f.gr. SS		green CLAY; iron-oxide COATINGS
	59					PK.GY	f. gr. SS		
	62					RD.BN	SILTSTONE/f. gr. SS		
1446	63					PK.GY	f. gr. SS		
	68					PK.GY	f. gr. SS		
	73						f. gr. SS		
	76					RD.BN	SILTSTONE		
1504									
	84					RUST RD	SILTSTONE		
	88					RUST RD	SILTSTONE/MUDSTONE		
1517									
	98					RD.BN + GY	SILTSTONE		

REMARKS _____

BORING HN-06

PAGE 2 OF 3

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN06D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	104					RD.BN + GY	SILTSTONE		
1536									
1545	118					RD.BN	SILTSTONE		
	123					RD.BN	SILTSTONE		
1556	128					RD.BN	f. gr. SS		
1602	133					RD.BN + GY	SILTSTONE		
	138					RD.BN + GY	f. gr. SS		
									Pick up ~5 GPM
1615	144					PK.GY	f. gr. SS		
1627	153					PK.GY	f. gr. SS		NO HNU > BK

REMARKS _____

BORING HN-06D

PAGE 3 OF 3

* See Legend on Back

PROJECT: NAWC WARMINSTER BORING NO.: HN-07S
PROJECT NO.: 0159 DATE: 12/1/93 DRILLER: RAAB
ELEVATION: FIELD GEOLOGIST:
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	0					BN	SILTY CLAY		
	3					RD-BN	CLAYEY SILT		MOIST
	5					RD-BN	SILTY Shale		SOFT
	8					RD-BN	SILTY Shale		MICACEOUS
	10					RD-BN	SILTY Shale/SILTSTONE		ARKOSIC
				8" at 10'			+ f. gr. SS		
1459	13					RD-BN GY	f. gr. SS MUDSTONE		
1501	17					GY	v.f. gr. SS		DRY
	21					LT.BN	f. gr. SS		DUSTY
	26								DAMP, less DUST
1517	28					LT.BN	f. gr. SS		
					&	RD-BN	SILTSTONE		
	31					LT.BN	f. gr. SS		
	33								DUSTY
	35			*		GY	v.f. gr. SS and SILTSTONE, IRON OXIDE STAINING		3 gpm
	38					LT.BN	f. gr. SS		
	43					GY	f.-m. gr. SS		
					&	RD-BN	SILTSTONE		
	45			TD		GY-TN	M. gr. SS		TOTAL YIELD
									4-5 gpm

REMARKS

BORING HN-0

PAGE 1 OF

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-07I
PROJECT NO.: 0159 — DATE: 12/1/93 — DRILLER:
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1010	1					OR	CLAY		DAMP
	3					RD-BN	SILTY CLAY		DAMP
	5					RD-BN	SILTY Shale		Soft, DRY
1023	10						SILTSTONE, f. gr. SS.		ARKOSIC
				8" at 10 ft					
	13					RD-BN	SILTSTONE		
	15					RD-BN	MUDSTONE		SOFT, DRY
	19					LT. BN	Sandstone		hard Drilling
									DRY
	23					TAN	f. gr. SS		
	25								H_2O at 1-2 gpm
	27					LT. BN	M. gr. SS		NO HNU > BK
	33					LT. BN	F-M. gr. SS		
1047	38					TAN	M-C. gr. SS		Add water TO
									borehole
	43						LITHOLOGY AS ABOVE		Angular quartz pebbles
	47					ER-GY	SILTSTONE / f. gr. SS		Lignitic film
1106	50					LT. GY	f. gr. SS		Lignitic film

REMARKS

BORING H1 7

PAGE 1 OF 2

* See Legend on Back

BORING LOG

PROJECT: _____ BORING NO.: HN07I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	52			*					GAIN 1-2 gpm
1113	53					TAN + LT. GY	f.-M. gR. SS		Iron oxide staining on cuttings
1128	58					LT-GR + GY	f. gR. SS		Iron oxide stainin
	60								Lignitic film
	62					RD-BN	f. gR. SS		
	64					BN	f. gR. SS		
1140	68					GY	f. gR. SS		Iron oxide stainin
					+	RD-BN	SILTSTONE		
	72								EASY DRILLING
	74					BN, RUST RED	SILTSTONE		
1149	78					BN, RUST-RED	SILTSTONE		
					+	Yellowish	SILTSTONE		
	83					RD-BN	vf- f. gR. SS and		
							SILTSTONE		
1206	88					PK-GY	f. gR. SS		
1218	93					PK-YL GY	f. gR. SS		
1226	97					PK-GY	f. gR. SS		
1240	103					RD-BN	SILTSTONE / f. gR. SS		TOTAL Yield ~8

REMARKS _____

BORING HN-07

PAGE 2 OF _____

* See Legend on Back

BORING LOG 1 **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER BORING NO.: HN-07D
PROJECT NO.: DATE: 11/3/93 DRILLER: RAAB
ELEVATION: FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
						OR	CLAY		
						RD-BN	SILTY CLAY		
	6					RD	SILTY Shale		
	10					BN	SS		Arkosic, friable
				8" at 10'					
1352	13					RD-BN	SILTSTONE		
1355	18					BN	SILTSTONE/f. gr. SS		
1401	23					LT. BN	f. gr. SS		Arkosic
1405	28					LT. BN	f-M. gr. SS		Arkosic; Angular qtz Pebble
1410	32					LT. BN	f. gr. SS		Arkosic; iron oxide staining
	36					BEIGE	f-M. gr. SS with		Quartz Pebble
1420							Some RED & GY SILTSTONE		
	42					YL-TN	M-C. gr. SS		near Conglomerate
1424									
	46					GY	SILTSTONE		Lignitic FILM 46 TO 49
	48					YL-TN	f. gr. SS		arkosic

REMARKS

BORING HN 7

PAGE 1 OF 4

* See Legend on Back

BORING LOG

PROJECT:
BORING NO.: HN07D
PROJECT NO.:
DATE:
DRILLER:
ELEVATION:
FIELD GEOLOGIST:
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1436	53					LT.BN	f. gr. SS		
1446	58					LT.BN	f. gr. SS		ARKOSIC
1450	63					RD-BN	f. gr-SS		
	65					BN	f. gr. SS		
	69								
1455	70					RD-BN	SILTSTONE		
1457	73					RD	SILTSTONE		
1501	78						LITHOLOGY AS ABOVE		
1510	83					RD-BN	SILTSTONE		NO HNU > BK
1515									
	88					RD-BN	SILTSTONE / f. gr. SS		
1519	90					GY-PK	f. gr. SS		
1523	93								20-30 ppm HN
1530	98					RD-BN	SILTSTONE		

REMARKS

BORING HN-0'

PAGE 2 OF 1

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HW07D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, FT)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	101					GY-PK	f. gr. SS		
1535	103					RD-BN	Siltstone		
	109					GY-PK	f. gr. SS		
	113					GY-PK	f. gr. SS		
1555	118					PK-GY	f. gr. SS		
	120								<10 ppm HNU
1602	123					RD-BN	Siltstone		
	126					GY-PK	f. gr. SS		
	129					RD-BN	Siltstone		
1616									
									NO HNU > BK
	133					RD-BN	Siltstone		
	138					PK-GY	f. gr. SS		
1637	143					PK-GY	f. gr. SS		
	147								lignitic film
	149					RD-BN	Siltstone/Mudstone		

REMARKS _____

BORING HW07D

PAGE 3 OF 4

* See Legend on Back

PROJECT: _____ BORING NO.: HN07D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	151								Pickup 2-3 gpm
1657	160					RD-BN	SILTSTONE		
1701	163					RD-BN	SILTSTONE		
	168					PK-GY	f. gr. SS		
	171					GY	f. gr. SS		lignitic film
	172					RD-BN	SILTSTONE		
	177					GY & RD-BN	SILTSTONE/f-gr. SS		
	182						SILTSTONE		
	188					RD-GY	f. gr. SS		
1744	193					PK-GY	f. gr. SS		
1752	198					PK-GY	f.-m. gr. SS		
1757	200					LT.GY	f. gr. SS		<10 ppm HNU

REMARKS _____

BORING HN-0

PAGE 4 OF _____

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-08 S
PROJECT NO.: 0159 — DATE: 11/17/93 — DRILLER:
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
							SILTY CLAY		
							↓		NO HNU > BK
							SILTY SAND		
	9					RD-BN	f-gr. SS		
928	14			8" at 13'		LT.BN	f. gr. SS		DRY
	18					RD-BN	Siltstone/f-gr. SS		
932	23								fracture
	26								fracture
	27					RUST RED	MUDSTONE		
937	36					RUST RD-BN	MUDSTONE		
941	43					RD-BN	SILTSTONE		
									H_2O at 47
944	48					RD-BN	SILTSTONE		
947	53			TD					TOTAL Yield 1.5 gpm

REMARKS

BORING HN 8

PAGE 1 OF 1

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-08I
PROJECT NO.: 0159 — DATE: 11/17/93 — DRILLER:
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
						BN	CLAY		
							↓		
							SILT & fine sand		
	9					RD-BN	F. GR. SS		
1208	13			8" at 13'		LT. BN	F. GR. SS		
	15					RD-BN	MUDSTONE & SILTSTONE		
	26					RUST RED	MUDSTONE		
1226									
	32					RD-BN	SILTSTONE		
	38					RD-BN	MUDSTONE		
	41								DRY
	43					RD-BN	SILTSTONE		
1234									
	48					RD-BN	SILTSTONE		

REMARKS

BORING HN-0

PAGE 1 OF 1

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN 08I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1237	53					BN	F.GR. Sandstone		
	58						F.GR. Sandstone		
1253	63					RD-BN	SILTSTONE		
	66								3-4 gpm
	68					TAN	F-M.GR. SS		
	72					TAN	F-M.GR. SS		
	76					BN	F.G.SS + siltstone		
1304	78					TAN	F.GR. SS		

REMARKS _____

BORING HN 3

PAGE 2 OF 2

* See Legend on back

BORING LOG

PROJECT: NAWC WARMINSTER BORING NO.: HN-08 D
PROJECT NO.: 0159 DATE: 10/26/93 DRILLER: RAAB
ELEVATION: FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					BN	TOPSOIL / SILTY CLAY		
							↓		
	7					OR-BN	SILTY SAND		
	8			TOR@ 8FT.		RD-BN	f. gr. SS.		DRY
				8" at 13'					
1141	15					RD-BN	Siltstone + f. gr. SS		
1147	20					RD-BN	Siltstone		Add water TO borehole (~3 gpm)
1153	25						Lithology AS Above		
1205	30						Lithology AS Above		
	32					GY-RD	MUDSTONE & SILTSTONE		
1215	36					RD-BN	Siltstone / f. gr. SS		hard Drilling
1419	39								DUSTY
	42					RD/GY	Siltstone		
1427	47					DK RD	Siltstone		

REMARKS Water added TO borehole 20 - 152 ft.

BORING HN-08

PAGE 1 OF 3

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN08D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1431	52					DK RD	Siltstone/f. gr. SS		
1439	57					RD-GY	f. gr. SS		
	62					PK-GY	f. gr. SS.		
	65			*					H_2O ~ 5 gpm
1449	67					GY-TN	M.-C. GR. SS		Angular frags.
1456	72					LT.GY	M.-C. GR. SS		Angular
1501	76					LT.GY	M.-C.GR. SS, Red Siltstone, pebble-size Angular QTZ		
1509	80					Red	Siltstone		
1518	87					PK-GY	Siltstone & f. gr. SS		
1524									NO HNU > BK
	92					GY-TN PK	Med-C. gr. SS		Poorly Sorted
1531	97					PK-GY	Arkosic, f. gr. SS		
1535	100					GY	Same as Above + mudstone		

REMARKS _____

BORING HN 3

PAGE 2 OF 2

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: BORING NO.: HN08D
PROJECT NO.: DATE: DRILLER:
ELEVATION: FIELD GEOLOGIST:
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1542	107					RUST RED	MUDSTONE		
	112					RED	MUDSTONE		Small fragment
1550	117					RED	SILTSTONE		larger fragment
	122					RED	SILTSTONE		
1600	125					PK-GY	f. gr. arkosic SS		
1612	132					GN-GY	f. gr. arkosic SS		No HNU > BK
1617	137					LT. GY.	f. gr. SS.		
1622	142					RED	MUDSTONE		
1627	147					GY-PK	f. gr. SS.		
1632	152			TD		PK-LT. GY	f.-C. GR. SS		

REMARKS

BORING HN-D8

PAGE 3 OF 3

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-09S
PROJECT NO.: 0159 — DATE: 11/22/93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST:
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					orange	CLAY		
						TO	↓		
	7					Brown	SILT		
	9					RD-BN	Clayey siltstone		
				8" at 14'					
	15					PK-GY	Siltstone/f.gr. SS		
	18					LT. BN	Siltstone/f. gr. SS		
1525	20					PK-GY	f. gr. SS		
	21					TAN	f.-m. gr. SS		
1529	25					RD-BN GY	SILTSTONE		
	28					PK-GY	SILTSTONE/f. gr. SS		FAST Drilling, DUST
	29					RD-BN	MUDSTONE		
	32					RD-BN	MUDSTONE, some greenish		DUSTY
							clay		
1538	36					PK-GY	f. gr. SS		DAMP at 38; 2-3 gpm at 39
	40								NO HNU > BK
1544	43					RD-GY BN	SILTSTONE		
1548	48					PK-GY	f. gr. SS		ADD 1-2 gpm
	52					BN	SILTSTONE		

REMARKS TD at 53 ft. TOTAL YIELD ~5 gpm

BORING HN 1

PAGE 1 OF

* See Legend on Back

PROJECT: NAWC WARMINSTER BORING NO.: HN-09I
PROJECT NO.: 0159 DATE: 11-19-93 DRILLER: RAAB
ELEVATION: FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	0					BN	SILTY CLAY		
	1					OR	CLAY		
	5					BN	CLAYEY SILT + SILTY CLAY		
	9					BN	SILT		
	10					RD, BN	CLAYEY SILTSTONE		MICACEOUS
				8" at 15'					
1059	20					LT. BN + TN	f. gr. SS		
1105	28					RD	MUDSTONE		DRY
	32					RD, GY	SILTSTONE		DUSTY
	36								DUSTY
	38					PK, GY	SILTSTONE / f. gr. SS		
1117	40					RD, GY	SILTSTONE / f. gr. SS		DUSTY
	43					REDDISH GY-BN	SILTSTONE		easy drilling
	45					Darker RED	MUDSTONE		
1126	48					LT. BN TO BGE	SILTSTONE		DUSTY

REMARKS

BORING HN-09

PAGE 1 OF 3

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN09I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	52					RED BN	SILTSTONE		NO DUST; MOIST
	57					RED	MUDSTONE		SOFT
	61								ADDING H2O TO Borehole
1149	68					PINK-GRAY	f. gr. SS		
						RED-BN	SILTSTONE		
1155	71					LT. GY	f. gr. SS		
						RED-BN	SILTSTONE		
	73								fracture
	76						F.GR. SS		
1214	81					LT. GY → RD-BN →	f. gr. SS SILTSTONE		
	85						conglomeritic SS (QTZ frags) w/ minor MUDSTONE		
	87					RD-BN	SILTSTONE/V.f.gr. SS		
						LT. GY	F. gr. SS		
	91						SILTSTONE		Fracture
	92					PURPLE/GY	SILTSTONE		
	93					LT. PK. GY	F. gr. SS		
	97					PK-GY	F. gr. SS		

REMARKS _____

BORING H1

PAGE 2 OF

* See Legend on Back

BORING LOG

HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN09I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	101					PK-GY	F-MGR SS		
	103					DKGY	Siltstone/ v.f.gr. SS		~2 gpm total yield

REMARKS _____

BORING HN-0[illegible]

PAGE 3 OF [illegible]

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-09 D
PROJECT NO.: 0159 — DATE: 11/2 & 11/3/93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					OR	SILTY CLAY		
	3					OR	SILTY CLAY		
	4					BN	CLAYEY SILT		micaceous
	8					BN	SILT		micaceous; DRY
	10					RD	SILTY Shale		
	14			8" at 14'		RD	SILTY Shale		DUSTY
1423	22					RD	MUDSTONE		
1425	28					RD	MUDSTONE		
	30						LITHOLOGY AS Above		
1431	33					BN.RD	f. gr. SS		
	38					RD.BN	f. gr. SS		large fragments
1443									
	43					RD.BN	SILTSTONE		
1450	48						LITHOLOGY AS Above		

REMARKS

BORING HN-09 D

PAGE 1 OF 4

* See Legend on Back

BORING LOG

PROJECT: _____ BORING NO.: HW09D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1457	53					RD.BN	f. gr - SS		
1505	58						Lithology As Above		
1510	63					RD.BN	f. gr. Quartzose SS		
	68					RD.BN	f. gr. SS		
1524	73					BN-GY	C. GR. SS; Quartz Pebbles		
1530	79					PK-GY	f.-M. gr. SS; Some siltstone		arkosic
	81								No HNU > BK
1542	83					PK-GY	f-M. gr. SS; arkosic		Some green frags.
1546	86					RD	Siltstone		
	90					PK-GY	f. gr. SS		
1611	98					PK-GY	f. gr. Arkosic SS		

REMARKS _____

BORING HW-09D

PAGE 2 OF 4

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN09D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1617	103					RD.BN	Siltstone		
1628	108					reddish GY-BN	Siltstone/f. gr. SS		
1635	113					reddish GY-BN	f. gr. SS		
1641	118					RD	Mudstone		
1644	123					RD	Mudstone		Soft
1647	127					RED + GY	Mudstone		
1657	132								No HNU > BK
1658	133					RD.BN	Siltstone		
1704	138					PK-GY	f. gr. SS		
						RD.BN	Siltstone		
1707	141								Yield 8-10 gpm
	148								Yield 12-15 gpm

REMARKS _____

BORING HN-01

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* See Legend on Back

· BORING LOG

HALLIBURTON NUS

PROJECT: _____ BORING NO.: HW 09D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA : _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	151					BN.GY	f. gr. SS		Large fragments
1719									2" - 4"
	154								No HNu > BK
1726	158					LT.GY	f. gr. SS		Yield = 20 gpm
1732	163					LT.GY	f. gr. SS		
	165					RD	Mudstone		
	168					RD	Mudstone		
1738									
	173					RD	Mudstone + Siltstone		Yield ~20 gpm
1744	178					RD	Siltstone		Stop 11-2-93
									Start 11-3-9
0919	181					RD.BN	f. gr. SS / Siltstone		Yield ~25 gpm
0925	188					RD.BN	f. gr. SS / Siltstone		
	191								lignite
0928	192					RD	Siltstone & Mudstone		
	198					RD	Siltstone		
0934	200					RD.BN	Siltstone		Stop Drilling; Yield ~25 gpm

REMARKS _____

BORING HW-09

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* See Legend on back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC Warminster — BORING NO.: HN-10S
PROJECT NO.: 0159 — DATE: 12-14-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen (0-12') + R. Conger (USGS; 12-53')
WATER LEVEL DATA (Date, Time & Conditions):

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1					LT. BN	SILTY CLAY		
	4					BN	SANDY SILT		
	7					GY + LT. BN	f. gr. SS		arkosic
	10					GY + LT. BN	SS		QTZ. fragments
									H2O at 11'
	14			8" at 12 ft.		BN	f. gr. SS		Fracture; DAMP
	21								Fracture; fast DRILLING
1039	23					RD	F. gr. SS / siltstone		2 gpm at 28; no HNU
							↓		
	29								
	31								LOST RETURN – BLOWING H2O OUT of HN-10D
	34					BN, GY	SS		Yield 5-8 gpm;
									NO HNU
	38								Yield 10 gpm
1043									
	46					RD	Siltstone		Fast Drilling
	47								47-49 fractures
1050	53								10-12 gpm Tota

REMARKS: Blew H2O for 30 minutes – almost cleared

BORING HN-10S

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-10 I
PROJECT NO.: 0159 — DATE: 12-15-93 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen (0'-12') & R. Conger (USGS; 12'-112')
WATER LEVEL DATA (Date, Time & Conditions):

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. or USCS	REMARKS
	2					LT. BN	Channery sand		Rock fragments
	5					OR. TO BN	Silty clay to silty sand with rock fragments		
	7					BN	f. gr. SS		large pieces
				8" at 12ft					
	15					RD	Siltstone & SS		
	21					BN & GY	Competent SS		
950									
	25								2-3 gpm
	28								Large fracture; loss &
									return briefly
	31								Yield 5 gpm
	34								Yield 10 gpm; 40 ppm HNU
									Fracture: 35'-36'
	40								40-43 Fractures; FAST DRILLING
1009									44-45 weathered. FAST DRILLING
	48					RD	Siltstone		
	49								Fractures

REMARKS

BORING HN-10 I

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN 10I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS PER 300 (ft)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	51					RD	F.G. SS		
									54-60 Competent
									Rock; slow drilling
	62								Fracture
1025	63								40 ppm on HNU
	68								Bit Jumpy
	71								71-73: fractures
	73							73:	Slow, hard drilling
	80					GY	SS		30-40 ppm HNU
1045									
	88								Fracture
	90								90-91 Fracture; Lost some returns
	92								30-40 ppm HNU water?
	96								Lost return briefly
	98								Fractured

REMARKS _____

BORING HN-10I

PAGE 2 OF 3

* See Legend on Back

PROJECT: _____ BORING NO.: HN 10I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	101					RD	Siltstone		
	103								30-40 ppm HNU
	112					RD	Siltstone		TOTAL YIELD 18-20 gpm
									30-40 ppm HNU Constant

REMARKS _____

BORING HN-10I

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* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER BORING NO.: HN-10D
PROJECT NO.: 0159 DATE: 11-15-93 DRILLER:
ELEVATION: FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK QD. OR USCS	REMARKS
	1					LT.BN	SILTY SAND WITH		
							rock fragments		
	7					BN-GY	f.-m. gr. SS		ARKOSIC
	10					GY-BN	f. gr. SS		DRY; arkosic
									8 ppm HNU
	13			8" at 12ft					fracture
	21					GY	M. gr. SS		arkosic
1121	25					BN	f.-m. gr. SS		
1128	29								Pick-up 0.5 gpm
	31					RD-BN	Siltstone/f. gr. SS		
	34					RD-BN	Siltstone		
	38					RD-BN	Siltstone/f. gr. SS		Some iron oxide stain
1148	40								Gain 1 gpm
	41								Fracture; gain 1-2 gpm
	42					BN	f. gr. SS		
	44					RUST RD	MUDSTONE		YIELD 7-8 gpm
	47					RD.BN	SILTSTONE		
	50					RD.BN	SILTSTONE		FRACTURE

REMARKS

BORING HN-10

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* See Legend on Back

BORING LOG

HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN 10D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	52								Gain 0.5 gpm ?
	54								Yield 9 gpm
	56					RD.BN	Siltstone		large frag.
	61					RUST RD.BN	Mudstone		
1220	65					PK + GY-BN	f. gr. SS		
	68								Gain 1 gpm
1231	73					PK-GY	f. gr. SS		Yield increase
									to 20-22 gpm
	78								Gain ~2 gpm
	80								
1344	81					BN-GY	f. gr. SS		
1349	85					BN + GN-GY	Mudstone		
	86					TN, GY, + LT. GN	f. gr. SS		
	88					RD + LT. BN	Mudstone, Siltstone, + f. gr. SS		
	93					RD.BN	f. gr. SS		
	95					RD.BN + GN	Shale		very soft
	97					PK.GY	f. gr. SS		
	99					RUST RD	Mudstone + Siltstone		

REMARKS _____

BORING HN-10D

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* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN 10D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1414	111					RD, BN	Siltstone		Gain H_2O
									TOTAL ~30 gpm
									Gain ~2 gpm
	118					PK, BN & GY	f. gr. SS		
	122								~33 gpm total
	123					RUST RD, BN	Mudstone/Siltstone		
	135					RD, BN	Siltstone/f. gr. SS		Pick-up 2-3 gpm at 136?
1448	137					GY	Siltstone/f. gr. SS		
					X	RUST RD	Mudstone		
1457									
	143					PK-GY	f. gr. SS		
	148					RUST RD	Mudstone/Siltstone		
	150								Rough drilling; Gain 2 GPM?

REMARKS _____

BORING HN-101

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN 10D
PROJECT NO.: _____ DATE: _____ DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA _____
(Date, Time & Conditions) _____

	SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1509	153								TOTAL YIELD ~35 gpm
		155					RD.BN	SILTSTONE		
		158								NO HNU > BK
	1522	162					PK.GY	f. gr. SS		
		167					PK + LT-GY	f. gr. SS		
	1548	173					LT. GY	f. gr - SS (arkosic)		
11/12 ↑										
↓										
11/15	0934	183					LT.GY	f. gr. SS		
		188					LT.GY	f. gr - SS		
		190					RD.BN	SILTSTONE		
		192								GAIN 1-2 gpm?
										10 PPM HNU
	0955	196					PK-GY	f. gr. SS		
		199					RD.BN	MUDSTONE/SILTSTONE		25 PPM HNU

REMARKS _____

BORING HN-1C

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN 10D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1008									
	207					PK.GY	f. gr. SS		
									40 ppm HNU
1019	213					PK.GY	f-m. gr. SS		
					X	RD.BN	SILTSTONE		
	218					PK.GY	f. gr. SS		
					X	RD.BN	SILTSTONE		
1036									
	226								Fracture
	228					RD.BN	SILTSTONE		
	235				X	PK.GY RD.BN	f. gr. SS SILTSTONE		Gain ~2 gpm
	236								Gain ~2-3 gpm
	238				X	PK.GY RD.BN	f. gr. SS SILTSTONE		
1101									
	241				X	PK.GY RD.BN	f. gr. SS SILTSTONE		
	244					RD.BN	SILTSTONE		
	247				X	PK.GY RD.BN	f. gr. SS SILTSTONE		
	249					RD.BN	SILTSTONE		
1126	253					PK.GY	f. gr. SS		Yield 50-60 gpm

REMARKS _____

BORING HN-101

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* See Legend on Back

· BORING LOG — HALLIBURTON N

PROJECT: NAWC Warminster — BORING NO.: HN-35 I,
PROJECT NO.: 1412 — DATE: 8/2/94 — DRILLER: Raab
ELEVATION: — FIELD GEOLOGIST: D whalen
WATER LEVEL DATA: —
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1012	0.0					gray	pavement crushed stone		
						gray BRN	silty sand		moist
1020	5.0					red-BRN gy-BRN	clayey silt silty sand and weathered silty fgr sandstone		
	10.0			MENENE		red-gy	v. fgr sandstone, micaceous		dry, dusty
1038	13.0								damp
							Vfgr - fgr sandstone		no dust
1048	15.0								
1058	18.0								
	20.0								
1305	22.0								
	23.0					BRN-Gy	silty fgr sandstone		dry, dusty
1306	25.0								
1308	28.0								dry, dusty
1310	30.0					red-gy	Vfgr - fgr sandstone micaceous		FOR
	33.0								
1319	37.0					red-gy	fgr sandstone		dry
	40.0								
	42.0			*		gy-brn	fgr sandstone		wet, cuttings
									stean
1327	46.0								mud. start o water
						red-brn	siltstone/mudstone, w/green mineral		soft
	50.0					gray	fgr-mgr sandstone		yield ~5gpm

REMARKS I.R. T-4 rig. 12" air hammer to 18'; 8" steel casing to 18'; 8" air hammer to 105'
* HN-35S also constructed within this borehole

HN-35S,
BORING
PAGE 1 OF

* See Legend on Back

· BORING LOG

HALLIBURTON NUS

PROJECT: NAWC Warminster
BORING NO.: HN-35
PROJECT NO.: 1412
DATE:
DRILLER: Raab
ELEVATION:
FIELD GEOLOGIST:
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
						red-brn	mudstone		yield drops
1348	55.0								EOR
						red-gy	vfgr-fgr sandstone		mud
1402	60.0						micaceous some calcite		
						red-brn	vfgr sandstone		
				* ?					possible yield inc. of 1-2 gpm
1408	65.0					rust-red	mudstone		mud
1409	67.0								
1410	70.0								
1411	72.0						same as above		mud
1413	75.0								mud, very little return
1414	77.0					red-brn	vfgr sandstone		
1415	80.0								EOR start next rod at 14
1425	82.0						same as above		
									damp
1426	85.0								
1427	87.0					gray	vfgr - fgr sandstone		damp
1429	90.0								
									mud
1431	94.0			*		gray	fgr sandstone		wet mud
									some flow
1433	97.0								yield 4-5 gpm
	100.0					red-brn and gy	siltstone		mud

REMARKS

BORING HN-35S

PAGE 2 OF

* See Legend on Back

· BORING LOG

HALLIBURTON NL.

PROJECT: NAWC Warminster

BORING NO.: HN-35I

PROJECT NO.: 1412

DATE: 8/2/94

DRILLER: Raab

ELEVATION:

FIELD GEOLOGIST: D. Whalen

WATER LEVEL DATA :

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	101.0								
1436	103.0								mud
1437	105.0					red-brn	vfgr sandstone, micaceous		EOR
									total yield ~5gpm

REMARKS

BORING HN-35S

PAGE 3 OF

* See Legend on back

· BORING LOG

HALLIBURTON NUS

PROJECT: NAWC Warminster

BORING NO.: HN-35D

PROJECT NO.: 1412

DATE: 5/17/94

DRILLER:

ELEVATION:

FIELD GEOLOGIST: D. Whalen

WATER LEVEL DATA :

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1252	0					gray	pavement crushed stone		
	4					BRN	clayey silt		
						red-BRN	silty clay and weathered silt stone / vfgr sandstone		
1257 1301					soft	red-BRN	siltstone / mudstone		
	10					purple	vfgr - fgr sandstone, micaceous		harder
1305									dry
							same as above		
1305	17								dry slow drilling
1309	20								blow out som when start dr
1333						gray BRN	fgr - mgr sandstone		no dust
									slightly damp
1336 1337	27								EOH water in the hole
	30			*					some stream, no ret ~1gpm
						red gray	vfgr - fgr sandstone		no HNU reading
						purple	fgr sandstone		lift up bit, clean out resume drilling @ 1346
									dry
									dry, dusty
	40								
						gray BRN	fgr sandstone		dry
1350	47								
						gray-BRN	slightly finer grained		dry
1352	50								no dust

REMARKS J.R. T-4 rig 10" air hammer to 19.5', 6" steel casing to 19.5' 6" air hammer to 152'

HN-35

BORING

PAGE 1 OF 4

* See Legend on Back

BORING LOG — **HALLIBURTON NU**

PROJECT: NAWC Warminster — BORING NO.: HN-35D
PROJECT NO.: 1412 — DATE: 5/17/94 — DRILLER:
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1439	102			*					fast drilling mud poss. fracture
1447									EOR yield ~3gpm a blowing out hol
1449	106					brn-gray	vfgr sandstone		—
									—
1451	110								Q ~3gpm (mud
							same as above		Start to add wat
	114								
1454	117			*					Q increases to ~8
	120								
1456						gray	mgr sandstone, some angular quartz grains		Q ~12gpm
1459 1504	127								EOR yield: ~12
						gray	fgr sandstone, some calcite		
1507	132						as above with some red mudstone, vfgr sandstone		Q ~12-15gpm
	137						as above, with some green mineral		
1512	142								
						red BRN	vfgr-fgr sandstone, some calcite		
1515	147								
	150					rust red	siltstone		

REMARKS

BORING HN-3

PAGE 3 OF 4

* See Legend on back

· BORING LOG

HALLIBURTON NI

PROJECT: NAWC Warminster

BORING NO.: HN-35D

PROJECT NO.: 1412

DATE: 5/17/014

DRILLER: Raab

ELEVATION:

FIELD GEOLOGIST: D. Whalen

WATER LEVEL DATA :

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK SYM. OR USCS	REMARKS
1517	152					rust red	siltstone		

REMARKS Blow out hole until 1614 – cave-in problem; blow out crumbly red fgn sandstone, red-gray fgn congl. piece of greenish gray mgr sandstone; TD = 150.5'

BORING H-3

PAGE 4 OF 1

* See Legend on back

JRB ASSOCIATES, INC.
8400 Westpark Drive, McLean, Virginia 22102

WELL LOG

PROFILE	DESCRIPTION
0	TOPSOIL/VEGETATION
1	
2	
3	BROWN SANDY LOAM - DRY. STIFF
4	
5	SPLIT SPOON 5'-5.7' 35-50/.1
6	
7	
9	BROWN SANDY LOAM - MOIST. WITH MANY SANDSTONE FRAGMENTS.
10	SPLIT SPOON 10'-10.1' 50/.1
11	
12	BROWN TO GRAY SANDSTONE. ALTERNATING HARD AND SOFT LAYERS.
13	
14	
15	AUGER REFUSAL
16	
17	
18	
19	
20	

PROJECT NADC WARMINSTER, PA

OWNER NAVAL AIR DEVELOPMENT CENTER

WELL NO. DG-9 (HN-36X)

LOCATION N. OF NADC HOUSING ALONG FENCE
S. OF SITE #6

	Date	Time
DRILLING STARTED	7/19/82	0820
DRILLING COMPLETED	7/19/82	1025

DRILLER LARRY CISLER SR
GEOLOGIST ED TOKARSKI JRB
RIG TYPE MOBILE B-56.
REFERENCE POINT LAND SURFACE
R.P. ELEVATION 342.8
TOPO POSITION FLAT LYING
PROFILE BY ED TOKARSKI
FIELD BOOK NO. 1 PAGES 44

WELL DATA

HOLE DIAMETER 6" O.D.
HOLE DEPTH 15.5'
CASING DIAMETER 2" I.D.
CASING LENGTH 10.23'
SCREEN DIAMETER 2" I.D.
SCREEN SETTING 15.25' - 10.95'
SCREEN SLOT/TYPE 10-SLOT / MICROMESH (2.15'/2.15')
STAINLESS STEEL - (JOHNSON)

PUMP TEST DATA

STATIC DEPTH TO WATER 7.68 // 9.53
DATE MEASURED 7/25/82 // 9/9/83
PUMPING DEPTH TO WATER SPARGE
TEST DURATION —
PUMPING RATE —
TEST DATE 9/9/83
TEST TYPE BAIL TEST
PUMP SETTING 14'
SPECIFIC CAPACITY SEE REPORT

REMARKS

WET FROM APP 8' ON. DRILLING DID NOT DETECT WATER UNTIL 14'.

SMC ENVIRONMENTAL SERVICES GROUP

DRILLING LOG

PROJECT NADC OWNER Navy

LOCATION Site 6 W.O. NUMBER 9710-40001

WELL NUMBER DG-18 (HN-36S) TOTAL DEPTH 27' DIAMETER 6"

SURFACE ELEV. WAT. LEV.: INIT. 26.20' 11/13/90 ~~24 HRS~~ 15.70'

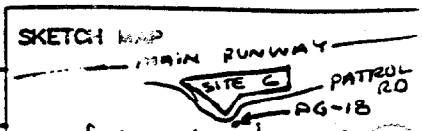
Open Hole: DIA. 6" LENGTH 22-27' SLOT SIZE NA

CASING: DIA. 6" LENGTH 0-22' TYPE PVC

DRILLING COMPANY C.S. Garber DRILLING METHOD Air Rotary

DRILLER E. Williams LOG BY PDB DATE DRILLED 11/2/90 11/5/90

SKETCH MAP



- Water levels were measured from top of inner casing.

NOTES

SHALLOW BEDROCK WELL

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	PID SAMPLE NUMBER	FID	DESCRIPTION / SOIL CLASSIFICATION (U.S.C.S.) (COLOR, TEXTURE, STRUCTURES, MOISTURE, OVA READING)
	SOIL	22' CASING	ND	ND	0-10' Brown organic silty sand (SM). Moist at bottom
17	BEDROCK				10-17' Dark brown medium grained arkosic sandstone. Dry. Comes to surface as granule sized particles.
27		OPEN HOLE			17-27' Gray very fine silty sandstone interbedded with olive medium to fine grained sandstone.
		2' BENT. SEAL. BENTGEM. GROUT w/ casing. well cap. PROTECT. SEE WORK PLAN SPECS.			* Casing set at 22'

Hydrogeology

- Bedrock / soil interface noticeably wet
- Well yield is approximately 1 gpm
- Well recovers 2-3 feet in 2 minutes
- Hit water around 23'
- There was 8 feet of water in the well when drilling resumed on 11/5.

013 9018 86001

· BORING LOG **HALLIBURTON NU**

PROJECT: NAWC Warminster BORING NO.: HN-36I1
PROJECT NO.: 1412 DATE: 5/18/94 DRILLER: Boak
ELEVATION: FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1151	0					BRN	silty loam		
						lt BRN	sandy silty clay		moist
						BRN	silty sand		
1154 1157	7			11.2 11.5		tan	fgr-mgr sandstone, weathered		add rod dry
1159	10					lt. BRN	fgr sandstone		
						gray-BRN	fgr sandstone		
						red-BRN	siltstone / vfgr sandstone		dry
1204	17				soft	red-BRN	siltstone / mudstone		
1205 1209	20								
1210	22					red gray	vfgr - fgr sandstone		harder, dry
						tan-gray	fgr sandstone		dry
1214	24								dry
	30								
1217	32					red gray	fgr sandstone		dry
1517									damp
1519	37								
1521	40								some dust
1523	42					tan-gray	vfgr - fgr sandstone		dry
									dry
1527	47					red BN	fgr sandstone		
1530	50					red gray	vfgr sandstone		dry

REMARKS T.R. T-4 rig: 10" air hammer to 32' set 6" steel casing to 32' 6" air hammer to 177.

BORING HN-36I1

PAGE 1 OF 4

* See Legend on Back

BORING LOG

HALLIBURTON NU

PROJECT: NAWC Warminster BORING NO.: HN-36I

PROJECT NO.: 1412 DATE: DRILLER:

ELEVATION: FIELD GEOLOGIST:

WATER LEVEL DATA:

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1531	52					red gray	vfgr - fgr sandstone		EOR
1535									dry
1538	55								
						Pink gray	vfgr - fgr sandstone		dry
1541	60								
									dusty
							same as above		
	65								poss. fracture
1545						brown gray	fgr sandstone		
1546	70								no dust
1547									slightly moist
1549 1557	77					Pink-gray	fgr sandstone, micaceous		EOR water in hole when
1558	80								start next red
1600									mud
	85								
1601						green-gray	fgr-mgr sandstone		damp
1602	90			*					thick slurry no HNU reading
1605	92								Q ~ 3gpm
					soft	red Brown	siltstone/mudstone		mud
									very little return
1608	97								mud
1610	100								

REMARKS

BORING HN-36I

PAGE 2 OF

* See Legend on back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HA-36I
PROJECT NO.: _____ DATE: _____ DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA: _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1611	102					red-brown	v fgr sandstone		EOR
1625									
									Q ≈ 3-4 gpm
1629	107					red-brown	v fgr - fgr sandstone		
	110								
1631							same as above		
	115								
1634	117						same as above		Q = 4-5 gpm
	120								
1636	122					red-gray	fgr sandstone		Q = 4-5 gpm
1639 1643	127						same as above		EOR
1644	130								Q = 5 gpm
						red gray	fgr sandstone, micaceous		
									yield drops
1647	135								
	140			----	soft	rust red	mudstone		
									Q ≈ 4 gpm
1651	145			----		red brn	fgr sandstone		
	150			----		pink gray			

REMARKS _____

BORING HN-36I

PAGE 3 OF 4

* See Legend on back

· BORING LOG

HALLIBURTON NU:

PROJECT: _____ BORING NO.: HN-36I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	152								EOR
1709	160					gray	fgr sandstone		Q ≈ 5gpm
1710									
						red brn	siltstone, mudstone		
1712	167					red brn	vfgr sandstone		Q ≈ 5gpm
	170								
1714	172						same as above		lignite film on water
1716	177						same as above		lignite film
									total yield ≈ 5g

REMARKS _____

BORING HN-36I

PAGE 4 OF 4

* See Legend on back

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 7/14/94, 1308, cloudy, 85°. RAW.

DATE: 7/14/94
FIELD GEOLOGIST P. WIMMER

BORING NO. HN-36D, HN-36I2*
DRILLER: RAAB

SAMPLE NO. & TYPE OR ADD	DEPTH (ft) OR AUG NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (DOCUMENT) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1308	0.0			SP		TAN	GRADED SAND w/ LT FRAGS	SP	POSSIBLE ROAD BASE
	4.0			ML		BRN	SILT and CLAY	ML	
1313	6.0								EOR @ 6'
1320	10.0					TAN	GRADED SAND w/SILT + CLAY SOME RX FRAGS		DRY - FAST
1325	12.0					TAN	FG to MG SS		
				NSII/FIII TOC=12					Soft @ 14
1328	15.0					BRN	FG SS w/ RSD Mudstone		BIT Gets clogged @ 15
1400	18.0			FGSS					Stop @ 18' to set Casing.
	20.0			6" CSG to 18' FGSS/ SILTSTONE			FG SS /SILTSTONE		DRY - DUSTY
						PINK	FG SS		DRY
				FGSS					SLOWER DRILLING
1403	25.0					PINK	AS ABOVE		
1406	26.0					PINK	FG SS		EOC @ 26. WATER while
1411	30.0					PINK	AS ABOVE		BLOWING - VERY DRY - DUSTY
1415	35.0					PINK	AS ABOVE		SOFTER - QUICK - POSS. FR
									FASTER
1417	40.0					PINK BRN	FG SS		DRY - LESS DUST
1420	45.0					PINK	AS ABOVE		DRY
									LARGER RX FRAGS
1422	50.0					PINK	FGSS		RAW starting

REMARKS T-4 RIG w/ 10" AIR HAMMER to 18 FT. 6" ø HAMMER TO 151 FT. 6" ø STEEL CASING TO 18 FT. CASING STICKS UP 2.3 FT. HOLE NOT LOGGED BY USGS.

* HN-36 I2 ALSO CONSTRUCTED within this borehole.

BORING HN-36D

PAGE 1 of 3

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7/14/94
FIELD GEOLOGIST P.NIMMER

BORING NO. HN-36D
DRILLER: RAAB

SAMPLE NO. & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Gradual) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1424	51.0								EOR @ 51
1428	55.0					Grey-Red	FG SS		Less Dust
1430	60.0						AS ABOVE		Dry
1431	62.0					Pink	FG to MG SS		Mud @ 62
				FG to MG SS					Q = ~3 GPM
1433	65.0					Pink	AS ABOVE		Hum = 5 PPM
									STEADY RAIN
1436	70.0					Grey-pink	AS ABOVE		Q = 5-7 GPM
									Q increasing
1439	75.0					Pink	AS ABOVE		Q = 10 GPM
1444	77.0			MG SS		Grey-Green	MG SS		EOR @ 76
	80.0								
	81.0			FG to MG SS		Dark Grey	FG to MG SS		Quiet Drilling
1448	84.0								Copter, noise more
	85.0			VFG SS		Red-Brn	VFG SS		Just mud
	89.0								Quiet @ 89 No flow, just mud
	92.0								No returns @ 92
	94.0			FG SS		Dark Gray	FG SS w/ calcite in Fx bands ?		Mud @ 94
1454	95.0								Q ≈ 3 GPM - Hard Drill
	97.0								Q to 5-7 GPM
1455	100.0			FG to VFG SS		Red-Brn	FG to VFG SS		Q down to 3-5 GPM

REMARKS

BORING HN-36P

PAGE 2 . 3

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7/14/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HW-36D
DRILLER: RAAB

SAMPLE NO. & TYPE OR ROD	DEPTH (FT) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (DOWNHOLE) OR SCREENED INTERVAL	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		REMARKS
1501	101.0			FG to VFG SS					EOR @ 101
	101.0					Pink-purple	AS ABOVE		Q to 5 @ 104
1504	105.0								
1505	107.0			*					Q to 7-10 GPM
	110.0					RED-BRN	VFG SS w/clink		Bcs. Fe
1508	112.0			*					Increasing Q
1509	113.0								Q = 10-12
	115.0			FG SS		BRN	FG SS w/clink		
									CLOUDSHOT - U. HEAVY RAIN
1513	120.0						AS ABOVE		Q = 12 GPM
1604	126.0								EOR - Stop for lightning
	128.0					GRY	FG SS		
1606	129.0			VFG SS		RED-BRN	VFG SS / MICASPAR?		Q = 7-10 GPM
									FASTER
1608	135.0			Sand		RED-BRN	AS ABOVE		
									Q increasing 10-12
1610	140.0					GREY-BLK	VFG SS to FG SS		LESS Q, mostly mud
	147.0			FG SS					more Q 7-10 GPM
1612	145.0			* Sand		GREY-BLK	FG SS w/ clink		Q = 12-15 GPM
									Light film on water
1614	150.0			Collar		GRY-BRN	FG SS micaceous		Q = 12-15 GPM

TD = 151

REMARKS

Below hole for 10 min. water did not clear. well making 10-12 GPM total. Good water bearing zones from 105 to 115 and 140 to 150.

BORING HW-36D

PAGE 3 . 3

JRB ASSOCIATES, INC.
8400 Westpark Drive, McLean, Virginia 22102

WELL LOG

PROFILE	DESCRIPTION
0	GRASS/VEGETATION.
1	
2	
3	BROWN-TAN. SILT LOAM DRY. SOME SANDSTONE FRAGMENTS
4	
5	
6	SPLIT SPOON - 5'-6.5' 6": 11/13/15
7	
8	
9	STIFF - GRAY SILT LOAM. MANY SANDSTONE FRAGMENTS
10	SPLIT SPOON 10'-10.6' 36 25/1'
11	
12	HARD RED-BROWN SANDSTONE. MOIST
13	
14	
15	AUGER REFUSAL.
16	
17	
18	
19	
20	

PROJECT NADC WARMINSTER, PA

OWNER NAVAL AIR DEVELOPMENT CENTER

WELL NO. D6-7 (HN-37X)

LOCATION DOWNGRADIENT SITE #7, SOUTH OF AIRFIELD. ACROSS PATH BETWEEN FENCE AND AIRFIELD.

	Date	Time
DRILLING STARTED	7/19/92	10 45
DRILLING COMPLETED	7/19/92	13 15

DRILLER LARRY CISLER. SCI

GEOLOGIST ED TOKARSKI JRB

RIG TYPE MOBILE B-56.

REFERENCE POINT LAND SURFACE

R.P. ELEVATION 338.6 SURVEYED

TOPO POSITION FLAT LYING

PROFILE BY ED TOKARSKI

FIELD BOOK NO. 1 PAGES 64-65

WELL DATA

HOLE DIAMETER 6" O.D.

HOLE DEPTH 15.5'

CASING DIAMETER 2" I.D.

CASING LENGTH 10.4'

SCREEN DIAMETER 2" I.D.

SCREEN SETTING 15.05'-10.75'

SCREEN SLOT/TYPE 10-SLOT/MICROMESH (2.15'/2.15') STAINLESS STEEL - (JOHNSON)

PUMP TEST DATA

STATIC DEPTH TO WATER 5.81 // 8.69

DATE MEASURED 7/25/92 // 9/9/92

PUMPING DEPTH TO WATER SAME

TEST DURATION —

PUMPING RATE —

TEST DATE 9/9/92

TEST TYPE BAIL TEST

PUMP SETTING 14.5'

SPECIFIC CAPACITY See Report.

REMARKS

DRY BUT CUTTING MOIST FROM 10'

SMC ENVIRONMENTAL SERVICES GROUP

DRILLING LOG

PROJECT NADC OWNER Navy

LOCATION Site 7 W.O. NUMBER 9710-40001

WELL NUMBER DG-25 (HN-375) TOTAL DEPTH 41' DIAMETER 6"

SURFACE ELEV. / WAT. LEV.: INIT. 40.2' 11/13/90 ~~24 HRS~~ 12.10'

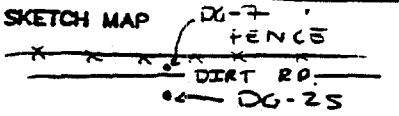
Open Hole: DIA. 6" LENGTH 21-41' SLOT SIZE NA

CASING: DIA. 6" LENGTH 0-21' TYPE PVC

DRILLING COMPANY C.S. Garber DRILLING METHOD Air Rotary

DRILLER E. Williams LOG BY PDB DATE DRILLED 11/9/90 11/13/90

SKETCH MAP



- Water level was measured from top of inner casing.

NOTES

SHALLOW BEDROCK WELL

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE NUMBER (PID/FID)		DESCRIPTION / SOIL CLASSIFICATION (U.S.C.S.) (COLOR, TEXTURE, STRUCTURES, MOISTURE, OVA READING)
	SOIL	21' CASING	ND		0-2' Orange-red sandy silt (SM). Dry
	BEDROCK				2-11' Brownish-red medium grained Sand. Dry
					11-16' Dark brown medium grained arkosic Sandstone. Dry
					16-29' Brown sandy siltstone. Dry
41		OPEN HOLE			29-41' Maroon-brown medium grained Sandstone. Sandstone contained equal amounts of quartz and feldspar with minor micaceous elements. Quartz grains were very coarse to granule sized.
		2' BENT. SEAL PROT. CASING w/ LOCKING CAP. GROUT TO SURFACE. SEE WORK PLAN SPECS.			* Set Casing at 21'

Hydrogeology

- Overburden appeared dry
- Water was hit at 36'
- Well yield = 1 gpm
- 5' of water collected inside the well in five minutes

· BORING LOG

HALLIBURTON NUS

PROJECT: NAWC Warminster
BORING NO.: HN-37 I, D*
PROJECT NO.: 1412
DATE: 5/19 and 5/20/94
DRILLER:
ELEVATION:
FIELD GEOLOGIST:
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1614	0					tan	silty clay		damp
1618						lt. brn	clayey silt		
1621	5					brn	clayey silty sand		damp added
1624									
	10					BRN-gray	vfgr-fgr sandstone		loud hammering
									steam
				*		gray-brn	vfgr-fgr sandstone micaceous		~4gpm large pieces of rock
1633	15								7-10gpm 10-12gpm
1640 1642							same as above		
5/19 5/20 1042	20								
						purple	vfgr-fgr sandstone		@ ~10gpm
1056	26								EOR no HNU rdg.
1058						tan	vfgr-fgr sandstone		
	30								
						light brn	fgr-mgr sandstone mostly quartz		
1102	36						gray vfgr sandstone, red-brn siltstone and tan fgr sandstone		
	40								
1106						purple	vfgr sandstone, micaceous		poss. fracture
						red-brn	siltstone/mudstone with green mineral		
	46								
						red-brn	vfgr sandstone, some calcite		
	50								

REMARKS I.R. T-4 rig 10" air hammer to 18'. set 6" shell casing to 18'. 6" air hammer to 159'
* HN-37 I & HN-37D CONSTRUCTED within same borehole.

* See Legend on back

BORING HN-37I,

PAGE 1 OF 1

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN-37 I

PROJECT NO.: _____ DATE: 5/20/94 DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK SR OR USCS	REMARKS
1111 1114	51								EOR yield 15-18 gpm
1115									
1116	55					red-brn purple	siltstone/mudstone and vfgr sandstone		15-18 gpm
112									
1118	60								
1119						grayish brn	fgr sandstone, rust staining		
1121									
	65			- - - -		red brn	vfgr sandstone		poss. fracture
1123									
1124	70								
						grayish brn	vfgr - fgr sandstone micaceous		15-18 gpm
1126	73								
1129	75					purple	vfgr - fgr sandstone w/ some red mudstone		EOR 15-18 gpm
1131 1132									
	80								
1133						red brn	siltstone/mudstone		
1136	85			*		grayish brn	fgr sand stone		yield inc. to 25-30 gpm
1130	90								
						gray	fgr sand stone, some greenish fgr sand stone		
1142	94								
							same as above		
1145	100								

REMARKS _____

BORING HN-37I, D

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* See Legend on back

· BORING LOG

HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN-37 I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1145	101								
1153	104					lt gray	fgr - mgr sandstone		
1155	106					brn, tan, red	fgr sandstone		
1157									25-30 gpm
	110								
1159						gray	fgr sandstone		
	115					red brn	v fgr sandstone / siltstone, some calcite		
1203	120								poss. fracture
1205						red-gray	v fgr sandstone		
1206									
1208 1209	125 126								EOR pickup ser water last 1 of rod
1214									vich ~35 gpm
	130								
1218						purple	fgr sandstone		
1220	134								~35 gpm
1221	136					gray-brn	fgr sandstone		
1223									
1234	140								
						red-brn	v fgr - fgr sandstone, micaceous		
1230	146					purple	v fgr - fgr sandstone, micaceous, some green-gray v fgr sandstone		
1232 1233	150								

REMARKS _____

BORING HN-I

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* See Legend on back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC Warminster — BORING NO.: HN-37I
PROJECT NO.: 1412 — DATE: — DRILLER:
ELEVATION: — FIELD GEOLOGIST:
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1233 1239	151					brn-gray	vfgr-fgr sandstone		EOR
1241							w/ some soft white mineral (Kaolinite?)		
1245						purple	vfgr-fgr sandstone		
1246	159								
									yield ~35gpm

REMARKS

BORING HN-37I

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* See Legend on back

BORING LOG **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER BORING NO.: MW-08 (HN-38X)
PROJECT NO.: 3933 (CTO-0022) DATE: 6-11-92 DRILLER: DON McMASTER
ELEVATION: FIELD GEOLOGIST: R. GOOD
WATER LEVEL DATA: DRY, 7/7/92
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
S-1 @	0.0	2 / 2				BRN.	SILTY CLAY w/ ROOTS		0 PPM, DAMP
1208	2.0	3 / 3	15"/24"		MED. STIFF			ML	
S-2 @		6 / 16				BRN TO LT. GRAY	6" CLAY & SILTY CLAY		0 PPM, DAMP
1214	4.0	10 / 9	16"/24"		STIFF	ORANGE BRN.	10" SILTY CLAY w/ WEATHERED RED-GRAY, FGR SS FRAGS	ML	
S-3 @		5 / 6				REDDISH	10" SILTY CLAY w/ SMALL SS FRAGS 3" SAND & WEATH. SS FRAGS		0 PPM, DAMP TO
1222	6.0	38 / 29	18"/24"		HARD	BRN	5" SILTY CLAY w/ SS FRAGS	ML	SLIGHTLY MOIST
S-4 @	7.0	20 / 50+	7"/12"		HARD	BRN - GRAY	FGR SAND, WEATH. SS FRAGS, SOME SILT & CLAY	SM	0 PPM, DAMP TO
1230							CONSOL. SS AT 7 FT APPR.		SLIGHTLY MOIST
									SAMPLE REF & AUGER
									REF @ 7'

REMARKS HSA - 7½" I.D., 12" O.D. - 24" x 2" SPLIT BARREL SAMPLE SPOONS. FAILING F-10 DRILL RIG. INSTALL 4" I.D. PVC WELL.

BORING MW-08

PAGE 1 OF 1

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: MW-05 (HN-38S)

PROJECT NO.: 3933 (CTO-0022) — DATE: 6-9-92 & 6-10-92 — DRILLER: DON MC MASTER

ELEVATION: — FIELD GEOLOGIST: R. GOOD

WATER LEVEL DATA: 8.73' TOC 7/7/92

(Date, Time & Conditions)

	SAMPLE NO. & TYPE / TIME	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY/CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	1428	0.0					BRN.	SILTY CLAY & CLAY	ML/CL	
	1432	5.0					REDDISH BRN.	SILTY CLAY W/ SILTSTONE & SANDSTONE FRAGS.	ML	
	1435	10.0								
					TEMPTEMP TOP BEDROCK	MED. HARD	REDDISH GRAY	WEATHERED FGR. SANDSTONE		
	1439	15.0								
	1443	20.0				MED SOFT	RED	SHALE & SILTSTONE		BEDROCK STILL WEATHERE NOT WELL CONSOLIDATED.
6/9 6/10	1448 1634	25.0			6" PVC CSG.	MED. HARD TO HARD	LIGHT GRAY	FGR SANDSTONE, HARD & VERY FRACTURED	V. BR	WATER BEARING ZONE, 2 GPM EST.
	1639	30.0					LIGHT GRAY	FGR SANDSTONE, HARD & VERY FRACTURED.		
	1643	35.0			TOTAL DEPTH				V. BR	TOTAL DEPTH APPX 35' SANDSTONE FRACTURED INTO LARGE FRAGS (UP TO 1" OR MORE) SOME DAMAGE TO LWR PART OF PVC CSG. EST YIELD = SEVERAL GPM.

REMARKS INGERSOLL-RAND T-4 DRILL RIG. 10" AIR HAMMER BOREHOLE & 6" I.D. PVC CSG TO APPX 25'. 6" DIA. AIR HAMMER OPEN BOREHOLE TO TOTAL DEPTH.

BORING MW-05

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* See Legend on Back

· BORING LOG

HALLIBURTON NUS

PROJECT: NAWC Warminster BORING NO.: HN-38
PROJECT NO.: 1412 DATE: 5/23/94 DRILLER:
ELEVATION: FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1024	0								
1027	4								
1032									
1033	9								
						gray	vfgr-fgr sandstone micaceous		
1037	17								damp
	20			*					fracture 3-4 gpm
						red brn	siltstone		
1047						red-BN	siltstone / vfgr sandstone micaceous, soft		
	30			*					Q = 10-15 gpm no HNU reading
1051									fracture
						pink-gray	fgr sandstone and red-BN siltstone/mudstone		fracture
									Q = 25-30 gpm
1055						red gray	fgr sandstone		
	40								large pieces of sandstone fracture
1102						pink gray	fgr sandstone		
1120	44								EOR Q ~ 30 gpm
						pink-gray	fgr sandstone and red-BN siltstone		
1122	50								

REMARKS J.L. T-3 via 10" air hammer to 50'; 6" steel casing to 50'; drill out with 6" air hammer to 110'

BORING HN-38

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC Warminster — BORING NO.: HN-38
PROJECT NO.: 1412 — DATE: 5/23/94 — DRILLER:
ELEVATION: — FIELD GEOLOGIST: D. whalen
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY* CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1358	51					red-BN	siltstone/vf-fgr sandstone		dry, dusty
									dusty
	55								
						red BN	siltstone		dusty
	60								
1403	64					red-BN	siltstone/mudstone		dusty EDR
1404									
1405									
	70			*		Pink gray	fgr sandstone		Q ~ 3 gpm no HNU reading
	74					purple	vf-fgr sandstone micaceous		
									lignite film on water
1408	80								
									lignite film
1411	84						same as above		EDR
1413									
				----		red gray	fgr sandstone		Q ~ 5 gpm
1417	90								
1419	94					red-gray	fgr sandstone		
1423	100								

REMARKS

BORING HN-38

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC Warminster — BORING NO.: HN-38
PROJECT NO.: 1412 — DATE: 5/23/94 — DRILLER:
ELEVATION: — FIELD GEOLOGIST:
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	101								
1424	104						same as above		EOR yield ~5g
1426									
				*					Q ~30gpm
	110					pink gray	fgr sandstone, micaceous		no HNU reading
1433									
1436	114								
							same as above		
1442	118								total yield ~35gpm

REMARKS

BORING HN-38

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: MW-09 (HN-39X)
PROJECT NO.: 3933 (CTO-0022) — DATE: 6-15-92 — DRILLER: DON McMASTER
ELEVATION: — FIELD GEOLOGIST: R. GOOD
WATER LEVEL DATA: 7.90' TOC, 7/7/92
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
S-1 @	0.0	5 / 3				BRN.	SILTY CLAY W/ ROOTS & TRACES		0 PPM, DAMP
1041	2.0	4 / 3	15"/24"		MED STIFF		OF SM. RK. FRAGS	ML	
S-2 @		2 / 2				BRN	10" SILTY CLAY 6" SILTY SD. & WEATHERED		0 PPM, DAMP TO WET
1045	4.0	2 / 5	16"/24"		MED. STIFF	&	SANDSTONE 1" CLAY LAYER	ML	IN LWR. 4"
S-3 @		4 / 4				BRN &	WEATHERED SANDSTONE &		0 PPM, MOIST TO WET
1048	6.0	10 / 13	13"/24"		STIFF	REDDISH BRN	SILTSTONE	SM	SAPROLITE
S-4 @	7.0	15 / 50+	6"/8"		HARD	REDDISH GRAY &	WEATHERED TO CONSOLIDATED SANDSTONE		0 PPM, MOIST TO WET
1101						BRN			SAPROLITE / BEDROCK
									SAMPLE REF @ 6'8"
									AUGER REF @ ~7'

REMARKS: HSA 7½" I.D. 12" O.D. - 24" x 2" DIAM. SPLIT BARREL SAMPLE SPOONS. FAILING F-10 DRILL RIG. INSTALL 4" I.D. PVC WELL.

BORING MW-09

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: MW-06 (HN-39S)

PROJECT NO.: 3933 (CTO-0022) — DATE: 6-9-92 & 6-11-92 — DRILLER: DON MC MASTER

ELEVATION: — FIELD GEOLOGIST: R. GOOD

WATER LEVEL DATA: 10.86' TOC, 7/7/92

(Date, Time & Conditions)

SAMPLE NO. & TYPE / TIME	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1613	0.0					BRN	SILTY CLAY	ML	MOIST
1616	5.0				MED	RED	WEATH. SHALE & SILTSTONE		SAPROLITE
					SOFT	RED	SHALE & SILTSTONE		TOP OF BEDROCK APPX 6' TO 7'
						REDDISH GRAY	FGR. SANDSTONE, SLIGHTLY WEATH.		
1620	10.0								WET
					MED HARD		9'-11' FRACTURED INTO LG. FRAGS	V. BR	WATER BEARING AT SEVERAL GPM
					TO HARD				
1623	15.0								
1625	18.0			6" PVC CSG		REDDISH GRAY	FGR SANDSTONE, HARD.		
1454	20.0								
					MED. SOFT	RED	SHALE & SILTSTONE		
					MED HARD	REDDISH GRAY	FGR SANDSTONE		SOME WATER FROM ZON AT 24'-25'
1499 / 1501	25.0								
1503	30.0								
						BRN.	FGR SANDSTONE		
1504 / 1507	35.0								STOP TO CHECK WATER EST. ≤ 1 GPM
1509	40.0								
					MED. HARD	BRN & RED	FGR SANDSTONE INTERBEDDED W/ SHALE & SILTSTONE LAYERS		
					MED SOFT				
1511	45.0								
									TOTAL DEPTH APPX 50'
1513	50.0								EST. YIELD ~2 GPM.

REMARKS INGERSOLL-RAND T-4 DRILL RIG. 10" AIR HAMMER BOREHOLE & 6" I.D. PVC CSG TO APPX 18'. 6" AIR HAMMER BOREHOLE OPEN TO TOTAL DEPTH.

BORING MW-06

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* See Legend on back

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 5/23/94, 1400, clear

DATE: 5/23/20
FIELD GEOLOGIST D. NIMMER

BORING NO. HN-39
DRILLER: RAAB

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS CODE	REMARKS
1400	X								
1410	05.0			ML		BRN	SILTY CLAY.	ML	
									ADD ROD AT 6 FT DRY
	10.0			TOP = 8'		BRN	FG SS		DRY
1415	11.0					TAN	FG SS		
1421	15.0					TAN	FG to MG SS		MOIST
	17.0								WATER @ 17 - JUST MUD SLOW DRILLING. HNU = 0.0 ppm
				6" OSC TO 18.5'					
1525	21.0					WHITE-GRY	MG SS		DRILLER HAMMERS CASING TO ATTEMPT TO STOP RETURNS FROM
									COMMING UP OUTSIDE CASING
1530	26.0					RED-BRN	VFG SS		Q = 10 GPM FAST DRILLING. FOR @ 26
	29.0								
	30.0					RED-BRN	MUDSTONE / SILTSTONE		
							CG to MG SS		FAST DRILLING
									HNU = 0.0
	35.0						CG to MG SS		LESS Q, ≈ 3-5 GPM
1538	40.0					REDDISH PURPLE	FG SS		HNU = 0.0 Q ≈ 3-5 GPM - MOSTLY MUD
1542	45.0						AS ABOVE		
									FEW RETURNS
	50.0								NO RETURNS

REMARKS Ingersoll-Rand T-[illegible] R16 w/ 10" AIR HAMMER to 19 ft. 6" AIR HAMMER to 19 ft. 6" Steel CASING to 18.5 ft. Hole also Logged by USGS. Stickup of 2.5 ft of Casing ABOVE GROUND SURFACE.

BORING HN-39

PAGE 1 . 3

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.:
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE:
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-39
DRILLER: RAAB

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK CODES	REMARKS
1545	51.0								EOR @ 51
									Q= 3-5 @ 53
	55.0					Grey	FG SS		
	60.0					Dark-grey	FG SS		Q= 3-5 gpm
									FAST Drilling
									LESS Q - NO MUD
	66.0					RED	MUDSTONE		Dry
1555	70.0						AS ABOVE		
1600	76.0								EOR @ 76 FT
							AS ABOVE		NO Return
	80.0					RED BRN	"		Dry
									water @ 84
1604	84.0								Q= 3-5 GPM
	85.0					RED-Purple	MUDSTONE / SILTSTONE		
									FAST DRILLING
	89.0 90.0					Red-Purple	FG SS		Q= 5-7 @ 89 HNU=0.0
	93.0								Q= 8-10 @ 93
1612	95.0					GREY-GREEN	MG SS TO FG SS		Q= 10-12 GPM
	100.0						AS ABOVE		Similar Q rate

REMARKS

BORING HN-39

PAGE 2 . 3

BORING LOG

Halliburton NUS

PROJECT: 1412
PROJECT NO.:
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 5/23/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-39
DRILLER: RAAB

SAMPLE NO & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	BORING CONDITIONS	REMARKS
1617	101.0					RED	FG SS		EOR @ 101
	105.0								Q=13-15 GPM
1621	110.0					RED-BRN	FG SS		Q= ~15 GPM @ 112
1624	115.0						FG SS		Q=13-15 GPM
	120.0						AS ABOVE		Q=13-15 GPM
	126.0								EOR @ 126
	129.0					GRAY	FG SS		
1639	131.0						AS ABOVE		
	135.0								Less Q = 7-10 GPM
	135.0						AS ABOVE		Increasing Q @ 134
									Q=12-15 GPM @ 136
	140.0					RED-BRN	FG SS		Similar Q
									FASTER Drilling
	145.0					RED	FG SS		Q= 15-18 GPM @ 145
1644	150.0					DARK RED	AS ABOVE		

REMARKS Blew hole for 10 min. Well making ~15 GPM.

BORING HN-39

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 5/27/94, 1022, Cloudy, strong winds, 55°. WELL LOCATED IN FRONT OF GATE 40A.

DATE: 5/27/94
FIELD GEOLOGIST P. Nimmer

BORING NO. HN-40 S
DRILLER: RAB

SAMPLE NO. & TYPE OR RUN	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		REMARKS
1022	0.0					BRN	SANDY SILT w/SOME CLAY		MOIST
1026	4.0								ADD ROD @ 4.0
	6.0						SANDY SILT w/SS FRAGS		DRY
						RBN	FG SS		DRY
				TREMIE TOP=9'					
1030	13.0					GRY	FG TO MG CC		
1031	~~14~~ 15.0					BRN	FG SS		DRY
1032	16.0					Purple BRN	FG SS		
	20.0					BRN to RED	SILTSTONE / RED MUDSTONE		Very soft @ 20 - EOR
1041	23.0				V. SOFT	RED	MUDSTONE		EOR @ 23
	30.0			6" CSG to 31'		RED	AS ABOVE		
1045	51.0				MED. HARD	GRAY-WHITE	FG SS		DRY - Very dusty
1130	52.0					GRY PURPLE	AS ABOVE		
1140	52.0					BRN	VFG to FG SS		MOIST - NO DUST
1142	42.0						AS ABOVE		
1145	45.0				SOFT	RED-BRN	MUDSTONE		DRY EOR @ 45
	45.0					RED-BRN	AS ABOVE		MOIST
									FAST drilling

REMARKS Ingersoll-Rand T-3 R16 w/ 10" AIR HAMMER TO 31 ft.
6" AIR HAMMER TO ft. 6" STEEL CASING TO 31 ft
CASING STICKS UP 1.5 ft. HOLE NOT LOGGED BY USGS.

BORING HN-40S

PAGE 1 . 2

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 5/27/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-40S
DRILLER: RAAB

SAMPLE NO. & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Coordinate) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		REMARKS
	51.0					RED-BRN	VFG SS / SILTSTONE		MOIST
1050	54.0								MUD @ 54'
									Cutting DRY AGAIN
	57.0								MORE MUD, THEN DRY
1152	60.0						VFG SS		SOME Q @ 60' < 5 GPM
1156	63.0								INCREASING Q @ 63 EOR @ 63
	65.0					BRN	FG SS		Q = 5-7 GPM @ 64 Q = 10-15 GPM @ 65
1159	68.0								Q = 15-18 GPM @ 68
				TD=68					HNU = 0.0 @ 68
							TOTAL DEPTH = 68 ft		

REMARKS BLEW Hole for 15 MIN. WELL Making 18-20 GPM.
WATER CLEARED SLIGHTLY AFTER 10 MIN.
(*) GOOD Potential SCREENING INTERVAL FROM 58 to 68 ft.

BORING HN-40S

PAGE 2 . 2

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 5/25/94, 0940, clear, 70°. Well on New town Road near Inertial Guidance Bld, NE of Gate 40A.

BORING NO. HN-40I
DRILLER: PAAB
DATE: 5/25/94
FIELD GEOLOGIST P. NIMMER

SAMPLE NO. & TYPE OR RUN	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (DEPTH) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
0940	0.0								
				SM		BRN	SANDY SILT	SM	DRY
						TAN	SANDY SILT	SM	DRY
0949	11.0			TOR = 9'		BRN	FG SS		DRY
						PURPLE	FG SS		DRY
0952	15.0					BRN	AS ABOVE		MOIST
	16.0					RED-PURPLE	MUDSTONE		VERY SOFT 16' to 28'
									FAST Drilling
0957	23.0					RED-PURPLE	AS ABOVE		EOR @ 23'
1001	28.0					BLK	FG TO VFG SS		Slower drilling
1004	29.0								Water @ 29'
1034	31.0			6" CSG TO 30'			AS ABOVE		MOIST
	35.0					GRAY	FG SS		DRY. water @ 33.5'
1037	35.0					RED-BLK	FG SS w/ orange oxidation patches on cuttings		Q = 5-7 GPM
	37.0								Q = 7-10 GPM
	40.0					RED	MUDSTONE LAYERS ?		VERY SOFT - Lost returns
1102	45.0					RED-BRN	VFG SS		EOR @ 43
									Less Q, 3-5 GPM
	48.0								Just mud @ 48'
	49.0								Q = 7-10 @ 49'

REMARKS INGERSOLL-RAND T-3 RIG w/ 10" AIR HAMMER TO 30 Feet.
6" AIR HAMMER TO 133 ft. 6" Steel CASING to 30 ft.
CASING sticks-up 2.5 ft. Hole ALSO LOGGED BY 4565.

BORING HN-40I

BORING LOG

Halliburton NUS

PROJECT. WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 5/25/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-40 I
DRILLER: RAAS

SAMPLE NO. & TYPE OR RUN	DEPTH FT OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		REMARKS
1106	51.0				MED. HARD	RED-BRN	FG to VFG SS		Q FLUCTUATING
1107	55.0					RED-BRN	AS ABOVE		Q=5-7 GPM
									Q=7-10 GPM
1109	60.0					RED-BRN	AS ABOVE		HNU=0.0
	61.0					GRY BLK	FG TO VFG SS		
1114	63.0								EOR @ 65
	65.0					GRY-BLK	AS ABOVE w/MICA FLAKES		Q=7-10 GPM
									Slowly increasing Q
	70.0					RED and GRY	FG to MG SS. Black mineral present on cuttings surface		Q=10-12 GPM
									HNU=0.0
1121	75.0					GRY-GREEN	FG TO MG SS		Q=12-15 GPM
	79.0					RED-BRN	VFG SS		Soft
							MUDSTONE / SILTSTONE interbeds?		
1128	83.0								EOR @ 83'
1129	85.0					GREY-BLK	FG SS		Q=12-15 GPM
1133	90.0					RED-BRN	VFG SS / SILTSTONE		Less Q, mostly mud
									FAST Drilling
	95.0								Q=5-7 GPM
1136	97.0								More Q, 12-15 GPM
1137	100.0					Brown-BRN	FG SS		HNU=0.0, Q=12-15

REMARKS

BORING HN-40I

PAGE 2 . 3

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 5/24 25/94
FIELD GEOLOGIST P. Nimmer

BORING NO. HN-40F
DRILLER: RAAB

SAMPLE NO. & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1139	101.0						BLACK FGONTER @ 101		BLACKER Gone by 102
1140	103.0								EOR @ 103
	105.0					Red-Brn	VFG SS w/ mudstone interbeds		more mud, Q @ ~10 GPM
1144	110.0						AS ABOVE		more Q, 15-17 GPM
									HNU = 0.0
1147	115.0					Red-Purple	VFG to FG SS		Q = 15-17 GPM
									LESS Q @ 119, to 12-15 GPM
1151	120.0					Grey-Blue	FG SS		
									Q ≅ 15 GPM increasing?
1200	125.0								Q up to 15-18 GPM
	125.0					Grey or Black	FG to MG SS		EOR @ 125.0' - HNU = 0.0
	127.0								Q increasing to ~20 GPM @ 125
	130.0					Red-Brn	mudstone / siltstone bed		Poss. FX - lost returns
									softer
1206	135.0								
							TOTAL DEPTH = 135 ft		

REMARKS (*) Good potential screening interval.
Blew hole for 15 min, well making ~20 GPM

BORING HN-

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 5/24/94, 1038, Clear 75°

DATE: 5/24/94
FIELD GEOLOGIST PNUMMER

BORING NO. HN-X40 DEEP
DRILLER: RAAB

SAMPLE NO. & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (DEPTH) OR SCREENED INTERVAL	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1038	0.0			ML		Red-Brn	Silty clay	ML	DRY
	9.0			SM		Red-Brn	Sandy silt	SM	DRY
1045	12.0					Purple	FG to VFG SS		DRY
	14.0			TOR=11		Brn	As above		MOIST
	18.0				Soft	Red	Mudstone/Siltstone		softer @ 16 - easy drilling
1110	19.0								DRY
									Eoe @ 21'
1111	23.0						As above		
	25.0			6" csg to 25'		Grey/Brn	FG to MG SS		
									MUP @ 27'
1115	31.0					Pink-Brn	FG SS		Q= 5-7 GPM
	36.0					Red-Brn	FG SS		Slightly less Q, Q= 3-5 GPM
1118	39.0								Q= 7-10 GPM @ 40'
1120	41.0					Red			
	43.0					Red-Purple	VFG SS		Q= 7-10 GPM
	48.0						As above		Q= 10-15 GPM
	50.0				Med-Hard	Red-Brn	VFG SS		more mud, less flow @ 50

REMARKS Ingersoll-Rand T-3 Rig w/10" Air Hammer to 19 ft. Washout to 25 ft. 6" Steel casing to 25 ft. 6" Air Hammer 19 to 161 ft. Casing Stick-up 2.1 ft above Ground. Hole also Logged by USGS.

BORING HN-40D

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· BORING LOG

HALLIBURTON NU

PROJECT: NAWC Warminster
BORING NO.: HN-35D
PROJECT NO.: 1412
DATE: 5/17/94
DRILLER: Raab
ELEVATION:
FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1354	52					gray-BRN	v fgr sandstone		very little return Ecr
1359									no water in hole when start hole rod
	55					lt. BRN gray	fgr-mgr sandstone		dry
						BRN	v fgr sandstone		
	60								
1405	64								
1406	67					BRN	siltstone / mudstone		dry
	70					rust red	mudstone		dusty
1410	73								
							same as above		
									dusty
1413 1420	77								Ecr mud
	90								no dust dry
1423	93								dry
1424									
						gray-Brown	fgr sandstone		dusty
1427									dry
1429	90								
1430						gray BRN	v fgr-fgr sandstone		dry
1432	94								poss. fracture
	100								poss. fracture

REMARKS

BORING HN-35

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* See Legend on Back

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 5/24/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-40 D
DRILLER: RAAB

SAMPLE NO. & TYPE OR RUN	DEPTH IN FT OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (DOCUMENT) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	[illegible]	REMARKS
	52.0								Q= 13-15 GPM. HNU=0.0
1127	56.0					RED-BRN	VFG SS		FAST DRILLING
	58.0						AS ABOVE		Q=15 GPM
1132	60.0					BRN-GREY	MG to FG SS		EOR @ 61
	63.0						AS ABOVE w/ PATCHES OF RED OXIDE PATCHES ON COATINGS		Q= 15 GPM
1136	66.0					BRN	AS ABOVE		
1136	68.0								Q= 15-18 GPM
	74.0					GREY-BRN	MG to CG SS		
1140	78.0					RED-BRN	SILTSTONE		
1142	81.0								EOR @ 81
1144	83.0				MED. HARD	GREY	FG SS.		
	86.0					RED-BRN	VFG SS		
1146	90.0					GREY			
	91.0					GREY-BRN	FG to VFG SS. BLACK FLOATING FILM @ 93'		Q= 18-20 GPM
	95.0					GREY-BRN	FG to MG SS		
	98.0					GREY-BRN	FG SS.		Q= 18-20 GPM

REMARKS

BORING HN-40D

PAGE 2 . 4

BORING LOG

Halliburton NUS

PROJECT. WARMASTER
PROJECT NO.:
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 5/24/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-40D
DRILLER: RMB

SAMPLE NO & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1154	101.0								EOR @ 101
	102.0					RED			
	106.0					RED-BRN	FG to VFG SS w/ white min. on cuttings		FX ZONE?
	108.0					RED-BRN			MORE Q, up to 20-23 GPM
	111.0					PURPLE-BRN	FG SS		Q = ~ 25 GPM
1201	115.0						AS ABOVE		
	118.0					PURPLE-RED	FG TO VFG SS		
1208	119.0								EOR @ 121'
	125.0					GREY	FG SS		
	126.0					RED-BRN	VFG SS		FAST DRILLING
	131.0					RED-BRN	FG to VFG SS		MORE Q, up to 30 GPM
	133.0								
1217	135.0						FG to MG SS		Q ≅ 30 GPM
	140.0					PURPLE BRN	FG to MG SS		
1224	141.0						-		EOR @ 141
1227	145.0					GREEN-GREY	FG TO MG SS		Q = 30 to 33 GPM (*)
	150.0						BLACK FLOATER @ 149'		

REMARKS (*) = GOOD SCREENING INTERVAL FROM 145 to TOTAL DEPTH.

BORING HN-40D

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 5/24/94
FIELD GEOLOGIST: P. Nimmer

BORING NO. HN-40 D
DRILLER: RAAB

SAMPLE NO. & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY & SAMPLE LENGTH	LITHOLOGY CHANGE (Good/Poor) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	151.0					GREY-GREEN	FG to MG SS		FLOATER CONTINUES Q= 35-38 GPM
	155.0			- - - -		GREEN-GRY	FG SS		FLOATER STOPPED
				Natural Collapse to 154'					FAST Drilling
	160.0					GREY-WHITE	VFG SS / SILTSTONE		
1237	161.0			TD = 161'		RED	MUDSTONE / SILTSTONE ?		Sudden color change at bottom of Hole.
							TOTAL DEPTH = 161 FE		
							NATURAL COLLAPSE to 154 FE		

REMARKS: Blew hole for 10 MIN. well making 35 + GPM.
Good Potential SCREEN interval From 145 FE to 161 FE.
WATER CLEARED IN ~5 MIN.

BORING HN-40 D

PAGE 4 . 4

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 5/25/94 , 1430 , clear 83°

DATE: 5/25/94
FIELD GEOLOGIST

BORING NO. HN-41 S
DRILLER: RAAB

SAMPLE NO. & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (N)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS CONSTITUENTS	REMARKS
1430	0.0					BEN-TAN	SILTY CLAY		DRY
									ADD ROD @ 3
1433	4.0								
	8.0					TAN	FG SILTSTONE		
	10.0					BRN	FG SANDSTONE		DRY. SLOW DRILLING
				TOP = 9'					
1440	14.0			~~TOP = 12~~		PURPLE-BLK	FG SS		DRY
1442	15.0					GREY-PURPLE	FG SS		DRY
1447	18.0						AS ABOVE		DRY - LESS DUST
1501	19.0					BRN	FG to MG SS		MUD @ 19
									DRY
1502	24.0						AS ABOVE		DRY. EOR @ 24
	28.0					PURPLE-BRN	VFG SS		
1507	30.0								MUD @ 30
1508	35.0						AS ABOVE		DRY
	37.5					RED-BRN	MUDSTONE / SILTSTONE		
							W/VFG SS		
1511	42.0								MUD @ 42
1513	44.0								EOR @ 44
	46.0								HNU = 0.0 . Q = 3-5 GPM
	48.0					PURPLE RED	FG SS		
1517	50.0								Q = 5-7 GPM

REMARKS INGERSOLL-RAND T-3 Rig w/ 10" Air hammer to 19 ft.
6" Air Hammer to 54 ft. 6" Steel Casing to 19 ft.
Casing sticks up ~2.0 ft. Hole logged By USGS.

BORING HN-41S

PAGE 1 . 2

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 5/25/94, Clear

DATE: 5/25/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-41S
DRILLER: RAAB

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	UNIFIED SOIL CLASSIFICATION	REMARKS
1517	51.0					Purple Brn	FG to MG SS		Q=7-10 GPM
1520	54.0								Loss Q @ 54 5-7 gpm
				TD=54'					
							TD = 54 ft		

REMARKS ⊗ Possible Screening interval. Blew Hole for 15 min. Well making 7-10 GPM.

BORING HN-41S

PAGE 2 of 2

BORING LOG — HALLIBURTON NUS

PROJECT: NAWC warminster
BORING NO.: HN-41-I
PROJECT NO.: 1412
DATE: 5/25
DRILLER: Raab
ELEVATION:
FIELD GEOLOGIST: D. whalen
WATER LEVEL DATA :
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1304	0								
1304	2					orange BN	silty sandy clay		moist
1305	5					BN	silty sandy clay pieces of		damp
1307	6						red-BN silty sandstone		
							~~silty sandy clay~~		hammering
						rd BN	silty v fgr - fgr sandstone micaceous		dry
1311	10								
						gray-BN	vf-f gr. sandstone, rust-stained grains		dry, dusty
1314	12								
1318	14								
~~1320~~	15						same as above		dry, dusty
1320	16					BN			
	17								
1324	19								
1353									
1354	22					gray BN	vf-fgr sand		dry
	25					rd-Black-Gray	vf gr sandstone, micaceous		dry, dusty

REMARKS: IR T-4 rig; 10" air hammer to 19'; 6" steel casing to 19'; 6" air hammer to 101'

BORING

PAGE ____ OF ____

* See Legend on Back

6 bags HY

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN-41-I

PROJECT NO.: 1412 DATE: 5/25 DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1357	27						Same as above		EOR
1358									dry, dusty
1359	30								
1401	31								jackup rig ~ 1/2'
									deep well · gushes at
	33								no dust ~ 32.5'
1403	35					BN	vf for sandstone, micaceous		damp
1404	36								
1407	41					9.2.4 BN	vf-for Sands		Some mud
1409	44								thick mud
1411	46						Same		thick mud
1413	50			*					

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN-41-I
PROJECT NO.: 1412 DATE: 5/25 DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA: _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1414	51								FOR ~8 gpm
1416									no HNU >Bkg
1419	56					red BM-gray	vfgr sandstone, micaceous		
							same		~8 gpm
	61								
1422	63								
1423	64								10+12
1425	66						same as above		
1428	68								
									poss fracture
	71					gray	vfgr sandstone/siltstone		lose return
									lignite film
									lignite film
1432									no film
	75								

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN-41-I

PROJECT NO.: _____ DATE: 5/25 DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1435	76					lt gray	f.gr sandstone		10-12 50R
1436									
	79								12-15
				*					
						Brn-gray	fgr sandstone micaceous		
1441	81								
	84								
1444									
1445	86					Brn-gray	fgr sandstone micaceous		
1447	88								
1448	89								
1449	91					gray BN	fgr sandstone		~15-20
1452	93								
1455	96						same as above		
	98								
1459	99					reddish gray	fgr sandstone, micaceous		

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HW-41-I

PROJECT NO.: 1412 DATE: 5/25 DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA : _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1500	101								final yield ~20 gpm
									yield gradually increased in the last 20 ft.

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC warminster — BORING NO.: HN-41-D
PROJECT NO.: 1412 — DATE: 5/24 — DRILLER: Raab
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA:
(Date, Time & Conditions) -

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1308	1					BN			
1309	2					orange BN	silty sandy clay		dry
1310	3								
	4					vlt BN	silty sandy clay		~~dry~~ dry
1312	5								
	6								some hammering
1316	7								
1319	8					vlt BN	vf gr sandstone micaceous		dry dusty
1323	9								
1328	10					pink gray	fgr sandstone		dry
1334	11								dry dusty
1337	12					lt BN - tan	vf - fgr sandstone rust staining		less dust
1339	13					pink gray			dusty
1342	14								dusty
13	15								
1351	16								dry dusty
1354	17					~~brown~~ gray	fgr sandstone		add rods, water in the hole
1405	18					brn - gray	fgr sandstone, orange rust staining		no dust moist
1412	19								some dust steam
1426 1428	20								drilling ~1 gpm
1428	21								
1441									
1442	23								~2 gpm
									no HNU above bkg
	25					purple	vf - fgr sandstone, micaceous		

REMARKS: FR T-4 drill rig, 10" air hammer to ~19', 6" steel casing to 19', 6" air hammer to 176'

BORING ____

PAGE ____ OF ____

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HX-41-D
PROJECT NO.: _____ DATE: 5/24 DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA: _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1444	26								Fov 2-3 gpm
1446									
1447	29					red-gray	vf-fgr sandstone, micaceous		mud
	30								
1450	36						same as above		~4 gpm
1450	38								
1453	41					gray	fgr sandstone, micaceous		4-5
1454	43								no HNV
1456	46					gray	fgr sandstone, micaceous		
									soft, poss. fract

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN-41-D
PROJECT NO.: _____ DATE: _____ DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA: _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS*	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1458	51								EOR 4-5 gpm
1500									
1502	53								
									~3 gpm
1504	56					rd BN	v fgr sandstone, micaceous		
1505	60								
	61					BN-gray	v f-fgr sandstone, micaceous ~~Sand~~		4-5 gpm
1509	63								Q- light pink-gray
									5-7
	66					pink gray	fgr sandstone		
1514	69					gray-BN	fgr sandstone		Q- BN
									Poss frac.
	71								
						pink gray	fgr sandstone		5-7
						l. gray	fgr sandstone, micaceous		Q- light gray

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG — HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN-41-D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1521	76								EOR 5-7
1523									
1524	78					gray	fgr sandstone, some rust staining		Q- tan-brown
1526	81					gray-BN	fgr sandstone		
1529	86					Brown-gray	fgr sandstone, some rust staining		
							Pile of hard grey mineral		
1533	90								
						Brn gray	fgr sandstone		
1535	93								
1537	96								
1539	98					Brn-gray	fgr sandstone		

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG — HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN-41D
PROJECT NO.: _____ DATE: 5/24 DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA: _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1540	101								EOR ~10 gpm
1544									
1547	103								no HNU > bkgd
1549	106					brn gray	fgr sandstone		
									poss inc. to 129 101–109
	111					rld BN	vf gr sandstone		
						rust rld	mudstone soft some green mineral		Q-rld
	115								
1555	118								
									Q- BN
	121					rld BN	vf gr sandstone		
									no HNU
1601	125								

REMARKS _____

BORING _____

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* See Legend on Back

BORING LOG — HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN-41-D
PROJECT NO.: _____ DATE: 5/24 DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA: _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1602	126								EOR ~10-12
1606									
1607	128								
1611	131					Pink gray	f-mgr sandstone		
1613	134								
1615	136						same as above		Q- light pink-gray
1618	139								
1620	141						same		~15
1623	144								
						l. grish gray, almost white	mgr-coarse gr sandstone mostly qtz some orbln		
	150								

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG

HALLIBURTON NUS

PROJECT: _____ BORING NO.: H-N-41-D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1630 ~~151~~	151								EOR ~15 gpm
1632									
1636	156					Pink gray	f.gr sandstone		
1640	161					Pink-gray	fgr-mgr sandstone		
1642	164								
1644	166					Pink-gray	fgr sandstone		
									15-18 gpm
1649	171								
						vrly BN	vfgr sandstone		

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG

HALLIBURTON NUS

PROJECT: _____ BORING NO.: HN-41-D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1652	176					red BN	vfgr sandstone		EOR 20-25

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 7/8/94, 0928, Clear; 95°.

DATE: 7/8/94
FIELD GEOLOGIST: P. NIMMER

BORING NO. HN-43S
DRILLER: RAAB

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (N)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	BORING CONDITIONS	REMARKS
0928	0.0					BRN	SILT AND SAND		MOIST
0932	4.0								EOR @ 4
						Purple	FINE SAND w/SILT W/RX FRAGS		DRY
0934	11.0					TAN-white	FG to MG SS		DRY
	~~14.0~~			TOR=11					
0938	16.0			FG SS			FG SS		
0942	18.0			6" CSG to 18		Purple	FG to VFG SS		
				VFG SS					
22.0						Pink-Grey	FG SS		
				FG SS					
1000	25.0					BRN	FG SS		EOR @ 25
						Grey/brn	FG SS		
1002	30.0					Grey	AS ABOVE		DRY
1004	35.0					Grey-brn	AS ABOVE		DRY. FAST Drilling
1006	40.0					Grey-brn	AS ABOVE		
1007	43.0			VFG SS		Purple	VFG SS		DRY
1010	45.0								EOR @ 45. Some mud
									while changing RODS at 45'
14	50.0								MUD @ 50 ft

REMARKS INGERSOLL-RAND T-3 RIG w/ 10" HAMMER to 18 ft. 6" HAMMER to 66 ft. 6" ø STEEL CASING to 18 ft. CASING STICKS UP ft. HOLE NOT LOGGED BY USGS.

BORING HN-43S

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7/8/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-43S
DRILLER: RAAB

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	UNIFIED SOIL CLASSIFICATION	REMARKS
1016	51.0					Purple	VFG SS		More mud @ 53 gpm
									More mud @ 53
1017	55.0			FG SS		Purple	FG SS		
									Q to ~3-4 gpm
1019	60.0						As above		
1021	63.0			MS		Red	Mudstone		Dry @ 63
1021	65.0								
				TD=65.0					

REMARKS Blew hole for 15 min, well making 3-5 GPM.
Driller adds water to clean hole out. Water cleared slightly
Potential screening interval from 45 to 65 ft.

BORING HN-43S

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 7/7/94, 1535, 95°, Sunny.

DATE: 7/7/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-45I
DRILLER: RAMS

SAMPLE NO. & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1535	0.0			SC		TAN	SANDY SILT W/CLAY	SC	
	5.0					Purple	SILT W/ FINE SAND		DRY
1543	10.0						FG to MG SS - weathered		SAPRALITE - weathered Bedrock
1546	12.0					Purple	FG SS		HARDER - DRY
				MEMBER TOP: 12. FG to MG SS		TAN	FG to MG SS		
1550	18.0			FG to VFG SS		Purple	FG to VFG SS		
1608	19.0								
				MG SS		TAN	MG SS		
1611	25.0								EOR @ 25
1614	30.0			FG SS		TAN	FG SS		SLOWER - DRY
1616	35.0					White	FG SS		
1618	37.0			FG to MG SS		TAN	FG to MG SS		
	40.0			VFG SS		Purple	VFG SS		DRY
1621	45.0					Purple	AS ABOVE		EOR @ 45
24	50.0					Purple	AS ABOVE		~~AMIST Scan~~

REMARKS INGERSOLL-RAND T-3 RIG w/10" Ø HAMMER to 18 ft.
6" Ø HAMMER to 105 ft. 6" STEEL CASING to 18 ft.
CASING STICKS UP 2 ft. HOLE ALSO LOGGED BY USGS.

BORING HN-43I

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7/7/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-43I
DRILLER: RAAB

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	UNIFIED SOIL CLASSIFICATION	REMARKS
									Slower @ 52
1626	55.0					Purple	VFG SS		DRY
1629	59.0			MS		Red	MUDSTONE		DRY
									FAST DRILLING
	6								
1631	65.0					RED	AS ABOVE		EOR @ 65
	67.0					Purple-BRN	FG TO VFG SS		
1634	70.0			FG/VFG SS		Purple-BRN	AS ABOVE		DRY
1638	75.0					Purple	AS ABOVE		DRY
1639	77.0								EASYER AT 77
1640	80.0			VFG SS		Red-BRN	VFG SS		DRY - DUSTY
1641	83.0			MS			MUDSTONE / SILTSTONE LAYER		
1643	85.0			VFG SS					EOR @ 85
	87.0					BRN-RED	VFG SS / SILTSTONE		DRY
1645	90.0						AS ABOVE		Slower @ 90
	92.0			MS			SILTSTONE / MUDSTONE LAYER		FASTER
				VFG SS		RED			
1648	95.0					Purple BRN	VFG SS		DRY
									MOIST
1650	100.0					BRN			SOME MUD

REMARKS

BORING HN-43I

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7/7/94
FIELD GEOLOGIST: P. NIMMER

BORING NO.: HN-43I
DRILLER: RAAB

SAMPLE NO. & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS CODES	REMARKS
1651	101.0					BRN	FG to VFG SS		Q=3-4 GPM @ 101
									Slower
1654	105.0					BRN	FG SS		Q=~5 GPM
				TD=105					

REMARKS: Blew Hole for 10 min. Well making ~5 GPM from ~100 to 105 FG. Water cleared slightly

BORING: HN-43I

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions) 7/7/94, 1151, Clear 95°

DATE: 7/7/94
FIELD GEOLOGIST P. Nimmer

BORING NO. HN-43 D
DRILLER: RAAB

SAMPLE NO. & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS CODES	REMARKS
1151	0.0					TAN	SILTY SAND W/CLAY	SC	
1201	3.0			SC					EOR @ 3
	7.0					Purple-BRN	SANDY SILT	SM	DRY
				SM					
1207	11.0					Purple	Med SAND and SILT		
1209	13.0			SM		TAN	SILT w/ SAND		DRY
	15.0			TOR @ 14		TAN-Purple	FG to MG SS		DRY - Dusty
1215	18.0			FG SS					10" Ø HAMMER TO 18'
1322	17.0								
1323	21.0					TAN	FG SS / SILTSTONE		FAST DRILLING
				6" CSG to 19 ft					EOR @ 24'
				FG SS/ SILTSTONE		white	AS ABOVE		
1327	30.0					TAN	AS ABOVE		DRY
				FG SS		BROWN			
	33.0					white	MG SS		
1331	35.0			MG SS			AS ABOVE		
						TAN			FASTER
1332	40.0								
	42.0					RED-BRN	FG to VFG SS		DRY - SLOWER
1334	44.0			FG to VFG SS		Purple-BRN			EOR @ 44
1336	45.0						VFG SS		
1340	50.0					Purple	AS ABOVE		DRY - LESS DUST.

REMARKS T-3 INGERSOLL-RAND R16 w/ 10" Ø AIR HAMMER to 18 ft. 6" AIR HAMMER to 150 ft. 6" STEEL CASING to 19 ft. Hole ABO LOGGED BY USGS. CASING sticks up 1.6 ft above ground.

BORING HN-43D

PAGE 1 . 3

BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7/7/94
FIELD GEOLOGIST P. NIMMER

BORING NO. HN-43D
DRILLER: RAAB

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	UNIFIED SOIL CLASSIFICATION	REMARKS
1340	53.0			FG/VFG SS					FASTER @ 53
	55.0					Purple	FG to VFG SS		DRY
	58.0					RED	MUDSTONE		FASTER @ 57. DRY
				MS					FAST DRILLING. DRY
1345	63.5					Purple-Red	VFG SS		EOR @ 64
1346	65.0					Purple	AS ABOVE		
				VFG SS					
1349	70.0					Purple	AS ABOVE		DRY.
	75.0					Gray-Blue	FG SS		FAST Drilling
	78.0			FG SS		Purple	FG SS		
1353	80.0					Purple-RED	AS ABOVE		
1356	84.0			FG SS					EOR @ 84
1357	85.0						AS ABOVE		MUD @ 85
1359	89.0					RED	FG to VFG SS		DRY
				FG to					
				VFG SS					
1401	95.0					RED	MUDSTONE / SILTSTONE		DRY
				MS / SILTSTONE					
1402	100.0					Purple	VFG SS		MOIST

REMARKS

BORING HN-43D

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BORING LOG

Halliburton NUS

PROJECT: WARMINSTER
PROJECT NO.: 1412
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7/7/94
FIELD GEOLOGIST P. NUMMER

BORING NO. HN-43D
DRILLER: RAAB

SAMPLE NO & TYPE OR ROD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK CODES	REMARKS
1405	102.0					Purple	VFG SS		Slower @ 102
1408	104.0								EOR @ 104
									Some mud @ 104 after EOR
1410	107.0			VFG SS		Purple-Red	VFG SS		Moist
1412	110.0					Purple-Red	As Above		Dry
1417	115.0					Gray	VFG SS to FG SS		Dry
1418	117.0			FG SS					Moist @ 117
1419	120.0								HNU = 0.0 @ 118
						Gray	FG SS		mud @ 121
1424	124.0								EOR @ 124
1426	125.0						As Above		Q = 5 gpm @ 126
1428	128.0								Black pluster @ 126
1430	130.0					Gray	As Above		Q = 5-7 @ 128
									Q = ~5 @ 130
	133.0								Q = 5-7 @ 133'
1434	135.0					Gray-Black	As Above		
									HNU = 0.0 @ 138
	140.0								Q = 7 gpm - Slowly increasing
1443	144.0								EOR @ 144
				VFG SS			VFG SS		
1445				SS/MS			Mudstone/silt stone		Less Q @ 149

REMARKS TOTAL DEPTH TD = 150 = 150 ft. Blew hole for 30 min.
Hole making ~8 gpm. Water did not clear much
Potential screening interval from 125 ft to 144 ft.

BORING HN-43D

PAGE 3 . 3

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-49 S
PROJECT NO.: 1412 — DATE: 11/1/94 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA: —
(Date, Time & Conditions) —

SAMPLE NO. & TYPE Time	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1102	2					LT. BRN	SILTY CLAY		DAMP
	4					BRN	SANDY SILT		
	6					RD-BRN	weathered SILTSTONE		DAMP
1111	9								DRY
	12					PINK, BRN-GY	v.f.-f.gr. sandstone		Micaceous; DRY.
1115	14					BRN	f. gr. sandstone		DRY, DUSTY
	16					BRN-GY	f-gr. sandstone		CRUMBLY; RUST-STAINED
	18								DRY, DUSTY
1123	19						v.f. gr. sandstone		harder drilling
	20			6" at 19'		purple, BN-GY	f. gr. sandstone		DRY
1247	24								DRY, DUSTY
	27								DRY
	30					RED-Brown	SILTSTONE		DRY, DUSTY
	32					GY	SILTSTONE		DRY
	34								DUSTY
1315	37					GY	v.f.-f.gr. sandstone		less DUST at 37.5 STOP DRILLING: DAMP
	40								
	42					BRN-GY	v.f.-f.gr. sandstone		POSSIBLE FX at 41
1328	45								STOP DRILLING TO BLOW OUT HOLE = TRICKLE
						BRN-GY	f. gr. sandstone		rust-stained
1331	52								DUSTY

REMARKS I.R. T-4 drilling rig; 10" air hammer to 19'; 6" steel casing to 19'; drill out with 6" hammer to 52'

BORING HN-49.

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-49I
PROJECT NO.: 1412 — DATE: 10/27/94 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA (Date, Time & Conditions):

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1241	2					LT. BN	CLAYEY SILT		DAMP
	4					MED. BN	SANDY SILT		
	6					BN	SILTY, v.f-gr. SAND, WEATHERED SANDSTONE		MICACEOUS, DAMP
	8					BN	WEATHERED, f. gr. SANDSTONE		
1248	10					RED-BN	WEATHERED SILTSTONE		DRY
1253	16					LT. BN	v.f.-f. gr. SANDSTONE		DRY, DUSTY
	18					RED-GRAY	f. gr. SANDSTONE		DRY
	20								
	22					BRN-GRAY	f. gr. SANDSTONE		DRY, DUSTY
1337	25					RED. GRAY	v.f.-f. gr. SANDSTONE		MICACEOUS, DRY, NO H2O AT EOR
	30								
						RED-BRN	SILTSTONE/MUDSTONE		DRY
						GREEN-GRAY	SILTSTONE/MUDSTONE		DRY
1344	37								
						LT. GRAY	f. gr. SANDSTONE		DRY, DUSTY
	41								
	43					PINK-GRAY	f. gr. SANDSTONE		DRY, DUSTY
	44					Purple	f. gr. SANDSTONE		
	47					beige	f. gr. SANDSTONE		DRY, DUSTY
1349	50								

REMARKS: I.R. T-4 drilling rig; 10" air hammer TO 20'; 6" steel CASING TO 20'; drill OUT with 6" air hammer TO 102'

BORING HN-49I

PAGE 1 OF —

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN 49I

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	52					beige	f. gr. sandstone		DRY, DUSTY
1353	54					LT. BN.	f. gr. sandstone		DRY, DUSTY, RUST-STAINED
	57								DRY, DUSTY
	60					GRAY-BN	f. gr. sandstone		Possible FX
									DRY, DUSTY
1357	66					LT. BN.	f. gr. sandstone, coarser grained		LESS DUST AT 65, STOP DRILLING — blow out hole; < 1 gpm
1409	70					LT. BN-GRAY	f. gr. sandstone		DRIPPING MUD
	74					RED-GRAY	f. gr. sandstone		MOIST CUTTINGS
1418	77								EOR, some water in hole
	80								DRIPPING MUD
	82						LITHOLOGY AS ABOVE		DAMP
						LT. BN, GRAY	f. gr. sandstone, COARSER		SOME DUST
1423	86								
						RED-GRAY	f. gr. sandstone		DAMP, NO DUST
	90								SOME DUST
1433	91								STOP DRILLING TO CHECK YIELD ≈ 1 GPM
	94						LITHOLOGY AS ABOVE		MUD
	95								MOIST CUTTINGS
	100					RED-BROWN	SILTSTONE/MUDSTONE		DAMP
1438	102								EOR; YIELD ~ 2-3 gpm

REMARKS _____

BORING HN-49I

PAGE 2 OF 2

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER — BORING NO.: HN-49 D
PROJECT NO.: 1412 — DATE: 10/25/94 — DRILLER: RAAB
ELEVATION: — FIELD GEOLOGIST: D. Whalen
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	2					MD-BRN TAN	CLAYEY SILT		DAMP
	4					RD-BRN	CLAYEY & SANDY SILT		DRY TO MOIST
1037	6					RD-BRN	v.f.gr. Sand & SILT		MICACEOUS; DAMP
	10				SOFT	RD-BRN	WEATHERED SILTSTONE & MUDSTONE		DRY
1045	14			TOR AT 12'		PRP	v.f.gr. to f.gr Sandstone		DRY
	16					RD-BRN	f.gr. sandstone		RUST STAINED; DRY - DUSTY
1053	18					GY-BRN	f. gr. sandstone		
	22			6" at 19'		RD-GY	f.gr. sandstone		RUST STAINED; DRY
					SOFT	BRN	f. gr. sandstone		SOFT
	25					RD-GY	v.f.-f.gr. Sandstone		DRY, DUSTY
	27				hard	PRP	v.f.-f.gr. Sandstone		
	30								
					SOFT		SILTSTONE/MUDSTONE		DRY, DUSTY
1134	34				SOFT	Green-GRAY	MUDSTONE		DRY, DUSTY
1137	40					LT. GY	f. gr. sandstone		DRY, DUSTY
	42					RD-GY	v.f. gr. sandstone		SOFT; NO DUST, possible FX
	45					RD-GY	v.f.-f.gr. sandstone		DRY, DUSTY
1142	50					TAN	f. gr. sandstone		RUST-STAINED

REMARKS I.R. T-4 drilling rig; 10" air hammer to 19'; Install 6" steel casing to 19'; drill out with 6" air hammer to 152'.

BORING HN-49

PAGE 1 OF 3

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: HN 49D
PROJECT NO.: _____ DATE: _____ DRILLER: _____
ELEVATION: _____ FIELD GEOLOGIST: _____
WATER LEVEL DATA _____
(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK SR. OR USCS	REMARKS
1144	52					RD-GY	f. gr. Sandstone		RUST-STAINED; DRY-DUSTY
	54					LT. BRN + GY	f. gr. sandstone		RUST-STAINED; BLOW OUT MIST AFTER EOR
									DRY, DUSTY
	57					RD-BRN	SILTSTONE		Possible Fx
1153	60					TAN	f. gr. sandstone		MORE RUST STAINING
	62					BRN-GY	f. gr. sandstone		DRY, DUSTY
	64					beige	f. gr. sandstone		
1157	66								DRY, DUSTY
						GY-BRN	f. gr. sandstone		RUST STAINS
	70								
1202	72								
						RD-BRN	v.f. gr. sandstone		DRY; MICACEOUS
	77								EOR; BLOW OUT SOME WATER; << 1 gpm
1211	80								NO DUST
	82					GY	f. gr. sandstone		MOIST
									SOME DUST
	85					LT. GY.	f. gr. sandstone		DAMP
1217	87					PK-GY	f. gr. sandstone		DAMP; SOME DUST
	92					LT. GY	f. gr. sandstone		DRY
						RD-BRN	v.f. gr. sandstone		DAMP; NO DUST
1224	95					RD-GY	v.f.-f. gr. sandstone		NO DUST
	97				Soft	RD-BRN	SILTSTONE		SOFT
	100								DRY

REMARKS _____

BORING HN-49

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* See Legend on Back

PROJECT: _____ BORING NO.: HN 49D

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
	102					RD-BRN	Siltstone		Yield < 1 gpm
									at EOR
1238	105					RD-BRN	v.f.-f. gr. sandstone		DAMP, no DUST
	110						Lithology as above		
	112					RD-GY	f. gr. sandstone		DAMP, no DUST
	115					RD-BRN	Siltstone/mudstone		DUSTY, DRY
1248	122					RD-BRN	Siltstone		DRY, DUSTY
						& green			
	127			*		Green-GY	f. gr. sandstone		Pick up 3-4 gpm from 122-127
1303	130				&	GY RD-BN	f. gr. sandstone v. f. gr. sandstone		Yield ~ 5 gpm
	132					RD-BRN	Siltstone		mud; less Q
1305	135								Yield 3-5 gpm
	137					RD-BRN & GRN	Siltstone - v.f. gr. sandstone		
	139								Lignitic film to 141
	142					Green-GRAY	f. gr. sandstone		Yield ~ 5 gpm
	145						Lithology as above		
	147					GY	f. gr. sandstone		
1315	152					GY	f. gr. sandstone		Yield ~ 5 gpm

REMARKS _____

BORING HN-49

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* See Legend on Back

BORING LOG

HALLIBURTON N

PROJECT NAWC Warminster BORING NO. HN-615
PROJECT NO. 1412 DATE 12-5-95 DRILLER Raab
ELEVATION FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1045	0								moist
1050	4								damp
1052	6								damp
						Red-Brn	weathered siltstone		soft dry, dusty
1057	9								hammering at 9' damp
1058	13					Brn-Gray	FGR arkosic sandstone		
1101	16								dusty, dry
1104	18					Red-Gray	FGR sandstone		poss. frac. at 17'
1245	21								dry, dusty
						Brn	FGR sandstone		dry, dusty
									dusty
						Red-Gray	FGR sandstone		
1247	30								dry, dusty FGR
						Red-Brn	silty FGR sandstone		dusty
						Brn			
1254	35					Gray	siltstone		dusty
1256	37					Red-Brn	siltstone		
	40					Red-Brn	siltstone		dusty
						red-gray	VFGR sandstone		poss. frac. at 41' harder
	44								
						lt. gray Brn	FGR sandstone		dusty
									dusty
1300	50						FGR sandstone		

REMARKS F.R. T-4 rig: 10" air hammer 0' to 19'. 6" dia steel casing set to 19'; 6" air hammer 19' to 140'.

BORING

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* See Legend on back

BORING LOG

HALLIBURTON N

PROJECT NAWC Warminster BORING NO. HN-615
PROJECT NO. 1412 DATE 12-5-95 DRILLER Raab
ELEVATION FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	51					GRAY	FGR sandstone, arkosic		dry, dusty
									very dusty
1301	55						as above		EOR
						BRN-Gray	FGR-MGR sandstone arkosic		dry
1306	60					to tan			dry, dusty
1307	63								dry, dusty
1309	67					light green-gray	FGR-MGR sandstone		dry, dusty
1310	70								
						red-gray	FGR sandstone		dry, dusty
1311	75					red-gray	FGR sandstone		dry, dusty
1313	80								dry, dusty EOR
						red-Gray	FGR sand stone		
1318	84								dry, dusty
									less dust at 86
1319	88			*		BRN-Gray	FGR-MGR sandstone		no dust
1322	90								3-5 gpm
						RED	siltstone		soft
1324	94								mud
						RED-Gray	VFGR sand stone		
									~5 gpm
	100								

REMARKS

BORING

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BORING LOG

HALLIBURTON

PROJECT NAWC Warminster BORING NO. HN-61S
PROJECT NO. 1412 DATE 12-5-95 DRILLER Raab
ELEVATION FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	101								
						red-BRN	VFGR sandstone, micaceous		~5 gpm
1333	105						VFGR-FGR sandstone		EOR
1339									
1340	108								
	110					red-gray	FGR sandstone, arkosic		
1342	112								3-5 gpm
1344	115						as above		
1348	118								no returns
	120					light green-gray	FGR sandstone		
1352	122								
1353	125					light gray	FGR sandstone		
									black floater
1354	130								EOR ~5 gpm
1403									
1408	132								
						light BRN-GRAY	FGR sandstone		
1410	135								
1416	140					Gray	FGR sandstone		
				T.D.					yield ~6 gpm

REMARKS

BORING

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BORING LOG

HALLIBURTON

PROJECT NAWC Warminster
BORING NO. HN 61 I
PROJECT NO.
DATE 12-5-95
DRILLER RAAB
ELEVATION
FIELD GEOLOGIST T. Perring
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1300						Brown	Silty Clay		Moist
1305	5					Red Brown	Clay		Damp
						Red Brown	weathered siltstone		Damp
	10					Red grey	fgr SS		Dry
						tan grey	fgr SS		slightly dusty
	15					red grey	fgr SS		
						brown grey	fgr SS		Dry/Dusty
1325	18				Harder	grey	fgr		Hard
1450	19					Brown grey	fgr SS		
	20								
						Brown	fgr SS		
						red brown			
	25								
						Brown	Fgr SS		Dry
	30					Brown	Fgr SS		Dry

REMARKS 20" at 6" Casing Set at 19'

BORING

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BORING LOG

HALLIBURTON

PROJECT NAWC Warminster
BORING NO.
PROJECT NO. 1412
DATE 12/6/95
DRILLER RAAB
ELEVATION
FIELD GEOLOGIST P. Pressing
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1550	30					Red Grey	fgr SS		Dry Hole
						Brown	fgr SS		"
	35					Red Brown	fgr SS		"
						Blue/Grey	fgr Silt Stone		
	40					Red Brown	— Thin layer SS		"
						Blue/Grey	Thin layer Red SS		"
						Blue/Grey			
	45					White Grey	— Silt Stone		"
						white grey	fg silt stone		
	50								
1510	55					"	"	"	

REMARKS

BORING
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BORING LOG

HALLIBURTON

PROJECT NAWC Warminster
BORING NO.
PROJECT NO. 1412
DATE 12-5-95
DRILLER RAB
ELEVATION
FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	55					Light Brown	fgr SS		Dry/Dust
						Grey to tan	fgr SS		"
	60					Brown	fgr SS		"
						Grey to tan	fgr SS		"
						Tan to white	fgr SS		"
	65								
						Grey	fgr SS		"
	70					Grey	fgr SS		
	75					White	fgr SS		Less Dust
						Tan	fgr SS		
									NO DUST
1525	80								

REMARKS

BORING 3086

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* See Legend on back

BORING LOG

HALLIBURTON NU

PROJECT NAWC, Warminster
BORING NO.
PROJECT NO.
DATE 12/5/95
DRILLER RAAB
ELEVATION
FIELD GEOLOGIST L. Perrin
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1529	80								Adding H2O
						Brown	MGR SS		
	85					Grey	MGR SS		
						Light Grey	fgr SS		
	90								
						Red	Silt Stone		
	95								
						Red Grey	Silt Stone to fine Gr SS.		
						Red	Silt Stone		
	100								
						Red	Silt Stone		
						Red/Grey	fgr SS		
1543	105								

REMARKS

BORING
PAGE 4 OF 6

* See Legend on Back

BORING LOG

HALLIBURTON NUS

PROJECT NAWC Warminster
BORING NO.
PROJECT NO.
DATE 12-5-95
DRILLER RAAB
ELEVATION
FIELD GEOLOGIST P. Perrin
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1551	105			grey		grey	fgr SS.		wet
						red grey	fgr SS		
	110								
						grey	fgr SS		
	115					light grey	fgr SS		
						red	silt stone		
	120					grey blue grey	mgr SS		
	125					grey	mgr SS		
1600	130					grey	mgr SS		

REMARKS

BORING 7

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* See Legend on back

BORING LOG

HALLIBURTON NUS

PROJECT NAWC Warminster
BORING NO.
PROJECT NO.
DATE 12-5-95
DRILLER RADIS
ELEVATION
FIELD GEOLOGIST P. Perrsin
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

	SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1604		130					grey	fgr-mgr SS		
							blue grey	mgr SS		
		135					blue grey	fgr SC		
							grey	fgr SS		
1612		140								

REMARKS Stop Drilling 6" open hole at 140' TD

BORING

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* See Legend on Back

BORING LOG

HALLIBURTON NL

PROJECT NAWC Warminster
BORING NO. HN-62S
PROJECT NO. 1412
DATE 12-7-95
DRILLER Raab
ELEVATION
FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	0.0					BRN	topsoil clayey silt		damp
1059	3.0						clayey silt		damp
				*					hammering at 6'
1103	7.0					l. gray to tan	FGR sandstone		some water on top of rock
1105	10.0					tan to beige	FGR sandstone		damp
1107	12.0								very little dust
							aa		damp
1112	16.0					RED-GRAY	VFGR to FGR sandstone		poss. frac. at 16'
									dusty dry
1115	20.0								
1254						RED GRAY	FGR sandstone		dry, dusty
						BRN-GRAY	FGR sandstone		dusty
1257	25.0			*		RED Gray	FGR sandstone		<1gpm, no dust steam
							alternating thin beds		
	30.0					RED to	of sandstone and		dusty at 29'
1300						RED GRAY	siltstone		dusty at 31' EOR
1306	34.0					RED BRN	VFGR sandstone		blow out a little wa
1307	36.0						VFGR-FGR sandstone, micaceous		dusty no dust
									wet cuttings steam
	40.0			*		BRN	FGR sandstone		dripping ~2gpm
1310									no returns, hammer getting gummed up
				*					5-7gpm
1312	45.0								
1313	47.0					RED BRN	VFGR to FGR sandstone		
	50.0						some siltstone		

REMARKS I.R. T-4 rig; 10" air hammer to 19'; 6" dia. steel casing installed to 19'; 6" air hammer to 57'.

BORING

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* See Legend on Back

BORING LOG

HALLIBURTO

PROJECT NAWC Warminster
BORING NO. HN-62S
PROJECT NO. 1412
DATE 12-7-95
DRILLER Raab
ELEVATION
FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARK
1316	52.0					light BRN-GRAY	FGR sandstone		
						light BRN-GRAY	FGR to MGR sandstone		
1319	57.0			T.D.					
									Yield ~10 g

REMARKS

BORING

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BORING LOG

HALLIBURTON NL

PROJECT NAWC Warminster
BORING NO. HN-62I
PROJECT NO. 1412
DATE 12-8-95
DRILLER Raab
ELEVATION
FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

~~SAMPLE NO.~~ Time	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
0939	0.0					Brn	topsoil		
	2.0								damp
0945	4.0					BRN	Clayey silt		
0947						tan	FGR sandstone, weathered		damp
0951									
0952	10.0						FGR sandstone		damp steam
									some dust steam
0956	14.0								
						RED BRN	siltstone		
0959	18.0					RED GRAY	FGR sandstone		dry, dusty
1112	20.0								dusty
						gray-BRN	FGR sandstone		damp
	24.0			*?			aa		damp
						RED	siltstone		dusty
1115	27.0					RED GRAY	VFGR to FGR sandstone, micaceous		dry, dusty
	30.0						thin siltstone bed		
1117						RED	siltstone		dry, dusty EOR
1121	34.0								dry, dusty
	36.0					RED GRAY	VFGR-FGR sandstone		dusty
1124	40.0								dry
				*?			FGR sandstone		damp dusty at 42'
	44.0					RED-GRAY	VFGR to FGR sandstone, micaceous		less dust at 43
1131	47.0			*?		GRAY-BRN	FGR sandstone		poss. frac. at 46' no dust
1132	50.0						siltstone ?		no returns no dust

REMARKS J.R. T-4 rig; 10" air hammer to 19'; 6" dia. steel installed to 19'; 6" air hammer to 140'

BORING

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* See Legend on Back

BORING LOG

HALLIBURTON NU

PROJECT NAWC Warminster
PROJECT NO. 1412
DATE 12-8-95
BORING NO. HN-62I
DRILLER Raab
ELEVATION
FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1135	52.0					RED	siltstone		no returns steam
				----		RED GRAY	FGR sandstone		dry, some dust
1137	57.0			----		light gray	FGR to MGR sandstone		EOR
1140	60.0								
1143	64.0					light gray	MGR to CGR sandstone		dry, dusty
	67.0						aa		dry, dusty
1146	70.0								dry
									poss. fract. at 72
						light green gray	MGR sandstone		dry
1149	75.0			*			MGR to CGR sandstone		dry, dusty steam at 76'
1152	78.0								mud 2-3 gpm
	80.0								
1153	82.0					light greenish gray	mGR sandstone		flowing mud EOR
1201				----					black film
	86.0					RED-GRAY	VFGR to FGR sandstone		no returns
	90.0								no returns, steam
						gray	FGR sandstone		steam
	94.0								some flow at 94'
							aa		2-3 gpm
1209	97.0								mud
1211	100.0					GRAY-BRN	FGR sandstone		

REMARKS

BORING

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* See Legend on Back

BORING LOG

HALLIBURTON NU

PROJECT NAWC Warminster
BORING NO. HN-62F
PROJECT NO. 1412
DATE 12-8-95
DRILLER Raab
ELEVATION
FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	101.0					RED	siltstone		~3gpm
						RED+ GREEN	siltstone		
1213	107.0								EOR
1219									
1221	110.0					RED-GRAY	VFGR to FGR sandstone		
						BRN-GRAY	FGR sandstone		
1225	116.0								3-5gpm
	120.0								
1229	122.0						aa, slightly coarser		3-5gpm
						BRN-GRAY	FGR sandstone		
1232	127.0								
	130.0								
1234	132.0								EOR 3-5gpm
1241						RED BRN	VFGR sandstone		
	136.0					RED	siltstone		
1244	140.0					RED	siltstone		
									yield ~5gpm

REMARKS

BORING

PAGE 3 OF 3

* See Legend on back

JRB ASSOCIATES, INC.
8400 Westpark Drive, McLean, Virginia 22102

WELL LOG

PROFILE	DESCRIPTION
0	LAND SURFACE
	TOP SOIL / VEGETATION
1	
2	
3	YELLOW BROWN - STIFF LOAM TO SANDY LOAM MOIST
4	
5	
6	SPLIT SPOON 5'-6.5' 6" = 5/8/9
7	
8	COLOR CHANGE 7' BLS. RED-BROWN TO DARK BROWN - SANDY LOAM.
9	
10	
11	SPLIT SPOON 10'-11.5' 6" = 12/21/30
12	
13	RED-BROWN HARD WEATHERED SHALE. SHALE FRAGMENTS IN CUTTINGS.
14	
15	SPLIT SPOON 15'-15.25' 45/25'
16	
17	
18	AUGER REFUSAL.
19	
20	

PROJECT NADC WARMINSTER, PA

OWNER NAVAL AIR DEVELOPMENT CENTER

WELL NO. BG-1 (HN-63X)

LOCATION SOUTH OF AIRFIELD UPGRADIENT SITE NO. 6.

	Date	Time
DRILLING STARTED	7/17/82	~~0700~~ 0925
DRILLING COMPLETED	7/17/82	~~0900~~ 1115

DRILLER LARRY CISLER

GEOLOGIST ED TOKARSKI JRB

RIG TYPE MOBILE B-56.

REFERENCE POINT LAND SURFACE

R.P. ELEVATION 362.8 (SURVEYED)

TOPO POSITION FLAT LYING

PROFILE BY ED TOKARSKI

FIELD BOOK NO. 1 PAGES 42-43

WELL DATA

HOLE DIAMETER 6" O.D.

HOLE DEPTH 18'

CASING DIAMETER 2" I.D.

CASING LENGTH 8.4'

SCREEN DIAMETER 2" I.D.

SCREEN SETTING 11.6' - 15.9' BLS

SCREEN SLOT/TYPE 10-SLOT / MICROMESH (2.15/2.1

STAINLESS STEEL - (JOHNSON)

PUMP TEST DATA

STATIC DEPTH TO WATER DRY HOLE

DATE MEASURED 7/25/82 // 9/8/82

PUMPING DEPTH TO WATER —

TEST DURATION —

PUMPING RATE —

TEST DATE —

TEST TYPE —

PUMP SETTING —

SPECIFIC CAPACITY —

REMARKS

MOTTLING IN SECTIONS OF SPLIT SPOON SHOW EVIDENCE OF WATER DURING WETTER PERIODS

BORING LOG

HALLIBURTON NUS

PROJECT NAWC Warminster
BORING NO. near BG-1 HN-63
PROJECT NO. 1412
DATE 4-4-96
DRILLER Raab
ELEVATION
FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1125	0.0					Red-Brn	sandy silt		moist
1126						BRN	clayey silt		moist
1128	6.0					BRN	silty sand and weathered FGR sandstone		soft, crumbles easily
1133	9.0					gray-BRN	FGR sandstone		dry-damp
1134	13.0								
1137	16.0					tan	FGR sandstone, some light green-gray siltstone		dry to damp
						tan	MGR sandstone		dry
1224	20.0								
							siltstone?		no return
1225	23.0								wet mud
				*		gray-BRN	FGR sandstone		
1227	28.0								EOR ~5gpm
	30.0					tan	MGR to CGR sandstone,		
				*					
1248	34.0								≈10gpm
1251	36.0					red-Gray	VFGR to FGR sandstone		
1253	38.0					Red	siltstone		
	40.0								
				*		purple	VFGR-FGR sandstone		
1255	43.0					↓			~15gpm
							as above		
1257	48.0								
	50.0					↓	as above		

REMARKS I.R. T-4 rig; 10-inch air hammer to 16 feet; 6-inch steel casing installed to 16 feet; 6-inch air hammer to 53 feet.

BORING HN-025

PAGE ___ OF ___

* See Legend on back

BORING LOG

HALLIBURTON NUS

PROJECT NAWC Warminster BORING NO. HN-635
PROJECT NO. 1412 DATE 4-4-96 DRILLER Raab
ELEVATION FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
						purple	VFGR to FGR sandstone		
1300	53.0			T.D.					

REMARKS

BORING HN-635

PAGE ___ OF ___

* See Legend on back

BORING LOG

HALLIBURTON NU.

PROJECT NAWC Warminster BORING NO. HN-64
PROJECT NO. 1412 DATE 4/4 and 4/5/96 DRILLER Raab
ELEVATION FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO. Time	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1554	0.0					Brn	clayey silt		
							clayey sandy silt		moist
									moist
1557	6.0					Brn	weathered FGR sandstone		addrod - water in the hole
									wet
1601	11.0					gray-Brn	FGR arkosic sandstone.		wet mud 3-5 gpm
1603									
1606	16.0						as above		~5 gpm
0854									dry-damp
0854	20.0								
									dusty
0855	23.0			*?		Brn	FGR sandstone		harder at 24'
0857	28.0					gray-Brn	FGR sandstone		EOR
0911	30.0								mud <1 gpm
				*?					
0913	33.0					Gray	FGR sandstone		~3 gpm
0914	35.0								
0916	38.0						as above		wet mud
0917	40.0								
									no returns
0919	44.0			*		Brn-Gray	FGR sandstone		
				*					
									~10 gpm water is dark brown
0921	50.0						as above		

REMARKS I.R. T-4 rig; 10-inch air hammer to 16 feet; 6-inch steel casing installed to 16 feet; 6-inch air hammer to 103 feet.

BORING HN-0r

PAGE 1 OF 3

* See Legend on back

BORING LOG

HALLIBURTON NU

PROJECT NAWC Warminster BORING NO. HN-64
PROJECT NO. 1412 DATE 4/5/96 DRILLER Raab
ELEVATION FIELD GEOLOGIST D. Whalen
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO. Time	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
0923	53.0								EOR 10-12 gpm
0928	55.0								
0929	58.0					purple	FGR sandstone		
	60.0								
0931	63.0					light gray	MGR to CGR sandstone angular quartz grains		
0934	68.0					gray-brn	FGR to MGR arkosic sandstone		10-12 gpm
	70.0								
	74.0					light green-gray	CGR sandstone		
0938	78.0					purple	VFGR to FGR sandstone		EOR
0944	80.0								
						Red	siltstone/VFGR sandstone		soft
	86.0						as above		
0947	90.0					purple	VFGR to FGR sandstone micaceous		harder
							as above		
									10-12 gpm
0953	97.0						as above		
	100.0								

REMARKS

BORING HN-64

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* See Legend on back

BORING LOG

HALLIBURTON NUS

PROJECT NAWC Warminster BORING NO. HN-64
PROJECT NO. 1412 DATE 4-5-96 DRILLER Raab
ELEVATION FIELD GEOLOGIST
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

SAMPLE NO.	DEPTH FT.	BLOWS 6"	SAMPLE RECOVERY LENGTH	LITHOLOGY CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
0958	103.0			T.D.					10-12 gpm

REMARKS

BORING HN-4

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* See Legend on Back

7601- 4.5- 016

BORING LOG HN-845

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE. TIME & CONDITIONS)

BORING NO. HN-845
DATE 4-28-98
DRILLER Joe Smith
FIELD GEOLOGIST Vince Shickora

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION: SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	0					BN	Silty clay		
	1					OR	clay		
	5					BN	Silty clay		
	9					Rd BN	weathered siltstone and sandstone		Rust Staining moist
	10			TOR-9.5ft					
1028	12					Lt BN Tan	V.F. gr. Sandstone		damp
1034	17					BN BGE	V.F. gr. Sandstone		Rust Staining moist
1036	19					Rd BN Gy	F. gr. Sandstone		Possible fracture wet dripping cuttings
				6" at 19 ft					
1118	23					Rd BN	Mudstone/siltstone		wet cuttings
1122	26					Rd	Mudstone		moist to wet
									—

REMARKS

BORING NO.

PAGE ____ OF ____

* See Legend on Back

BORING LOG HN-845 **TETRA TECH NUS, INC.**

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-855
DATE 4-28-98
DRILLER Joe Smith
FIELD GEOLOGIST Vince Shickora

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1124	30					Rd BN	Siltstone		Moist cuttings
1125	34					DK Rd-BN	Mudstone		wet ≈ 0.5 gpm
1128	38					Rd BN	Siltstone		est ≈ 1.0 gpm EOR
1131	41					Rd BN	Siltstone / V. F. gr. Sandstone		
1134	46					BN GY	Sandstone with some larger quartz grains		est ≈ 1.5 gpm
	50					BN GY	lithology same as above		
	52					TAN-BN GY	lithology same as above		est ≈ 2.0 gpm to 2.5 gpm
									—

REMARKS 10" hammer to 19'
20' length of 6" casing set to 19 feet BGS
9 bags bentonite seal around casing
6" hammer from 19 feet to 52 feet

BORING NO.
PAGE 1 OF ____

* See Legend on Back

BORING LOG HN-84I

TETRA TECH NUS, INC.

PROJECT 7606
PROJECT NO.
ELEVATION
WATER LEVEL DATA
(DATE. TIME & CONDITIONS)

BORING NO. HN-84I
DATE 4-27-98
DRILLER Joe Smith
FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	0					BN	silty clay		
	1					OR	clay		
	5					BN	silty clay		
	9					Rd BN	weathered silt / V.F sandstone frags		
	10								
	12			TOR-10 Ft		Lt. BN Tan	V.F. gr. SS / Siltstone		
									moist cuttings
	20			8" at 19'					wet cuttings
	24					Rd	Mudstone		moist
	25					OR Rd	Mudstone		moist cuttings
									—

REMARKS 10" hammer to 19'
8½ bags bentonite to seal around casing
20' length of 6" casing set to 19 feet BGS
6" hammer from 19' to 122'

BORING NO.
PAGE 1 OF ____

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* See Legend on Back

BORING LOG HN-84I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-84I
DATE 4-27-98
DRILLER Joe Smith
FIELD GEOLOGIST Vincent Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	30					Rd Brn	Siltstone/Mudstone		Soft
	36					Rd Brn	Siltstone/mudstone		Soft
						"			
	40					Rd Brn	Siltstone		
	45					Rd Gy-BN	Siltstone/V.F. gr. SS		
	50					Rd Gy-BN	conglomeritic SS (Quartz Frags) with some Siltstone		
	56					BN Gy	F. gr SS		—

REMARKS

BORING NO.
PAGE 2 OF ____

* See Legend on Back

BORING LOG HN-84I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-84I
DATE 4-27-98
DRILLER Joe Smith
FIELD GEOLOGIST Vince Shickora

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	62					RD-BN BGE	F.gr. SS with Quartz / calcite frags		
	64					BN BGE	F.gr SS large calcite frags		
	70					Tan. BGE	F.gr. SS with some larger quartz frags		some rust staining Blowout some water ≈ 1 gpm
	75					Tan BGE	V.F. / F.gr. SS with larger Quartz frags.		rust staining
	80					Tan BGE	lithology same as above		
									—

REMARKS

BORING NO.

PAGE 3 OF ____

* See Legend on Back

BORING LOG HN-84I

TETRA TECH NUS, INC.

PROJECT
PROJECT NO.
ELEVATION
WATER LEVEL DATA
(DATE, TIME & CONDITIONS)

BORING NO.
DATE
DRILLER
FIELD GEOLOGIST

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	86					Rd Brn	F. gr. SS some larger Quartz Frags.		Blowout hole ≈ 1 gpm
	90					Rd Bn-BGE	lithology same as above		
	94					Rd-BN	F. gr. SS		
	98					Rd Gy	Siltstone		Softer
	102					Rd Brn	Siltstone		Yield ≈ 1 gpm at EOR
	108					DK Rd Brn	Siltstone / Mudstone		Soft.
	112					Rd Gy	V.F. gr. Sandstone		Harder

REMARKS

BORING NO.
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* See Legend on Back

BORING LOG HN-84I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-84I
DATE 4-27-98
DRILLER Joe Smith
FIELD GEOLOGIST Vince Shickora

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	114					Rd Gy	V.F.gr. Sandstone		
	118					Rd Brn	lithology same as above		
	122					Gy	F.gr. Sandstone		Yield ≈ 1.5 to 2.0 gpm

REMARKS

BORING NO.

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* See Legend on Back

BORING LOG HN-855

TETRA TECH NUS, INC.

PROJECT NAWC warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE. TIME & CONDITIONS)

BORING NO. HN-855
DATE 4-29-98
DRILLER Joe Dipasquale
FIELD GEOLOGIST Vince Shiktora

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1031	1					BN	Silty Clay		damp
1032	2					OT BN	clay		damp
1036	5					Rd BN	clayey silt		moist
1039	9					DK-Rd BN	silt/clay with Mica flakes		moist
1042	12			TOR at 10ft.		DK Rd BN	Siltstone with Mica flakes		Soft Dry
1045	16					Rd BN	Siltstone with Mica flakes		harder Dry
1046	17					Rd BN	lithology Same as above		wet Dripping cuttings
				6" at 19ft.					
1128	20					BN	Siltstone		≈ 2.0gpm
1131	22					BN	siltstone		≈ 3.0gpm
1135	26					BN GY	F.gr. Sandstone		≈ 4.0gpm
									—

REMARKS 10" Air hammer to 17 feet
20' 6inch steel casing set to 19 feet BGS
9 Bags Bentonite for seal around casing
6" Air hammer from 19 feet to 43 feet.

BORING NO.
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* See Legend on Back

BORING LOG HN-85S

TETRA TECH NUS, INC.

PROJECT NAWC warminster

PROJECT NO. 7606

ELEVATION —

WATER LEVEL DATA —

(DATE, TIME & CONDITIONS)

BORING NO. HN-85S

DATE 4-29-98

DRILLER Joe Dipasquale

FIELD GEOLOGIST Vince Shuckora

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1140	32					BN GY	Sandstone with some larger quartz grains		≈ 5.0 gpm
1146	38					TN GY	Sandstone		> 5.0 gpm
1150	43					BN TN	Sandstone		> 5.0 gpm
									—

REMARKS

BORING NO.

PAGE 2 OF ____

* See Legend on Back

BORING LOG HN-85I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-85I
DATE 4-28-98
DRILLER Joe Smith
FIELD GEOLOGIST Vince Shickora

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION: SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1402	1					BN	Silty clay		damp
1403	2					OR	clay		damp
1404	5					Rd BN	Silty clay		moist
1407	8					DK Rd-BN	silty clay with mica flakes		moist
1409	10			TOR-9 Ft.		Rd BN	siltstone/Mudstone		Soft moist
1411	13					DK Rd-BN	Siltstone with mica flakes		dry
1414	15					Rd BN	lithology same as above		dry
1420	19					BN-	Siltstone		dry
1421	22			6" at 19 Ft.		Rd BN	lithology same as above		dry
1504	25'					BN Gy	F.gr. Sandstone		wet cuttings ≈ 1.0 to 1.5 gpm
									—

REMARKS

BORING NO.

PAGE 1 OF ____

* See Legend on Back

BORING LOG HN-85I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-85I
DATE 4-28-98
DRILLER Joe Smith
FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1514	29					BN GY GR	Sandstone		Rust staining ≈ 3.0 gpm
1516	33					BN GY	Sandstone / some larger Quartz grains		
1518	38					TN GY	Sandstone		≈ 3.5 gpm
1520	41					RD BN	Siltstone / Mudstone		≈ 5.0 gpm
1524	45					BN-TN	Sandstone		rust staining ≈ 6.0 gpm
1528	49					GY-TN-BN	Sandstone		Possible fracture from 47' to 50' > 10 gpm
1531	53					PK RD BN	Siltstone / Mudstone		Soft
									—

REMARKS

BORING NO.

PAGE 2 OF ____

* See Legend on Back

BORING LOG HN-85I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION
WATER LEVEL DATA
(DATE. TIME & CONDITIONS)

BORING NO. HN-85I
DATE 4-28-98
DRILLER Joe Smith
FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1538	59					DK Rd-BN	Siltstone		> 10 gpm Total
1544	63					DK BN-Rd	Siltstone / V.F. gr. Sandstone		
1548	69					BN Gy	V.F. gr. Sandstone		> 12 gpm Total
1550	74					Rd BN Gy	Siltstone		
1552	79					BN TN	F. gr. Sandstone		Possible fracture from 78' to 81'
	83					Tan Gy	Sandstone with larger Quartz grains		≈ 15 gpm

REMARKS

BORING NO.

PAGE 3 OF ____

* See Legend on Back

BORING LOG HN-85I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster

PROJECT NO. 7606

ELEVATION —

WATER LEVEL DATA —

(DATE, TIME & CONDITIONS)

BORING NO. HN-85I

DATE 4-28-98

DRILLER Joe Smith

FIELD GEOLOGIST Vince Shuckora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	90					BN GY TAN	lithology same as above		
	94					BN GY TAN	lithology same as above		≈15 to 20 gpm Total
									—

REMARKS

BORING NO.

PAGE 4 OF ____

* See Legend on Back

BORING LOG HN-86S

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-86S
DATE 4-30-98
DRILLER Joe Dipasquale
FIELD GEOLOGIST Vince Shickora

SAMPLE NO. Start 1330	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1330	1					BN	Silty clay		moist
1331	3					OR BN	clay		moist
1332	5					Rd BN	Silty Clay		damp
1335	8					DK Rd BN	Silt with weathered siltstone Frags		damp
1337	10					DK Rd BN	V.F. gr. sandstone with some siltstone		rust stains damp cuttings
1339	12			TOR 9.5ft		Rd BN	lithology same as above		dry
1342	15					Rd BN Gy	lithology same as above		Hard Dry - Dusty
1355	19			6" at 18'		Rd BN	lithology same as above		Dry - Dusty
1359	23					Rd BN	lithology same as above		Hard damp cuttings
1402	27					Rd BN	V.F.gr. Sandstone		wet dripping cuttings.

REMARKS 10" Air hammer to 18'
20' steel casing set to 18' BGS
10 bags bentonite seal around base
6" Air hammer to 50'

BORING NO.
PAGE 1 OF ____

* See Legend on Back

BORING LOG HN-86S

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-86S
DATE 4-30-98
DRILLER Joe Dipasquale
FIELD GEOLOGIST Vince Shickora

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1406	32					BN GY	F-gr. Sandstone		≈ 2.0gpm
1414	37					Rd BN	Siltstone		≈ 3.0gpm
1424	42					DK Rd BN	Siltstone		≈ 4.0gpm
1428	44					Rd BN	Siltstone/Mudstone		≈ 4.0 to 5.0gpm
1432	48					DK Rd	Siltstone		≈ 5.0gpm
1435	50					DK RL	Siltstone		≈ 5.0gpm
									—

REMARKS

BORING NO.

PAGE 2 OF ____

* See Legend on Back

BORING LOG HN-86I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-86I
DATE 4-30-98
DRILLER Joe Dipasquale
FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
Start 0945									
0946	2					OR BN	Clay		damp
0948	5					Rd BN	Silty clay		moist
0950	8					DK Rd BN	Silt with weathered siltstone Frags		damp
0958	10					DK BN Rd	V.F.gr sandstone and some siltstone		rust staining damp
				TOR 9.5 Ft					
1008	13					Rd BN	lithology same as above		Hard Dry-Dusty
1025	16					Rd BN GY	lithology same as above		Hard Dry-Dusty
	18			6" at 17.5 Ft		RD BN	lithology same as above		Hard Dry-Dusty
1038	22					RD BN	lithology same as above		Hard Damp cuttings
1043	27					RD BN	V.F.gr Sandstone		wet dripping cuttings
									—

REMARKS

BORING NO.

PAGE 1 OF ____

* See Legend on Back

BORING LOG HN-86I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-86I
DATE 4-30-98
DRILLER Joe Dipasquale
FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1047	31					BN GY	F.gr. Sandstone		≈1.0 to 2.0 gpm
1053	36					Rd BN	Siltstone		≈ 2.0 gpm
									— —
1100	41					DKRd BN	Siltstone		≈ 2.5 to 3.0 gpm
1105	47					DK. Rd	Siltstone		3.0 to 3.5 gpm
1207	52					DK Rd	Siltstone / Mudstone		3.5 gpm
	57					RD BN	Siltstone		≈ 4.0 to 5.0 gpm
									—

REMARKS

BORING NO.

PAGE 2 OF ____

* See Legend on Back

BORING LOG HN-86I

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-86I
DATE 4-30-98
DRILLER Joe Dipasquale
FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1220	61					DK Rd	Mudstone		
1227	65					BN GY	F.gr. Sandstone		≈ 5.0gpm
1236	69					BN GY	Sandstone		≈ 5.5gpm
1238	75					GY BN	Sandstone		> 5.0gpm
1243	80					GY Rd	Sandstone / siltstone		rust staining > 5.0gpm
1247	85					DK Rd	Siltstone		> 5.0gpm
									—

REMARKS

BORING NO.
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* See Legend on Back

BORING LOG HN-86I

TETRA TECH NUS, INC.

PROJECT

PROJECT NO.

ELEVATION

WATER LEVEL DATA

(DATE, TIME & CONDITIONS)

BORING NO.

DATE

DRILLER

FIELD GEOLOGIST

SAMPLE NO	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1249	90					GY BN	Siltstone		>6.0gpm
1252	95					BN GY	F.gr. Sandstone		>6.0gpm
	100					BN GY	lithology same as above		> 7.0gpm
	102					BN GY	lithology same as above		

REMARKS

BORING NO.

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* See Legend on Back

BORING LOG HN-875

TETRA TECH NUS, INC.

PROJECT NAWC warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-875
DATE 4-29-98
DRILLER Joe Dipasquale
FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1346	1					BN	Silty clay		damp
1347	3					Rd BN	clayey silt with mica Flakes		damp
1350	7					Lt BN	Silt with weathered Sandstone Frags		damp
1352	9					BN	V.f.gr Sandstone / Siltstone		moist to wet cuttings
				TOR at 9.0 Ft					
1358	14					BN Gy	Sandstone		wet Dripping cuttings ≈ 1.0 gpm
1404	17					Rd BN	Sandstone		Some Rust stains wet cuttings
				6" at 19.5 ft.					
1545	21'					Rd BN	Siltstone		damp cuttings
1548	25					Rd BN	Siltstone		moist clumping cuttings
1551	28					BN Gy	Siltstone / V. F. gr. Sandstone		damp
									—

REMARKS 10" Air hammer to 19.5 feet
20' 6 inch steel casing set to 19.5 ft BGS
9.5 Bags Bentonite seal around casing
6" Air hammer to 62 feet

BORING NO.
PAGE 1 OF ____

* See Legend on Back

BORING LOG HN-875

TETRA TECH NUS, INC.

PROJECT NAWC Warminster
PROJECT NO. 7606
ELEVATION —
WATER LEVEL DATA —
(DATE, TIME & CONDITIONS)

BORING NO. HN-875
DATE 4-29-98
DRILLER Joe Dipasquale
FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION* SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	32					DK Rd BN	Siltstone		Harder clumping cuttings
1555	36					Rd BN	Siltstone		clumping cuttings
1557	40					Rd BN	V.F.gr. Sandstone		clumping cuttings
	43					Rd BN	lithology same as above		
1603	47					DK Rd BN	Siltstone		≈ 0.5 gpm
1604	50					Rd BN	Siltstone		≈ 1.0 gpm
1606	53					Rd BN Gy	F.gr. Sandstone		
1608	58					TN BN	F.gr. Sandstone		≈ 1.5 gpm

EMARKS

BORING NO.

PAGE 2 OF ____

* See Legend on Back

BORING LOG HN-875

TETRA TECH NUS, INC.

PROJECT NAWC Warminster

PROJECT NO. 7606

ELEVATION

WATER LEVEL DATA

(DATE, TIME & CONDITIONS)

BORING NO. HN-875

DATE 4-29-98

DRILLER Joe Dipasquale

FIELD GEOLOGIST Vince Shickora

SAMPLE NO.	DEPTH (FT.)	BLOWS 6"	SAMPLE REC. LENGTH	LITHO. CHANGE	MATERIAL DESCRIPTION*			USCS	REMARKS
					SOIL DENSITY HARDNESS	COLOR	MATERIAL CLASSIFICATION		
1610	60					BN BGE	F.gr. Sandstone		
1612	62					BN BGE	lithology same as above		≈ 1.5 to 2.0 gpm

REMARKS

BORING NO.

PAGE 3 OF ____

* See Legend on Back

JRB ASSOCIATES, INC.
8400 Westpark Drive, McLean, Virginia 22102

WELL LOG

PROFILE	DESCRIPTION
0	
	TOPSOIL / VEGETATION / FILL
1	
2	SANDY-LOAM TO SILT DRY. RED-BROWN.
3	
4	
	RED BROWN SILT-CLAY-HARD. DRY WITH MANY FRAGMENTS.
5	
	SPLIT SPOON 5'-6.5' 6" = 10/13/25
6	
7	
8	
9	
10	
	SPLIT SPOON 10'-10.75' 41/50/1
11	
	SANDSTONE WITH HARD AND SOFT LAYERS. WET FROM 10'
12	
13	
14	
15	
16	ROCKS INTERBED
17	
18	
19	
20	

PROJECT NADC WARMINSTER, PA

OWNER NAVAL AIR DEVELOPMENT CENTER

WELL NO. DG-10

LOCATION EAST WELL DG-9. N OF HOUSING DEVELOPMENT. DOWN-GRADIENT OF SITE #6

	Date	Time
DRILLING STARTED	7/16/82	1135
DRILLING COMPLETED	7/16/82	1410

DRILLER LARRY MISLER SCI

GEOLOGIST ED TOKARSKI JRB

RIG TYPE MOBILE B-56.

REFERENCE POINT LAND SURFACE

R.P. ELEVATION 345.1

TOPO POSITION FLAT LYING

PROFILE BY ED TOKARSKI

FIELD BOOK NO. 1 PAGES 40-41

WELL DATA

HOLE DIAMETER 6" O.D.

HOLE DEPTH 16'

CASING DIAMETER 2" I.D.

CASING LENGTH 10.31'

SCREEN DIAMETER 2" I.D.

SCREEN SETTING 15'-10.7'

SCREEN SLOT/TYPE 10-SLOT / NIKROMESH (2.15'/2.15') STAINLESS STEEL - (JOHNSON)

PUMP TEST DATA

STATIC DEPTH TO WATER 5.13 // 8.46

DATE MEASURED 7/25/82 // 9/9/82

PUMPING DEPTH TO WATER SAME

TEST DURATION —

PUMPING RATE —

TEST DATE 9/9/82

TEST TYPE BAIL TEST

PUMP SETTING 15'

SPECIFIC CAPACITY SEE REPORT

REMARKS

SMC ENVIRONMENTAL SERVICES GROUP

DRILLING LOG

PROJECT NADC OWNER Navy

LOCATION Site 6 W.O. NUMBER 9710-40001

WELL NUMBER DG-17 TOTAL DEPTH 38' DIAMETER 6"

SURFACE ELEV. / WAT. LEV.: INIT. 37.5' 11/13/90 ~~24 HRS~~ 16.70'

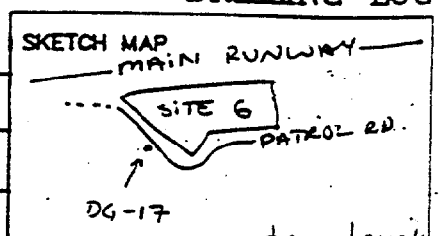
Open Hole: DIA. 6" LENGTH 16.5 - 38' SLOT SIZE NA

CASING: DIA. 6" LENGTH 0 - 16.5' TYPE PVC

DRILLING COMPANY C.S. Garber DRILLING METHOD Air Rotary

DRILLER E. Williams LOG BY PDB DATE DRILLED 10/31/90 11/1/90

SKETCH MAP



—water levels were measured from top of inner casing

NOTES

SHALLOW BEDROCK WELL

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	SAMPLE NUMBER (FID)	PID	DESCRIPTION / SOIL CLASSIFICATION (U.S.C.S.) (COLOR, TEXTURE, STRUCTURES, MOISTURE, OVA READING)
	SOIL		ND	ND	0-5' Orange-red organic silt (OL). Dry
11					5-7' Brown quartzitic medium grained Sand. Dry
		16.5' CASING			7-11' Brown quartzo-feldspathic medium grained sand
					11-16' Brown and white medium grained arkosic sandstone. Dry
	BEDROCK	OPEN HOLE			16-20' Maroon-brown siltstone with medium grained sand inclusions. Quartz + feldspar. Dry
					20-23' Olive-brown fine to medium grained arkosic sandstone. Dry
					23-30' Dark red micaceous siltstone. Dry.
					30-37' Maroon brown very fine silty sandstone. Moist near bottom
38		2" BENT. SEAL / B/C GROUT PROTECT. CAS. w/ locking cap SEE work plan specs.			37-38' Maroon-brown fine to medium grained quartzo-feldspathic sandstone.
					* Set Casing at 16.5'
					Hydrogeology
					-Hit water at 37'
					- Well yield is < ½ gpm
					- Bedrock / soil interface was dry
					-Well recharged 1' in 2 minutes

SMC ENVIRONMENTAL SERVICES GROUP

DRILLING LOG

PROJECT NADC OWNER Navy

LOCATION Site 6 W.O. NUMBER 9710-40001

WELL NUMBER DG-19 TOTAL DEPTH 47' DIAMETER 6"

SURFACE ELEV. / WAT. LEV.: INIT. 45' 11/13 ~~24 HRS~~ 17.05'

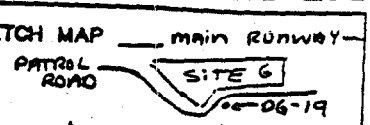
Open Hole: DIA. 6" LENGTH 21.75-4' SLOT SIZE NA

CASING: DIA. 6" LENGTH 0-21.75' TYPE PVC

DRILLING COMPANY C.S. Garber DRILLING METHOD Air Rotary

DRILLER E. Williams LOG BY PDB DATE DRILLED 11/2/90 11/5/90

SKETCH MAP



- Water levels were measured from top of inner casing

NOTES

SHALLOW BEDROCK WELL

DEPTH (FEET)	GRAPHIC LOG	WELL CONSTRUCTION	PID SAMPLE NUMBER	FID	DESCRIPTION / SOIL CLASSIFICATION (U.S.C.S.) (COLOR, TEXTURE, STRUCTURES, MOISTURE, OVA READING)
	SOIL		ND	ND	0-6' Orange brown silty sand (SM)
		21.75' CASING			6-7' Dk. maroon-red clayey silt (ML). Slightly moist.
	BEDROCK				7-28' Dark maroon red micaceous siltstone. Dry.
					28-46' Olive gray fine grained arkosic sandstone. Moist around 40-42'
47					46-47' Light green very fine grained arkosic sandstone.
		OPEN HOLE			
		2' BENT. SEAL; BENT./CEM. GROUT. PROTECT. CASING w/LOCKING CAP. SEE WORK PLAN SPECS.			Hydrogeology - Hit water at 42' - Yield is ½ gpm - Soil / bedrock interface slightly moist. - 1.7-2 ppm hit on development water. This water was containerized.

BORING LOG **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER, CTO-139 & 12-28-94 BORING NO.: EW-12
PROJECT NO.: 0286.0304 DATE: 12-21-94 & 12-27-94 DRILLER: EDI; BOB ATKINSON & MIKE MILLICAN
ELEVATION: TOC 333.60 FIELD GEOLOGIST: ROBERT GOOD
WATER LEVEL DATA (Date, Time & Conditions): 10.54

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR OR USCS	REMARKS
1341	0.0					BRN	SILT LOAM & SILTY CLAY LOAM		DAMP - MOIST
	2.0								
						ORANGE BRN	SILT-CLAY SUBSOIL		MOIST
	4.0								
1359	5.0					BRN	SANDY SILT TO SILTY SAND		MOIST 6'-7' SLIGHTLY HARDER
						BRN & GRAY	VERY WEATHERED FGR SANDSTONE W/ RUSTY STAINS		
									9½'-10' WET ZONE, EST ≤ 1 GPM, SLIGHT INCREASE FROM 10' TO 12'
1420	12.0								
1435	14.0					BRN & GRAY	FGR SANDSTONE, SOME RUSTY STAINED WEATHERED LAYERS & FRACTURES		12' COMPETENT BEDROCK
1451	16.0								15' FRACTURE, POSS H_2O
1510	18.0					REDDISH BRN & GRAY	SILTY FGR SANDSTONE W/ SOME RUSTY STAINS		17' FRACTURE, POSS H_2O
1520	20.0								
'21 12/27 0841						BRN & GRAY	FGR SANDSTONE, RUSTY STAINED		MUDDY, ≤ 1 GPM
0924 0928	23.0						SOME MGR SANDSTONE		23', 2-3 GPM
0936	25.0								
						REDDISH BRN & GRAY	SILTY FGR SANDSTONE		HARDER 28'-29' SOFT OR FRACTURED
1013	30.0								SOME WATER INCREASE, 3-5 GPM
1056 1059	33.0								
1020	35.0					BRN & GRAY	FGR SANDSTON, SOME MGR-CGR SANDSTONE, RUSTY STAINED		34'-40' SOFTER ZONES OR FRACTURES, POSS. SLIGHT WATER INCREASE
1134	40.0								
						RED	SILTSTONE		
1139 1143	43.0					REDDISH BRN & GRAY	SILTY FGR-VFGR SANDSTONE		HARDER, TOTAL YIELD EST 5-7 GPM
1149	45.0								POSS WATER INCREASE TO 47 EST 7-10 GPM 2/10 GPM AT 48'
1233	50.0					REDDISH GRAY	FGR SANDSTONE		

REMARKS TAMROCK DRILL-TECH DK 25 RIG. 14" ROLLER BIT FROM 0' TO 20'. 10" AIR HAMMER 20' TO 53½'. 6" AIR HAMMER 53½' TO 100' (SEPARATE LOG). 10" AIR HAMMER 53½' TO 100' OVER-REAM. 10" STEEL CASING GROUTED TO 20'.

BORING EW-12

PAGE 1 OF 2

* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER CTO-139 BORING NO.: EW-12

PROJECT NO.: 0286.0304 DATE: 12/21/97, 12/27/97, 12/28/97 DRILLER: EOE, BOB ATKINSON, MIKE MILLIGAN

ELEVATION: TOC 333.60 FIELD GEOLOGIST: R. GOOD, HNUS

WATER LEVEL DATA: 10.54

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS ON 300 (ft)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1233	50.0					REDDISH GRAY &	FGR SANDSTONE		HARD, YIELD EST 10-15 GPM
1325	52.0					BRN			
1357 0803	53.5								
	55.0								54'-58' FRACTURED, PSS WATER INCREASES
									EST ≥ 20 GPM
0831	60.0					RED	SILTSTONE W/ SOME SILTY VFGR SANDSTONE		
0850 0875	63.0								
0846	65.0					REDDISH BRN	SILTY VFGR SANDSTONE & SOME SILTSTONE		
0852	70.0								
0855	75.0					RED	SILTSTONE		
						REDDISH GRAY	FGR SANDSTONE		
0904	80.0								79'-80' FRACTURED
0912 0914	83.0								
0927	85.0					LIGHT GRAY	FGR SANDSTONE		
1102	90.0						SOFTER, MORE ARKOSIC		
									90'-92' SOME FRACTURES
						LIGHT GRAY	FGR-MGR ARKOSIC SANDSTONE, SOME CONGLOMERATE		94' SOFTER
1118	95.0					"	ARKOSIC CONGLOMERATE		
						REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SILTSTONE		
1131	100.0								

REMARKS

BORING EW-12

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* See Legend on Back

BORING LOG

HALLIBURTON NUS

PROJECT: Naval Warminster CTO-139 BORING NO.: EW-12
PROJECT NO.: 0286.0304 DATE: 12/27/94 DRILLER: EDE Ron Atkinson Mike Willie
ELEVATION: TOC 333.60 FIELD GEOLOGIST: A. Good Anni
WATER LEVEL DATA: 10.54
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1443	53.5					REDDISH	FGR SANDSTONE		
						GRY & BRN			
1445	60.0								Pass WATER INCREASE
1450	62.0								15-20 GPM ?
1453						REDDISH BRN	SILTSTONE & SILTY FGR-VFGR SANDSTONE		
1456	65.0								
1459	70.0								
	72.0						MORE SILTSTONE		NUMEROUS SMALL FRACTURES
1502	75.0					REDDISH	FGR SANDSTONE		
						GRAY & BRN			
1507	80.0								
1508	82.0								
1510									
1517	85.0					LIGHT GRAY	FGR SANDSTONE, SOME MGR-CGR SANDSTONE & CONGLOMERATE		
1519	90.0								
1522	95.0					LIGHT GRAY	FGR-MGR ARKOSIC SANDSTONE & CONGLOMERATE		
						REDDISH BRN	SILTY FGR-VFGR SANDSTONE		
1524	100.0					RED	SILTSTONE		

REMARKS 6" BOREHOLE 53.5' TO 100'

BORING EW-12

PAGE ____ OF ____

* See Legend on Back

BORING LOG — HALLIBURTON NUS

PROJECT: NAWC WARMINSTER, CTO-139 BORING NO.: EW-14
PROJECT NO.: 0286.0304 DATE: 1/6/95 & 1/9/95 DRILLER: CDI, BOB ATKINSON
ELEVATION: TOC 331.43 FIELD GEOLOGIST: R. GOOD, HNUS
WATER LEVEL DATA: 8.03
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK ER OR USCS	REMARKS
1542	0.0					BRN	SILT LOAM		MOIST
						LT BRN	SILTY CLAY LOAM, RK FRAGS		
						LT BRN	SILTY SAND & ROCK FRAGMENTS		"
						LT BRN	WEATHERED FGR SANDSTONE		
1558	5.0					TO BRN			DAMP
				WEATHERED		BRN	FGR SANDSTONE		HARDER COMPETENT ROCK AT 5'
						BRN &	FGR SANDSTONE		8'-8½ FT MOIST
1620	10.0					GRAY			8½-10 FT FRACTURES & WATER (FEW GPM)
0857						BRN & GRAY	FGR SANDSTONE		SLIGHT WATER, APPROX 1-2 GPM
									13' POSSIBLE FRACTURE
0901	15.0								
									DAMP – DRY
0904	20.0					BRN &			
						REDDISH GRAY	FGR SANDSTONE		
									23'-24.5' SOFTER OR FRACTURED, POSS. WATER
0907 0909	24.5								27'-28' FRACTURED, WATER 2-3 GPM
0914	30.0								
						BRN & REDDISH	SOMEWHAT SILTY FGR SANDSTONE		
						BRN REDDISH	FGR SANDSTONE		
0920	35.0					GRAY REDDISH	SILTY FGR - VFGR SANDSTONE		2-3 GPM
						BRN & GRAY	w/ POSSIBLE FEW THIN SILTSTONE BEDS		
0924	40.0								
						BRN &	FGR SANDSTONE		43' POSS. FRACTURE & WATER INCREASE
0929 0931	44.5					GRAY			EST 5 GPM
						REDDISH GRAY	FGR SANDSTONE		45' HARDER
0937	50.0								

REMARKS TAMROCK DRILL-TECH DT 25 RIG. 14" ROLLER BIT TO 10'. 10" STEEL CASING TO 10'. 10" AIR HAMMER 10' TO 100'.

BORING EW-14

PAGE 1 OF 2

* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER, CTO-134 — BORING NO.: EW-14
PROJECT NO.: 0286, 0304 — DATE: 1/6/95 & 1/9/95 — DRILLER: EDI ROB ATKINSON
ELEVATION: TOC 331.43 — FIELD GEOLOGIST: R. GOOD, HNU
WATER LEVEL DATA: 8.03
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
0937	50.0					REDDISH GRAY &	FGR SANDSTONE		EST 5 GPM TOTAL
						LT GRAY			
0942	55.0					MED GRAY	FGR SANDSTONE		55' SOFT OR FRACTURED POSS WATER
0946	60.0					REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SOME SILTSTONE		
						RED	SILTSTONE		
									POOR CUTTINGS RETURNS 63'-67', 68'-72'
0949 0953	64.5					LIGHT GRAY	FGR SANDSTONE W/ MGR-CGR SANDSTONE & ARKOSIC CONGLOMERATE		
1001	70.0								
1006 1017	73.0								
1018	75.0								EST YIELD 7 GPM 75'-79' POSS INCREASE
1022	80.0								EST 7-10 GPM
									80'-81' FRACTURED ?
1027 1029	87.5								85' FRACTURED ?
1032	90.0								
						REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SOME SILTSTONE		
1036	95.0								
						RED	SILTSTONE		
1039	100.0			T.D.					EST YIELD 10-12 G

REMARKS

BORING EW-14

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* See Legend on Back

BORING LOG

HALLIBURTON NUS

PROJECT: NAWC WARMINSTER CTO-139 BORING NO.: OB-5

PROJECT NO.: 0286.0304 DATE: 1/10/95 & 1/11/95 DRILLER: EDE, BOB ATKINSON

ELEVATION: TOC 338.09 FIELD GEOLOGIST: R. GOOD, HNUS

WATER LEVEL DATA: 5.43

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
0837	0.0					BRN	SILT LOAM W/ SOME ROCK FRAGMENTS		DAMP
						ORANGE BRN	SILTY-CLAY LOAM		"
0843	5.0					REDDISH BRN	VERY WEATHERED FGR SILTY SANDSTONE		MOIST
0845	10.0					R-BRN	SLIGHTLY WEATH. FGR SILTY SANDSTONE		9' HARDER
						REDDISH GRAY	FGR SANDSTONE		10' HARDER, COMPETENT ROCK DAMP - DRY
0850	15.0								DRIER
0854 1041	19.5					BRN & GRAY	FGR SANDSTONE		DAMP
1043	22.0								
1046									
1047	25.0								
						LT. GRAY & BRN	FGR SANDSTONE SOME RUSTY STAINS		DAMP - MOIST
1049	30.0								
						RED	SILTSTONE & SILTY SANDSTONE		DRY
1051	35.0					REDDISH GRAY & BRN	FGR SANDSTONE		37' SLIGHTLY MOIST ZONE
1054	40.0								
1055 1057	42.0					REDDISH BRN & RED	SILTY FGR-VFGR SANDSTONE & SILTSTONE		SOME STEAM AT ROD CONNECTION
1058	45.0								DAMP
1100	50.0								

REMARKS TAMROCK DRILL-TECH DK 25 RIG. 10" AIR HAMMER 0' TO 19.5'. 6" STEEL CASING TO 19.5'. 6" AIR HAMMER 19.5' TO 100'

BORING OB-5

* See Legend on Back

BORING LOG — HALLIBURTON NUS

PROJECT: NAWC WARMINSTER, CTO-139 BORING NO.: OB-5
PROJECT NO.: 0286.0304 DATE: 1/10/95 & 1/11/95 DRILLER: EDE, BOB ATKINSON
ELEVATION: 338.09 TOC FIELD GEOLOGIST: R. GOOD HNUS
WATER LEVEL DATA: 5.43
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1100	50.0					REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SILTSTONE		DRY
1102	55.0								
						GRAY & BRN	FGR-VFGR SANDSTONE		55'-60' SOME MOISTURE APPX 1 GPM
1104	60.0								
1105	62.0								60'-62' SOFTER
1106						REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SILTSTONE		DRY
1108	65.0								
1109	70.0						SOME THIN GRAY VFGR		
							SANDSTONE BEDS 68'-80'		
1111	75.0								75'-76' ENCOUNTER WATER BEARING ZONE
1114	80.0								EST 3-5 GPM
1115	82.0					GRAY	FGR-VFGR SANDSTONE		
1117									EST 8-10 GPM
1119	85.0					GRAY & BRN	FGR, MGR, CGR SANDSTONE & SOME ARKOSIC CONGLOMERATE		
									POSS SLIGHT ADD'L WATER
1122	90.0								
1124	95.0						- SAME AS ABOVE, LIGHTER COLORED		
1126	100.0			T.D.					

REMARKS

BORING OB-5

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* See Legend on Back

BORING LOG — HALLIBURTON NUS

PROJECT: NAWC WARMINSTER, CTO-139 — BORING NO.: OB-6
PROJECT NO.: 0286.0304 — DATE: 1/10/95 & 1/11/95 — DRILLER: EOE, BOB ATKINSON
ELEVATION: TOC 334.03 — FIELD GEOLOGIST: R. GOOD, [illegible]
WATER LEVEL DATA: 12.22
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1006	0.0					BRN	SILT LOAM		FROZEN DAMP
						MED-BRN DARK BRN	SILTY CLAY LOAM		DAMP - MOIST
1013	5.0					BRN	VERY WEATHERED FGR SANDSTONE RUSTY STAINED		MOIST
							WEATHERED FGR SANDSTONE		
1015	10.0								
				HARDENED		GRAY & BRN	FGR SANDSTONE W/ SOME RUSTY STAINS		DAMP, HARDER COMPETENT BEDROCK
									SOME FRACTURES
1018	15.0					GRAY & BRN	MGR-CGR ARKOSIC SANDSTONE & CONGLOMERATE		15' ≤ 1 GPM
									18½'-19' FRACTURED,
1022 0757	19.0					BRN &	FGR SANDSTONE		3-5 GPM
0758 0800	21.5					GRAY REDDISH	SILTY FGR-VFGR SANDSTONE &		DRY
						BRN & RED	SILTSTONE		
0801	25.0								
									28' SLIGHT MOISTURE
0803	30.0								30' SLIGHT MOISTURE
						REDDISH GRAY	FGR SANDSTONE		DRY
0806	35.0								
0809	40.0								39' SOFT/FRACTURED SLIGHT MOISTURE
0810 0813	41.5								
0815	45.0					BRN & GRAY	FGR SANDSTONE		DRY
									47'-48' SOME WATER
0817	50.0					REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SILTSTONE		

REMARKS: THMROCK DRILL-TECH DR 25 RIG. 10" BOREHOLE 0' TO 19'. 6" STEEL CASING TO 19'. 6" AIR HAMMER 19' TO 100'.

BORING OB-6

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER CTO-139 BORING NO.: OB-6
PROJECT NO.: 0286 DATE: 1/10/95 & 1/11/95 DRILLER: EDI [illegible] ATKINSON
ELEVATION: TOC 334.03 FIELD GEOLOGIST: R. FOOD, HNUS
WATER LEVEL DATA: 12.22
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
0817	50.0					REDDISH BRN &	SILTY FGR-VFGR SANDSTONE & SILTSTONE		DRY
						RED			
0820	55.0					REDDISH GRAY	FGR SANDSTONE		SLIGHTLY MOIST
						GRAY,	FGR SANDSTONE		DRY - DAMP
0823	60.0					LT. GRAY & BRN			
0824 0825	61.5								60' + SLIGHTLY MOIST
0827	65.0								SLIGHTLY DAMP ZONE
						REDDISH BRN	SILTY FGR-VFGR SANDSTONE		67' FRACTURED? MOIST
0830	70.0								
									72'-73' SOFT/FRACTURED
						GRAY & BRN	FGR SANDSTONE		
0833	75.0								
0836	80.0					GRAY & BRN	FGR-CGR SANDSTONE, ARKOSIC, SOME CONGLOMERATE		78'-83' SOFT ZONES OR FRACTURES
0837 0838	81.5								SOME WATER AT CONNECTION
0840	85.0								86'-87' FRACTURED, SOME WATER, ~1 GPM
0843	90.0					GRAY	MORE CONGLOMERATE & CGR SANDSTONE		89-90' WATER INCREASE 2-3 GPM TOTAL
									92' 3-5 GPM EST TOTAL
0845	95.0					RED & REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SILTSTONE		93'-95' SOFT OR FRACTURED
0847	100.0			T.D.					TOTAL YIELD ≥ 5 GPM

REMARKS

BORING OB-6

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER CTO-139 BORING NO.: OB-7
PROJECT NO.: 0286.0304 DATE: 12/29/94, 12/30/94 DRILLER: EDI: MIKE MILLICAN
ELEVATION: TOC 332.06 FIELD GEOLOGIST: R. GOOD, HNUS
WATER LEVEL DATA: 9.20
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1746	0.0					BRN	SILT LOAM		MOIST
						LT. BRN	SILTY CLAY LOAM		
						ORANGE REDDISH	VERY WEATHERED SANDSTONE		
1754	5.0					BRN & GRAY			
						REDDISH GRAY	WEATHERED, FGR SANDSTONE		
1758	10.0					BRN	WEATHERED SANDSTONE, RUSTY STAINED		MOIST, 9'-10 HARDER, MORE COMPETENT
						BRN & REDDISH	FGR SANDSTONE		
						GRAY			13' SOME WATER
1506	15.0					REDDISH	SILTY FGR-VFGR SANDSTONE		
						BRN	W/ SOME SILTSTONE		
509	19.0								
0802	20.0					RED	SILTSTONE & SILTY VFGR		DRY
0803	22.0						SANDSTONE		
0807						REDDISH BRN	SILTY VFGR-FGR SANDSTONE		
0809	25.0					REDDISH GRAY	FGR SAND STONE		26'-27' VERY SLIGHT
									WATER
0812	30.0					REDDISH BRN &	FGR SANDSTONE		
						GRAY			32'-33' SOFTER OR
									FRACTURE, SLIGHT WATER
0815	35.0								
						REDDISH	SILTY VFGR SANDSTONE &		DRY
0818	40.0					BRN	SILTSTONE		
0819	42.0					BRN & GRAY	FGR SANDSTONE		1-2 GPM AFTER ROD
0821									CONNECTION
0823	45.0								HARD
0825	50.0								HARD

REMARKS TAMROCK DRILTECH DK-25 RIG. 10" AIR HAMMER FROM 0' TO 19'. 6 ~~10~~" STEEL CSG TO 19'. 6" AIR HAMMER FROM 19' TO 100'.

BORING OB-7

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: LAUC WARMINSTER CTC-139 BORING NO.: OB-7
PROJECT NO.: 286-0304 DATE: 12/29/94 - 12/30/94 DRILLER: EDI - MIKE MILLIGAN
ELEVATION: TOC 332.06 FIELD GEOLOGIST: R. GOOD HNUS
WATER LEVEL DATA: 9.20
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
0825	50.0					BRN & GRAY	FGR SANDSTONE		HARD, EST 1-2 GPM 50'-51' WATER INCREASE
									EST 5 GPM, SOFT OR
0828	55.0					REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SILTSTONE		FRACTURED 53'-54'
0831	60.0					RED	SILTSTONE		
0832	62.0								61' SOFT OR FRACTURED, WATER INCREASE 7-10
0834									GPM EST.
0835	65.0								
						BRN & GRAY	FGR SANDSTONE		
0837	70.0					GRAY	FGR SANDSTONE		
									POSSIBLE WATER INCREASE
0840	75.0					LIGHT GRAY	FGR SANDSTONE		EST 10-15 GPM
0843	80.0					MEDIUM GRAY	FGR SANDSTONE w/ SOME LIGNITE		
0845	82.0								
0848									
0849	85.0					LIGHT GRAY	FGR SANDSTONE		
						REDDISH BRN	SILTY FGR-VFGR SANDSTONE w/ SOME SILTSTONE BEDS		
0852	90.0								
0854	95.0								
						REDDISH GRAY	FGR SANDSTONE		FRACTURED ? POSSIBLE
0856	100.0								WATER INCREASE.

REMARKS DEVELOP BOREHOLE WITH AIR APPX 15 MIN, EST TOTAL YIELD ≥ 15 GPM.

BORING OB-7

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* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: HUC WARMINSTER CTC-139 BORING NO.: OB-8
PROJECT NO.: 286-0304 DATE: 12/28/94 12/29/94 DRILLER: EDI: MIKE MILLIGAN
ELEVATION: TOC 330.97 FIELD GEOLOGIST: R. GOOD HNUS
WATER LEVEL DATA: 7.80
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1325	0.0					BRN	SILT LOAM		DAMP
						ORANGE BRN	SILTY CLAY LOAM		
1328	5.0					BRN BRN	SANDY SILT - SILTY SAND VERY WEATHERED SANDSTONE		DAMP
						R-BRN R-BRN	VERY WEATHERED SILTSTONE SILTY FGR SANDSTONE		
1335	10.0					R-GRAY	FGR SANDSTONE, WEATHERED		9'-10' HARDER, MORE COMPETENT
						BRN &	FGR SANDSTONE		12' HARDER, DRIER
						R-GRAY			14' SOME WATER, FEW
1343	15.0								SOFT BROWN ZONES
									17' MOIST BRN ZONE 18' HARDER
353 0858	17.0 20.0								DRY - DAMP
0859	22.0					REDDISH GRAY &	FGR SANDSTONE		
0902						BRN			
0903	25.0								DAMP - SLIGHT WATER
0908	30.0								
						REDDISH GRAY &	FGR SANDSTONE		
0909	35.0					BRN			
									38'-39' SOFTER
0912	40.0								
0914	42.0								
0917									SLIGHT WATER INCREASE
0919	45.0								45' HARDER
						REDDISH			47' SOFT ZONE
0923	50.0					GRAY & BRN	FGR SANDSTONE		

REMARKS TAMROCK DRILL TECH DK-25 RIG. 10" AIR HAMMER FROM 0' TO 19'
6" STEEL CASING TO 19'. 6" AIR HAMMER FROM 19' TO 100'.

BORING OB-8

PAGE 1 OF 2

* See Legend on back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER, CTC-139 BORING NO.: OB-8
PROJECT NO.: 0286.0304 DATE: 12/28/94, 12/29/94 DRILLER: EDI: MIKE MILLICAN
ELEVATION: TOC 330.97 FIELD GEOLOGIST: R. COOD, HALLS
WATER LEVEL DATA: 7.80
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 5" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
0923	50.0					REDDISH GRAY &	FGR SANDSTONE		HARD, DRY
						BRN REDDISH	SILTY FGR - VFGR SANDSTONE		53' SOFTER, DAMP
0926	55.0					BRN RED	SILTSTONE		
0929	60.0					BRN & GRAY	SILTY FGR SANDSTONE		
0931	62.0					REDDISH GRAY	FGR SANDSTONE		DRY
0934									MORE WATER AFTER ROD CONNECTION
0935	65.0								APPX 1 GPM
0938	70.0					LIGHT	FGR SANDSTONE		DRY
						REDDISH GRAY			
									75'-76' INCREASED WATER
0941	75.0								76'-77' SOFT OR FRACTURED, MORE WATER
									EST 1-2 GPM
0945	80.0					LIGHT GRAY	FGR SANDSTONE SOME MGR - CGR SANDSTONE		80' MORE WATER, 2-3 GPM
0946	82.0								
0949							POSS SOME CONGLOMERATE		
0950	85.0								2-3 GPM
						REDDISH BRN	SILTY VFGR - FGR SANDSTONE & SILTSTONE		
0953	90.0								
0957	95.0						LESS SILTSTONE, SOME GRAY VFGR SANDSTONE		96'-98' HARDER, POSS MOD'L WATER
1004	100.0								

REMARKS DEVELOP BOREHOLE WITH AIR FOR OVER 30 MIN. TOTAL YIELD EST 3-5 GPM MAXIMUM.

BORING OB-8

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* See Legend on Back

BORING LOG — HALLIBURTON NUS

PROJECT: NAWC WARMINSTER, CTO-139 — BORING NO.: OB-9

PROJECT NO.: 0286.0304 — DATE: 1/6/95 & 1/9/95 — DRILLER: EDE, BOB ATKINSON

ELEVATION: TOC 333.03 — FIELD GEOLOGIST: R. GOOD, HNUS

WATER LEVEL DATA: 7.44

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1731	0.0					BRN	SILT LOAM		DAMP
						LT. BRN-ORANGE	SILTY CLAY LOAM		MOIST
						BRN TO GRAY	CLAYEY SUBSOIL		
1735	5.0								POOR CUTTINGS RETURNS
						ORANGE-BRN	VERY WEATHERED SANDSTONE, FGR, RUSTY STAINED		6' TO 12'
1440	10.0			MEMEMEME		BRN & GRAY	FGR SANDSTONE, SOME RUSTY STAINS		9' HAMMER COMPETENT ROCK
									DAMP TO MOIST
1444	15.0								
1447	20.0								
1239 1240 1242	21.5					REDDISH BRN	SILTY FGR SANDSTONE		DAMP
						REDDISH GRAY	FGR SANDSTONE		DRY
1245	25.0								
									28' MOIST ZONE
1248	30.0								
									DRY
1249	35.0								
						GRAY & BRN	FGR SANDSTONE		SLIGHTLY MOIST
1251	40.0								
1252 1253	41.5					REDDISH GRAY	FGR SANDSTONE		
1254	45.0								MOIST - DAMP
1256	50.0								

REMARKS: TAMROCK DRILL-TECH DK-25 RIG. 10" AIR HAMMER 0' TO 20'
6" STEEL CASING 0' TO 20'. 6" AIR HAMMER 20' TO 100'

BORING OB-9

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* See Legend on Back

BORING LOG

HALLIBURTON NUS

PROJECT: NAWC WARMINSTER, CTO-134 BORING NO.: OB-9

PROJECT NO.: 0286.0204 DATE: 1/6/95 & 1/9/95 DRILLER:

ELEVATION: TOC 333.03 FIELD GEOLOGIST:

WATER LEVEL DATA: 7.44

(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1256	50.0					REDDISH GRAY	FGR SANDSTONE		MOIST
									53'-54' SOFTER AND/OR FRACTURED
1259	55.0					REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SILTSTONE		
									DRY - DAMP
1302	60.0								
1303 1304	61.5								
						BRN &	FGR SANDSTONE		63' HARDER
1308	65.0					GRAY			
						REDDISH BRN	SILTY FGR-VFGR SANDSTONE & SILTSTONE		DRY
1310	70.0					BRN & GRAY	FGR SANDSTONE		
						LIGHT	FGR SANDSTONE SOME		DRY - DAMP
						GRAY	MGR-CGR SANDSTONE & ARKOSIC CONGLOMERATE		
1313	75.0								SOME SMALL FRACTURES W/ SLIGHT MOISTURE
1315	80.0								
1316 1324	81.5								81' SOFTER OR FRACTURED, SOME WATER AFTER ROD CONNECTION
1326	85.0								
1331	90.0								
						REDDISH	SILTY FGR-VFGR SANDSTONE		DRY TO DAMP
1334	95.0					BRN & RED	& SILTSTONE		
1337	100.0			T.D.					EST TOTAL YIELD 1-2 GPM ?

REMARKS CLOGGED DIVERTER STACK; POOR CUTTINGS & WATER RETURNS 63' TO 100'. INSUFFICIENT WATER TO EFFECTIVELY DEVELOP BOREHOLE

BORING OB-9

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* See Legend on Back

BORING LOG — **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER OTC-139 BORING NO.: OB-10
PROJECT NO.: 1286.0304 DATE: 12/29/94 - 12/30/94 DRILLER: EDE - MIKE MILLIGAN
ELEVATION: TOC 330.20 FIELD GEOLOGIST: R. GOOD HNUS
WATER LEVEL DATA: 7.45
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1124	0.0					BRN	SILT LOAM		DAMP
						LT. BRN	SILT CLAY LOAM		
						R-BRN	SILT-CLAY		DAMP
1138	5.0					R-BRN	SANDY SILT		
						R-BRN	VERY WEATHERED SILTSTONE		
						REDDISH GRAY	WEATHERED FGR SANDSTONE		DRY - DAMP
1143	10.0					REDDISH GRAY	FGR SANDSTONE		DRY, VERY FRACTURED 10' TO 17'-19'
						BRN &	FGR SANDSTONE, RUSTY		WATER AT 10' 3-5 GPM AT 11'
						REDDISH GRAY	STAINED		WATER INCREASING
1154	15.0								
						REDDISH	SILTY FGR-VFGR SANDSTONE		EST 10 GPM OR MORE
158	19.0					BRN			
1113	20.0								DRY
1115	22.0					REDDISH BRN	AS ABOVE		SOME WATER AFTER
1116									ROD CONNECTION
1118	25.0					BRN &	FGR SANDSTONE		
						GRAY			27'-28' WATER, 3-5 GPM
1121	30.0								
									34'-35' INCREASED WATER
1123	35.0								TO 40'
1125	40.0					REDDISH	SILTSTONE & SILTY FGR —		EST 10 GPM
1126	42.0					BRN	VFGR SANDSTONE		
1127									
1128	45.0								
1130	50.0								

REMARKS TAMROCK DRILLTECH DK-25 RIG. 10" AIR HAMMER FROM 0' TO 19'
6" STEEL CASING TO 19'. 6" AIR HAMMER FROM 19' TO 100'

BORING OB-10

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* See Legend on Back

BORING LOG **HALLIBURTON NUS**

PROJECT: NAWC WARMINSTER CTC-139 BORING NO.: OB-10
PROJECT NO.: 0286.0304 DATE: 12/29/94, 12/30/94 DRILLER: EDI MIKE MILLIGAN
ELEVATION: TOC 330.20 FIELD GEOLOGIST: R. GOOD HNUS
WATER LEVEL DATA: 7.45
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK BR. OR USCS	REMARKS
1130	50.0					RED	SILTSTONE & SILTY FGR-VFGR SANDSTONE		YIELD ≥ 10 GPM
						LIGHT REDDISH	FGR SANDSTONE		POSS. WATER INCREASE
1132	55.0					GRAY			
1138	60.0					BRN & GRAY	FGR-MGR SANDSTONE		SOFTER
1136	62.0								
1138						LIGHT	FGR SANDSTONE		
1139	65.0					GRAY			
1140	70.0					REDDISH BRN	SILTSTONE & SILTY VFGR SANDSTONE		
1142	75.0								
						RED	SILTSTONE		
1144	80.0								
1145	82.0								
1149						REDDISH	FGR SANDSTONE		
1150	85.0					GRAY			86'-87' POSS FRACTURE & WATER INCREASE
1152	90.0					REDDISH BRN &	SILTY FGR-VFGR SANDSTONE		
1153	92.0					GRAY			
1154						GRAY	FGR SANDSTONE		HARDER
1156	95.0					LIGHT GRAY	FGR SANDSTONE, SOME MGR-CGR SANDSTONE		POSS. WATER INCREASE
						REDDISH GRAY	FGR SANDSTONE		
1200	100.0								EST TOTAL YIELD ≥ [illegible]

REMARKS DEVELOP BOREHOLE W/ AIR APPX 18 MIN.

BORING OB-10

PAGE 2 OF 2

* See Legend on Back

NAWC WARMINSTER AREA B

MONITORING WELL CONSTRUCTION DETAILS

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-08S

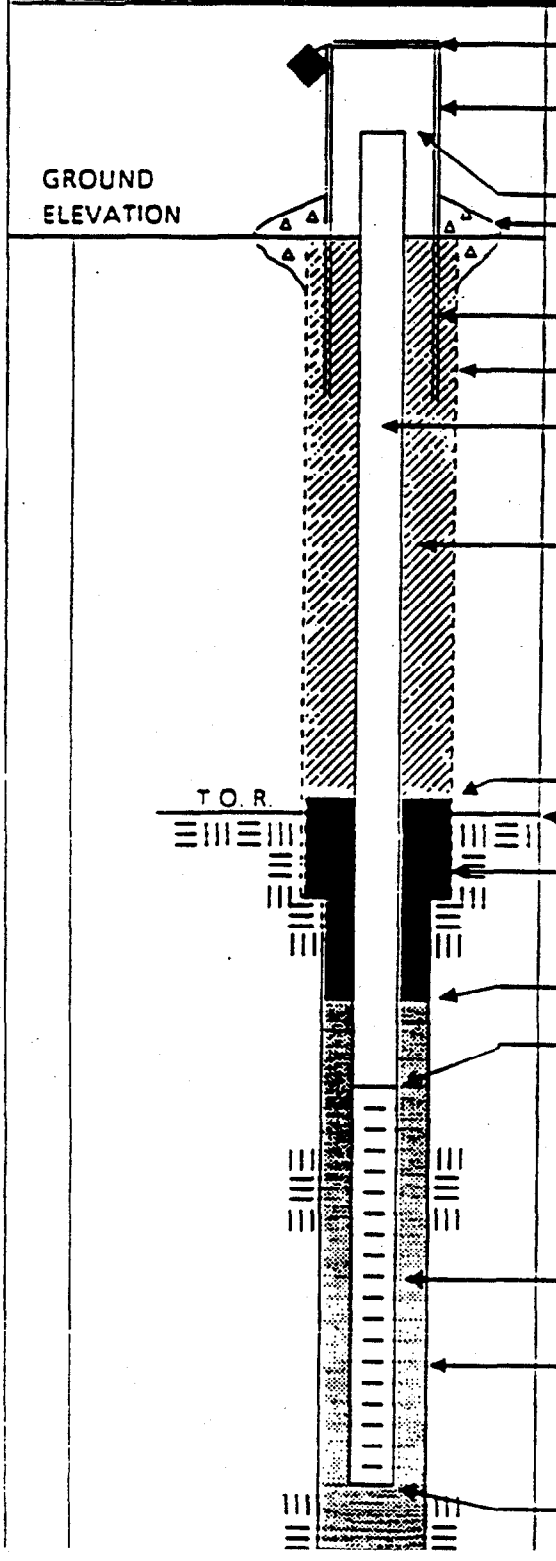
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-08S
DATE 12/8/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 8

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 24

ELEVATION / DEPTH TOP OF SCREEN: 29

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" X 15'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 44

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-01I

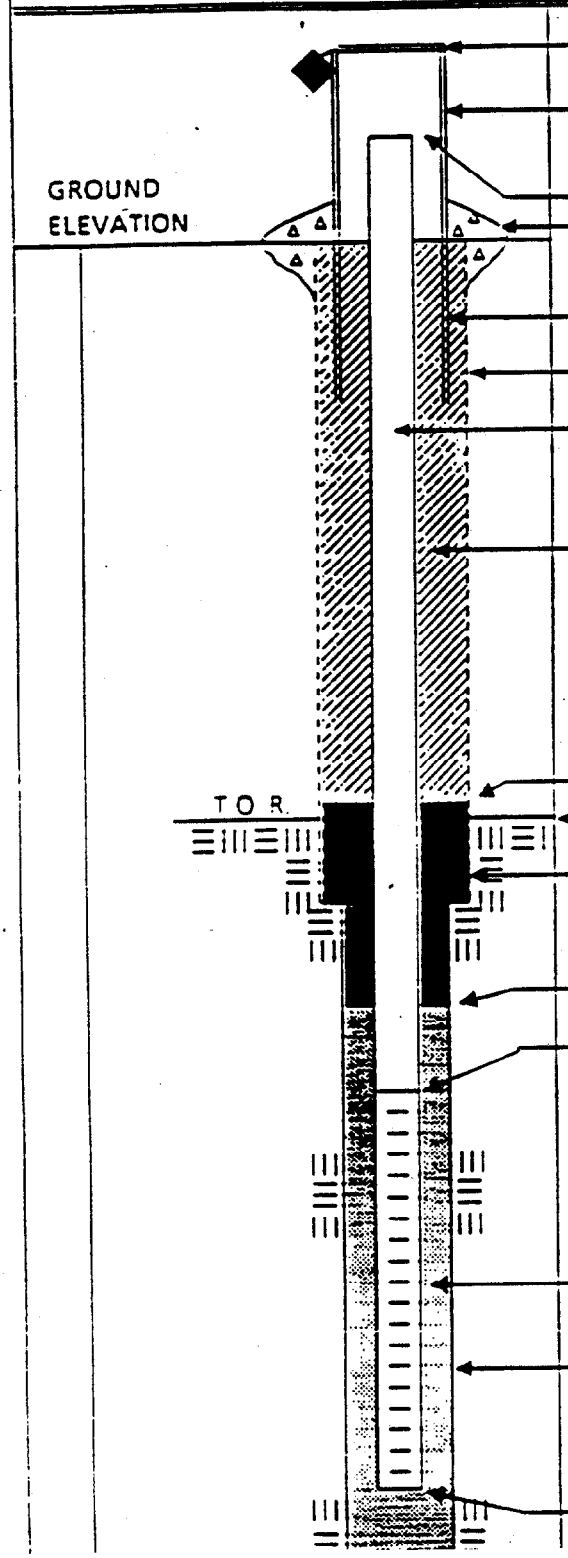
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-01I
DATE 12/10/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 7

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 68.5

ELEVATION / DEPTH TOP OF SCREEN: 74.5

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 15'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 89.5

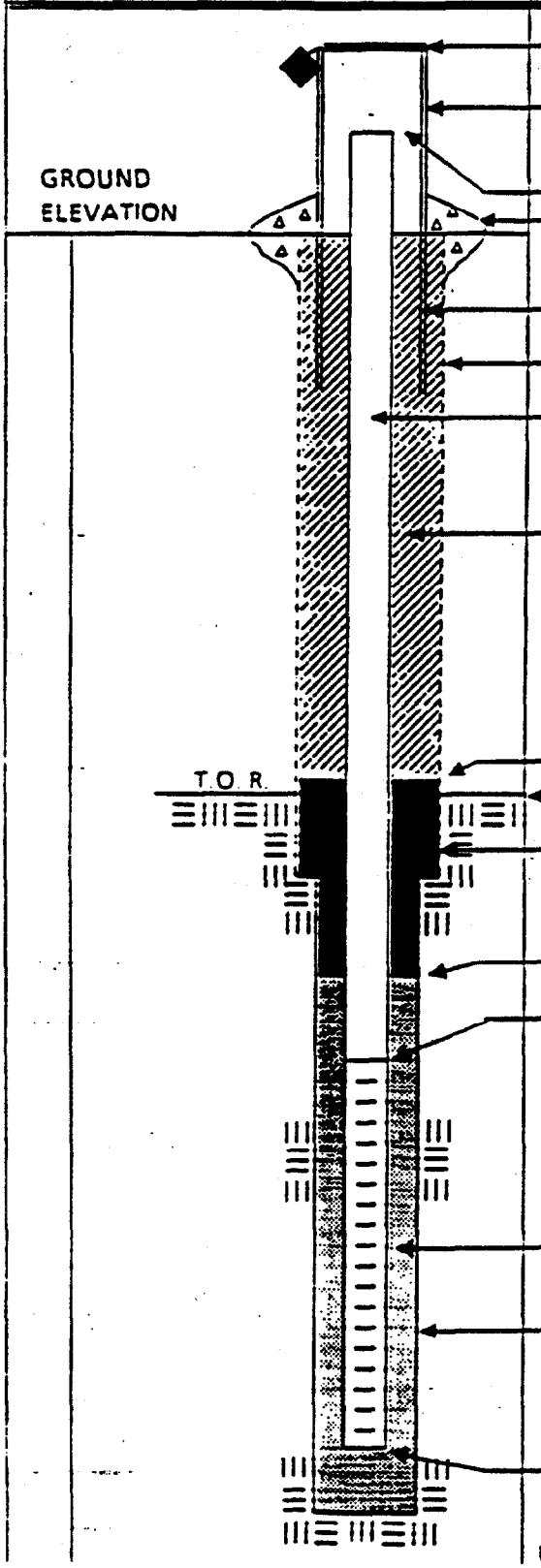
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-01D

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER LOCATION
PROJECT NO. BORING HN-01D
ELEVATION DATE 12/10/93
FIELD GEOLOGIST D. Whalen

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 7
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 108.5
ELEVATION / DEPTH TOP OF SCREEN: 113
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" X 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 123
ELEVATION / DEPTH BOTTOM OF HOLE: 154.5

BACKFILL w/ Bentonite TO 127'

NUS CORPORATION
A Halliburton Company

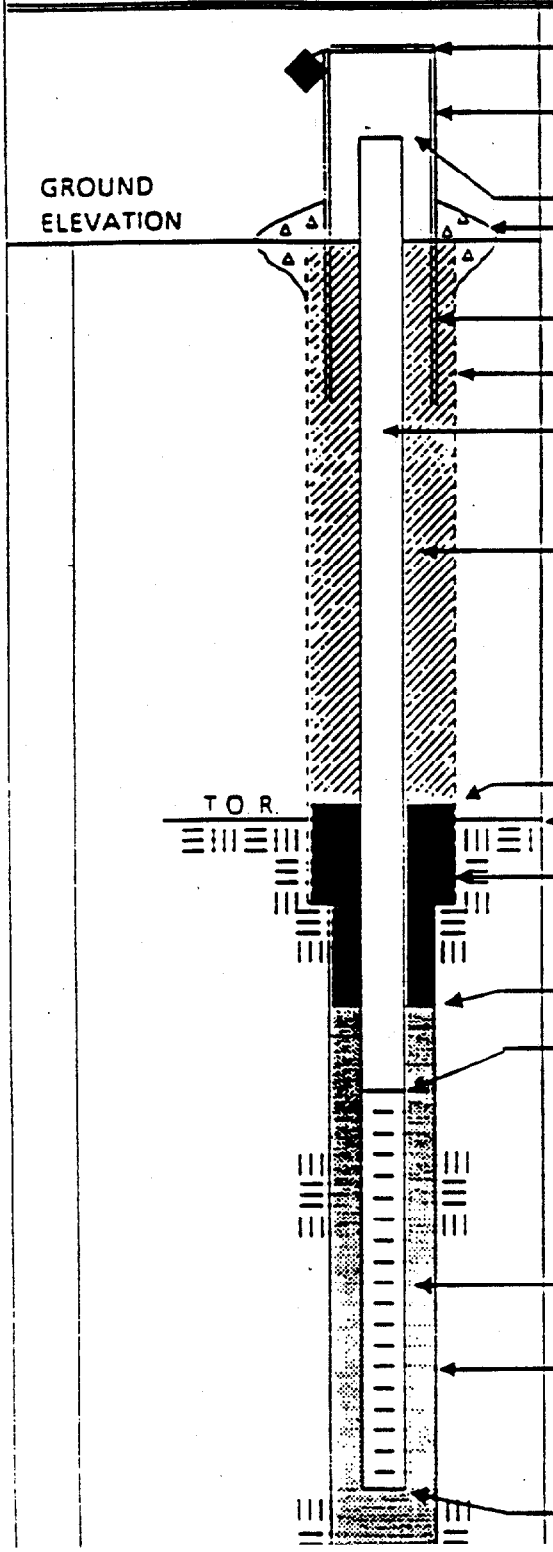
BORING NO.: HN-02I

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-02I
DATE 12/6/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 9
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 85
ELEVATION / DEPTH TOP OF SCREEN: 87
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 97

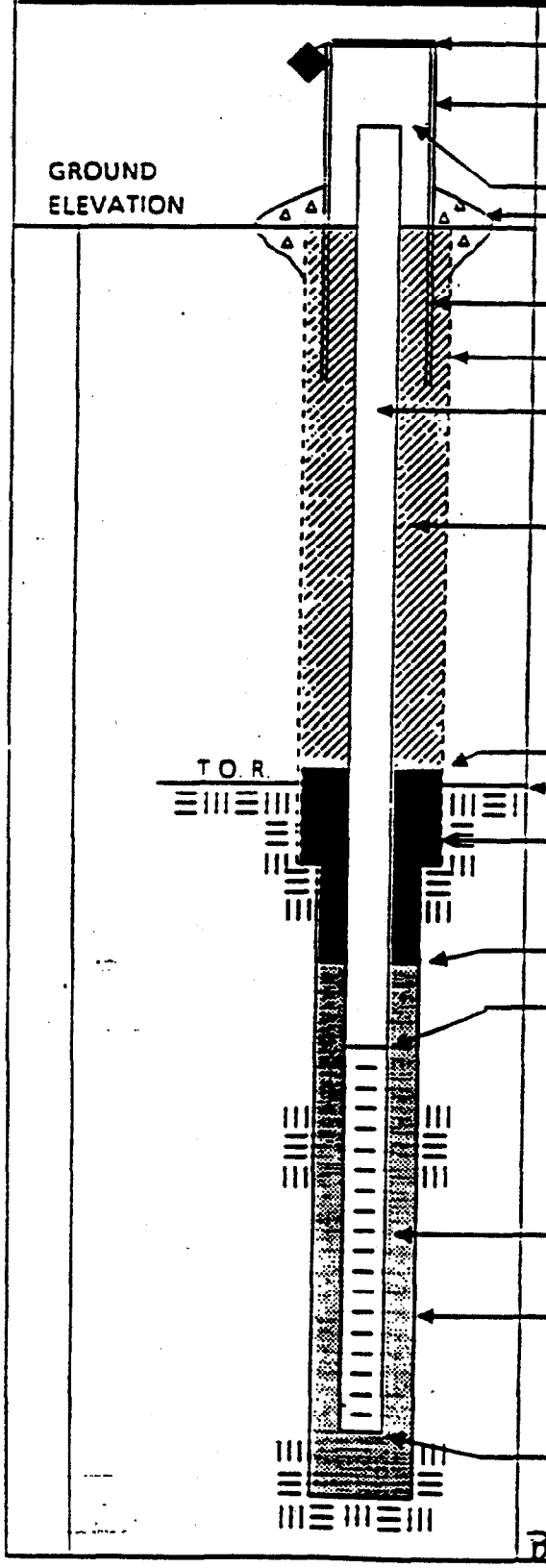
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-02D

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER LOCATION
PROJECT NO. BORING HN-02D
ELEVATION DATE 12/3/93
FIELD GEOLOGIST D. Whalen

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



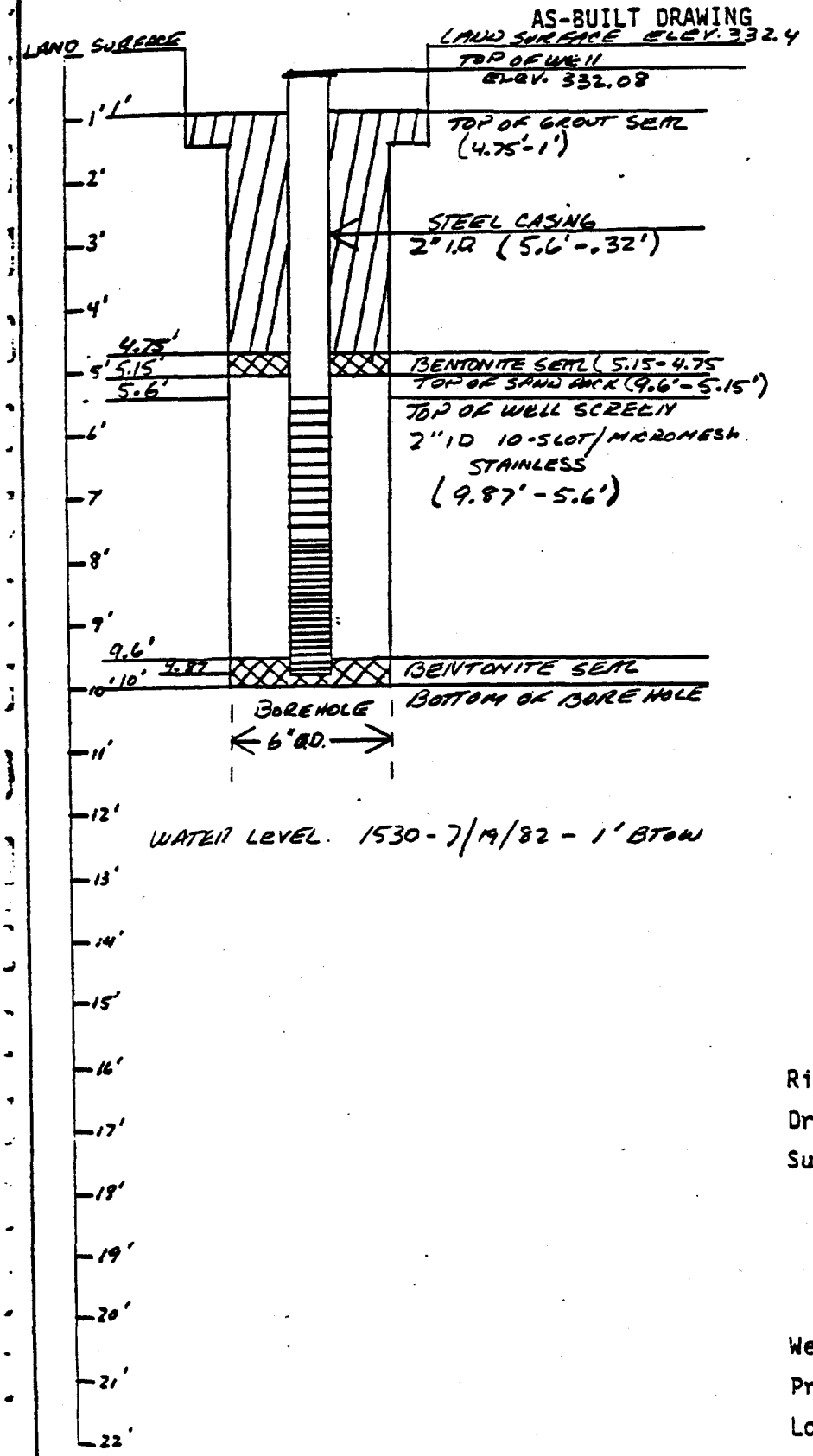
ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 9
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 116
ELEVATION / DEPTH TOP OF SCREEN: 123
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 133
ELEVATION / DEPTH BOTTOM OF HOLE: 153
BACKFill w/ bentonite TO 136'

AS-BUILT DRAWING



CHECKLIST

Land Surface Elevation 332.4

Casing Height Above L-S -.32'

Total Depth 10'

Borehole Diameter 6" O.D.

Casing Diameter 2" I.D.

~~Casing Thickness~~

Casing Lengths 5.28'

Screen Data

- Material STAINLESS
- Diameter 2" I.D.
- Slot Openings 10 SLOT/MM
- Settings 9.87-5.6.

~~Centralizers~~

Grout Type PORTLAND

Gravel Pack SILICA.

~~K-Fittings~~

~~Packers~~

~~Cement Baskets~~

Rig Type MOBILE B-56

Driller LARRY CISLER - SCI

Supervisory Geologist ED TOKARSKI - JRB

Well No. DG-8 (HN-03X)

Project NADC-WARMINSTER, PA

Location ACROSS FROM HOUSING SOUTH OF BAMFIELD + N. OF DRAINAGE DITCH DOWN GRAD #5

Date Drilled 7/19/82

Prepared By: ED TOKARSKI 10/6/82

Scale: AS SHOWN

NUS CORPORATION
A Halliburton Company

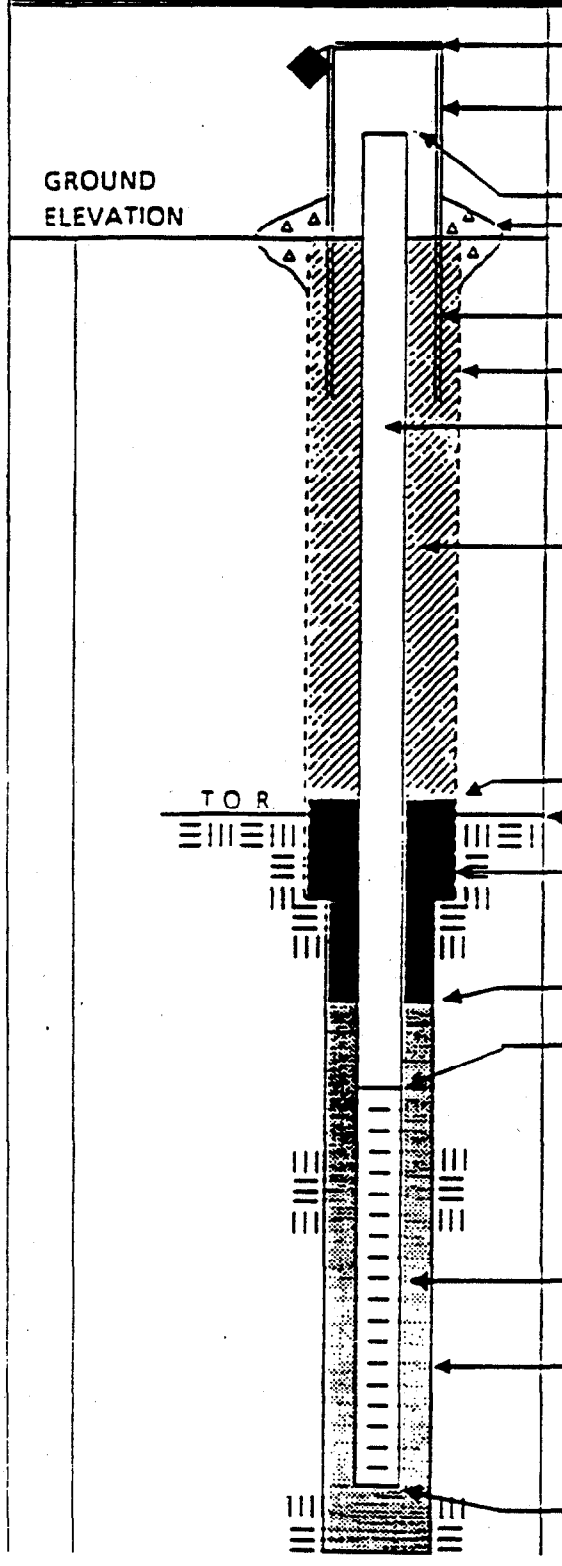
BORING NO.: HN-03I

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-03I
DATE 12/27/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite
ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 3
TYPE OF SEAL: Bentonite
ELEVATION / DEPTH TOP OF SAND: 81
ELEVATION / DEPTH TOP OF SCREEN: 85
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" X 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: NO. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 95

NUS CORPORATION
A Halliburton Company

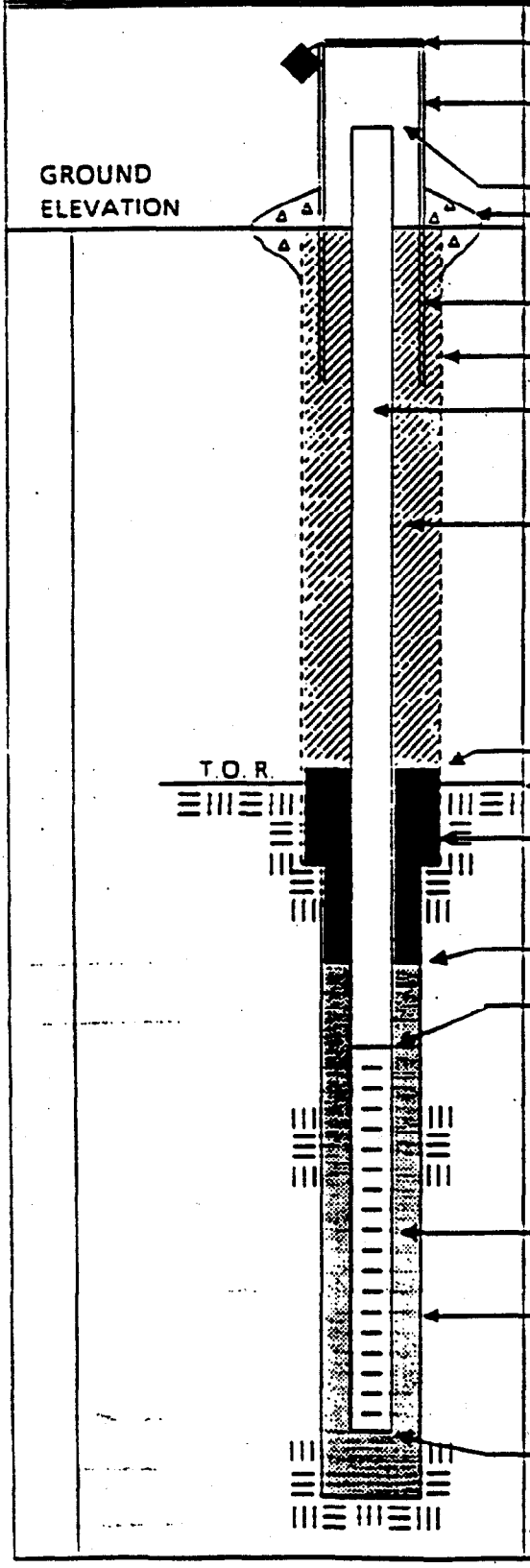
BORING NO.: HN-03D

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER LOCATION
PROJECT NO. BORING HN-03D
ELEVATION DATE 12/27/93
FIELD GEOLOGIST D. Whalen

DRILLER RAAB
DRILLING METHOD Air Hammer
DEVELOPMENT METHOD Sub. Pump



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 3
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 115
ELEVATION / DEPTH TOP OF SCREEN: 130
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 5'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie Equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 135
ELEVATION / DEPTH BOTTOM OF HOLE: 162

Backfill w/ bentonite to 140'

NUS CORPORATION
A Halliburton Company

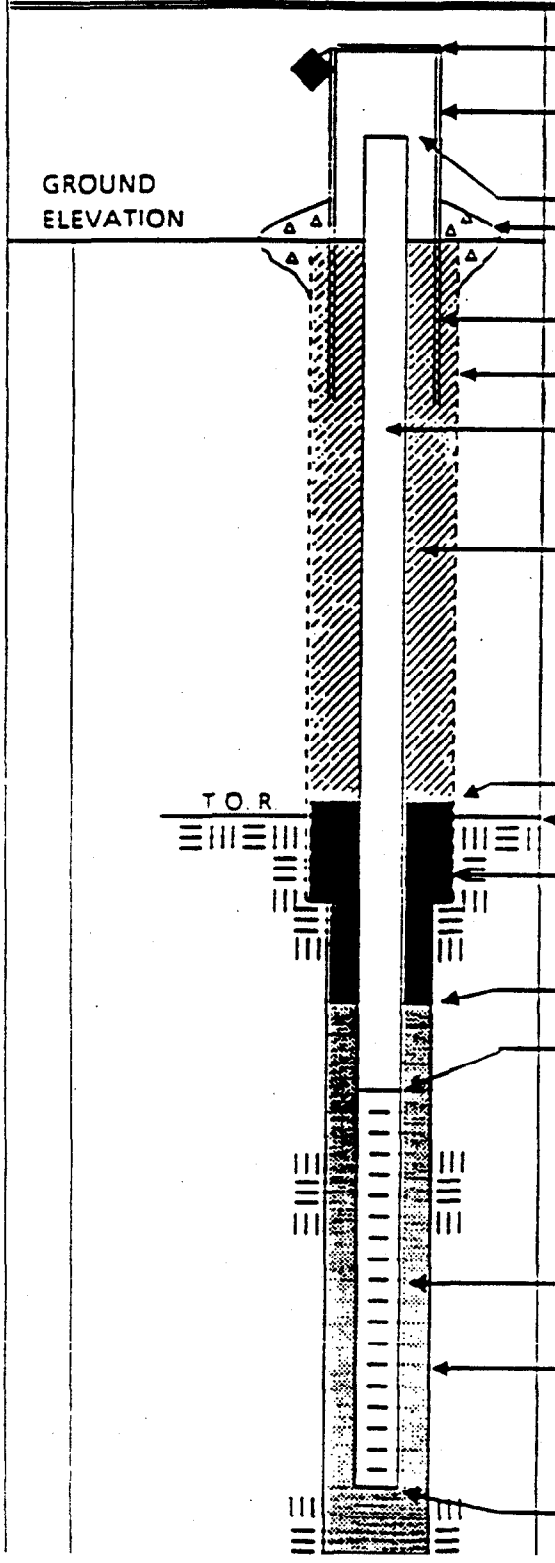
BORING NO.: HN-04 S

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-04 S
DATE 12/17/93

DRILLER RAAB
DRILLING METHOD Air Rotary
DEVELOPMENT METHOD Sub. Pump



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 6

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 20

ELEVATION / DEPTH TOP OF SCREEN: 25

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 10'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 35

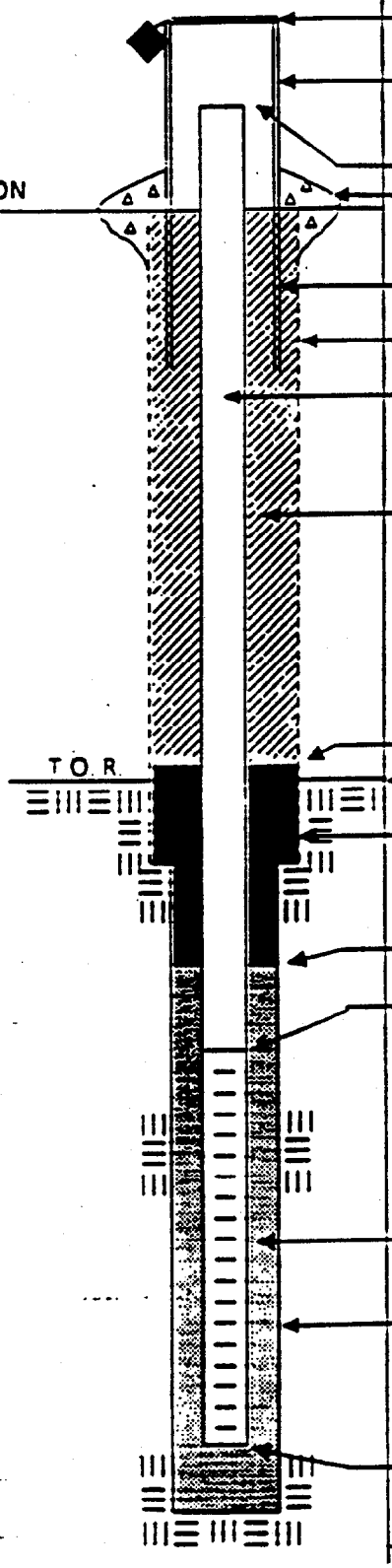
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-04I

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-04I
DATE 12/22/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 6
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 55
ELEVATION / DEPTH TOP OF SCREEN: 60
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 70
ELEVATION / DEPTH BOTTOM OF HOLE: 104
Backfill w/ bentonite to 72

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-04 D

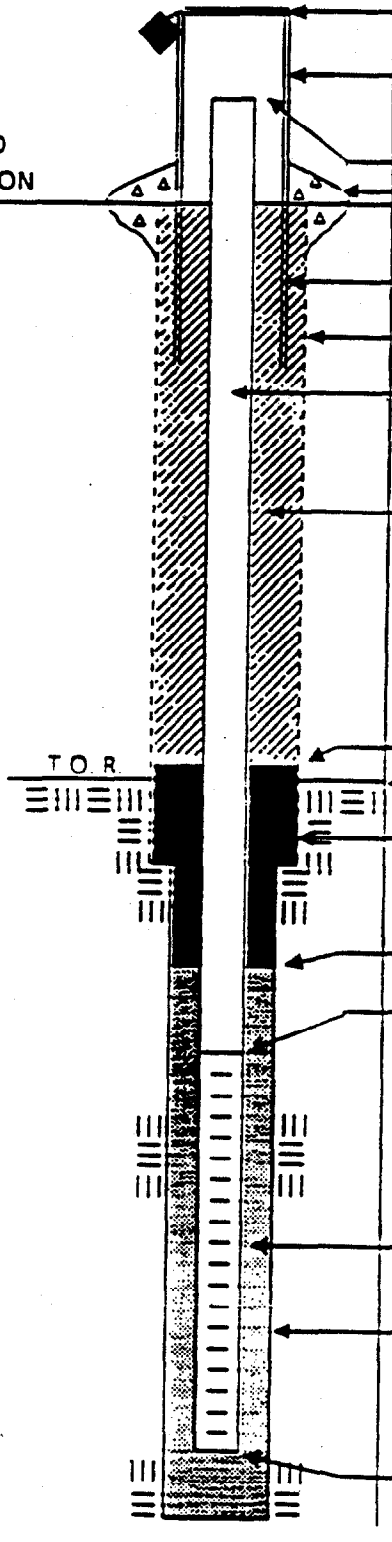
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-04 D
DATE 12/17/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 6

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 105

ELEVATION / DEPTH TOP OF SCREEN: 108

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" X 10'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 118

179

BORING NO.: HN-05S

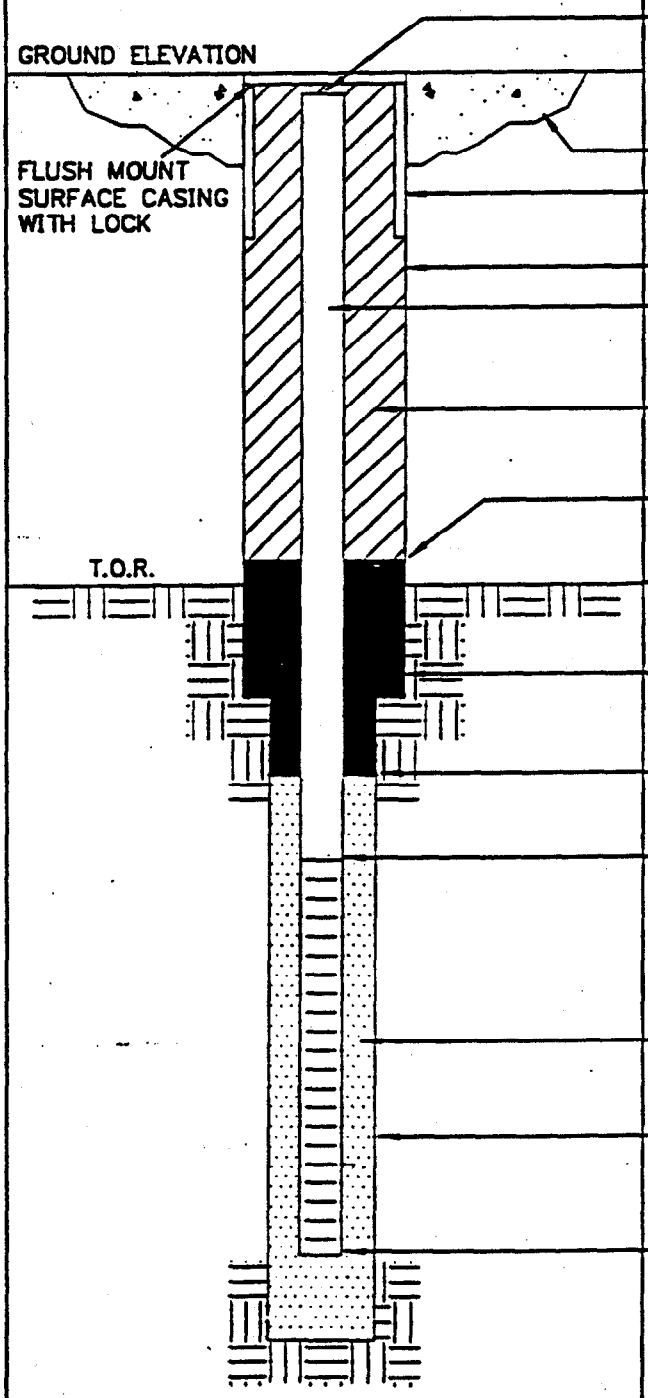
Halliburton NUS CORPORATION

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: NAWC WARMINSTER
PROJECT NO.:
ELEVATION:
FIELD GEOLOGIST: D. UGHALEN

LOCATION:
BORING: HN-05S
DATE: 12/7/93

DRILLER: RAAB
DRILLING METHOD: AIR ROTARY
DEVELOPMENT METHOD: SUB. PUMP



ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement

TYPE OF PROTECTIVE CASING: Steel

I.D. OF PROTECTIVE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: SCHED 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION/DEPTH TOP OF SEAL:

ELEVATION/DEPTH TOP OF BEDROCK: 7

TYPE OF SEAL: Bentonite

ELEVATION/DEPTH TOP OF SAND: 36

ELEVATION/DEPTH TOP OF SCREEN: 41

TYPE OF SCREEN: SCHED 40 PVC

SLOT SIZE x LENGTH: 0.020" X 10'

I.D. SCREEN: 4"

TYPE OF SAND PACK: NO. 2 MORIE EQUIV.

DIAMETER OF HOLE IN BEDROCK: 8"

ELEVATION/DEPTH BOTTOM SCREEN: 51

ELEVATION/DEPTH BOTTOM HOLE: 55

Halliburton NUS CORPORATION

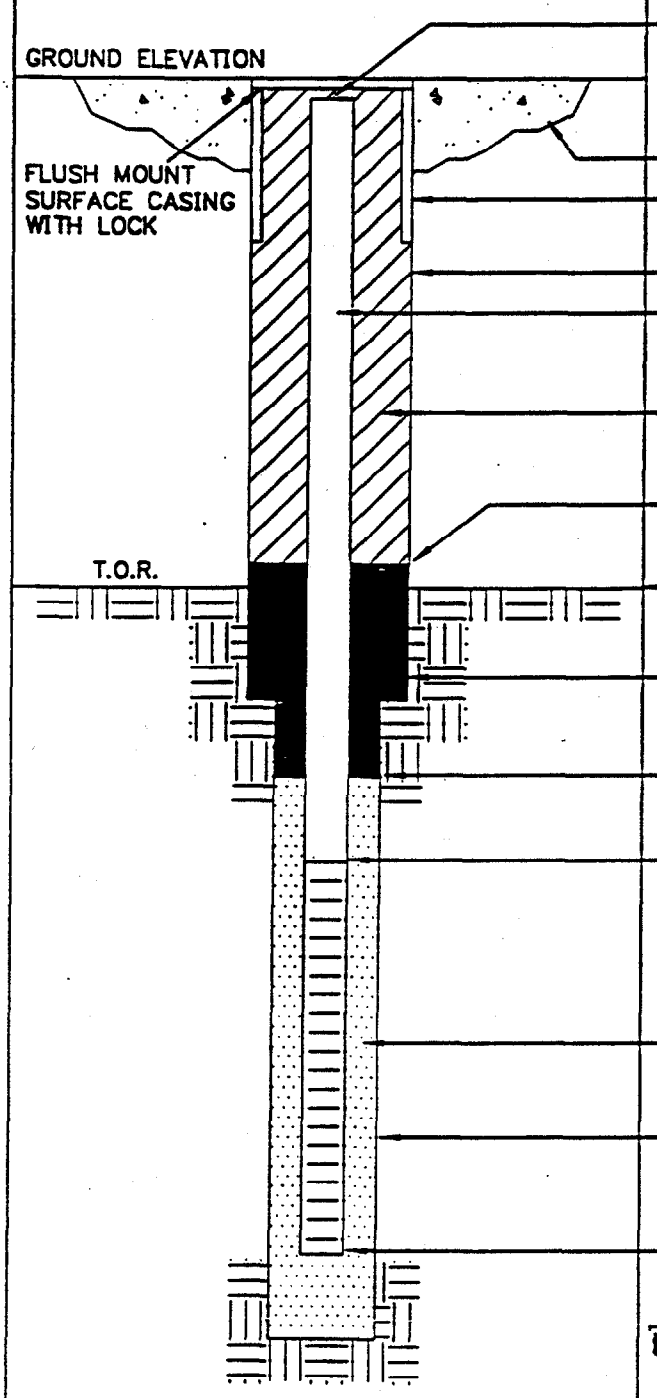
BORING NO.: HN-05I

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-05 I
DATE 12/8/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement

TYPE OF PROTECTIVE CASING: STEEL
I.D. OF PROTECTIVE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: SCHED 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION/DEPTH TOP OF SEAL:

ELEVATION/DEPTH TOP OF BEDROCK: 7

TYPE OF SEAL: Bentonite

ELEVATION/DEPTH TOP OF SAND: 70

ELEVATION/DEPTH TOP OF SCREEN 74
TYPE OF SCREEN: SCHED 40 PVC
SLOT SIZE x LENGTH: 0.020" X 10'
I.D. SCREEN: 4"

TYPE OF SAND PACK: NO. 2 MORIE EQUIV.

DIAMETER OF HOLE IN BEDROCK: 8"

ELEVATION/DEPTH BOTTOM SCREEN: 84
ELEVATION/DEPTH BOTTOM HOLE: 154

Backfill w/ bentonite TO 88'

ACAD: C..EFF.DWG 06/14/94 TD

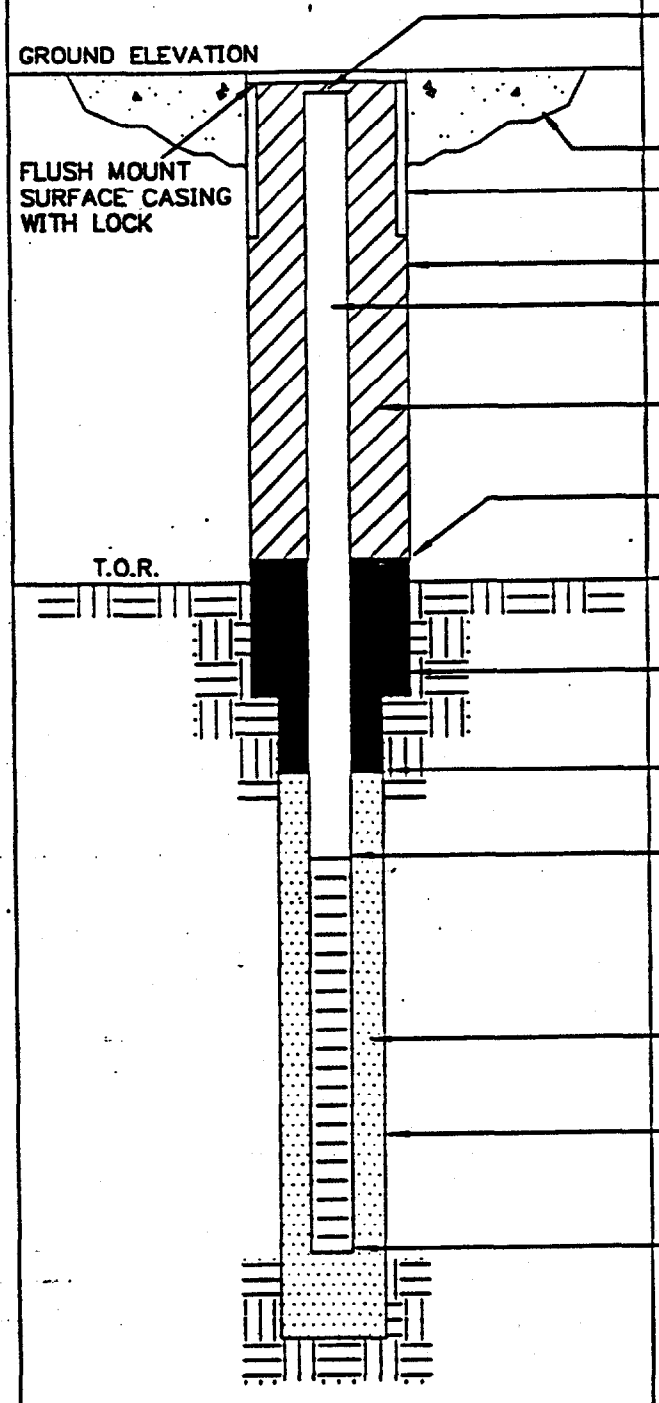
Halliburton NUS CORPORATION

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. WHALEN

LOCATION
BORING AN-05D
DATE 12/7/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement

TYPE OF PROTECTIVE CASING: Steel

I.D. OF PROTECTIVE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION/DEPTH TOP OF SEAL:

ELEVATION/DEPTH TOP OF BEDROCK: 7

TYPE OF SEAL: Bentonite

ELEVATION/DEPTH TOP OF SAND: 180

ELEVATION/DEPTH TOP OF SCREEN: 183

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" X 15'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie Equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

ELEVATION/DEPTH BOTTOM SCREEN: 198

ELEVATION/DEPTH BOTTOM HOLE: 204

ACAD: C:JEFF.DWG 06/14/94 TD

NUS CORPORATION
A Halliburton Company

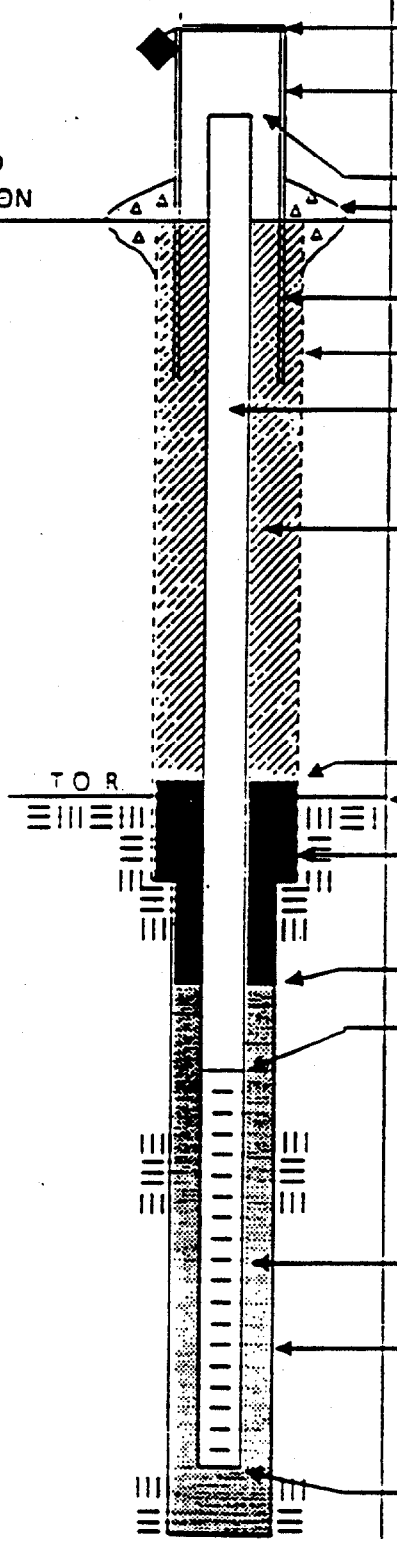
BORING NO.: HN-06S

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-06S
DATE 12/9/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB. PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 8

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 30

ELEVATION / DEPTH TOP OF SCREEN: 36

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 15'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie Equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 51

53

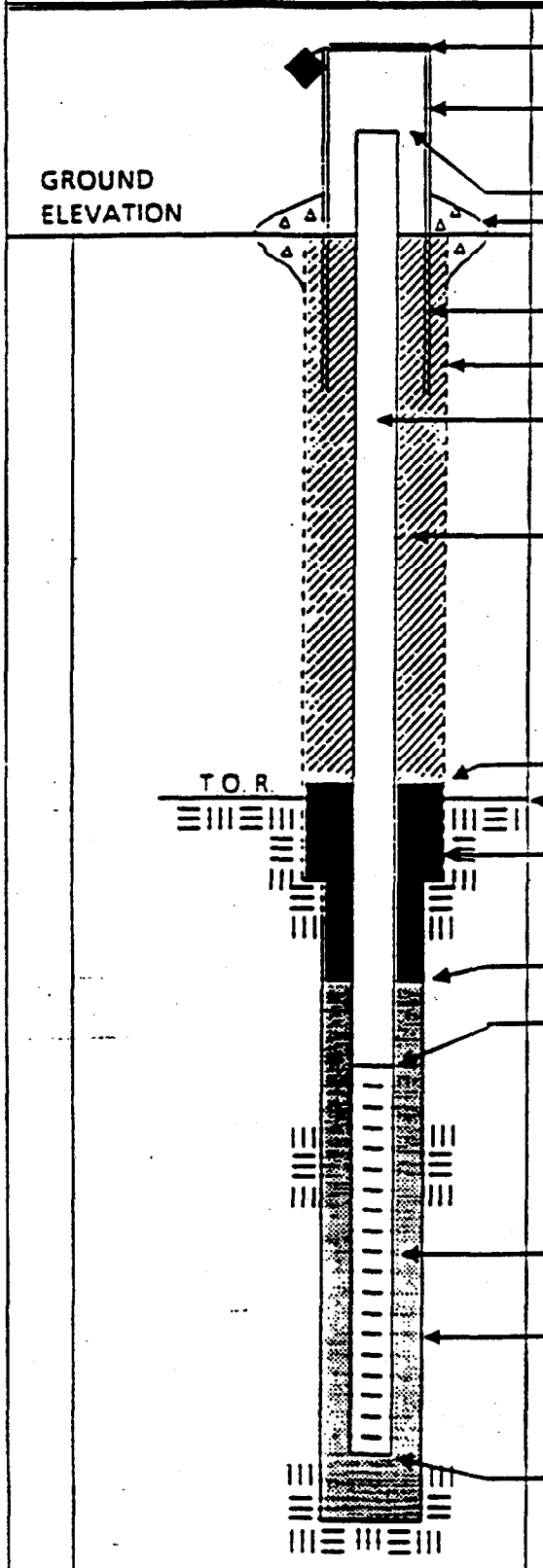
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-06I

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAUX Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-06I
DATE 12/9/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 8
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 80
ELEVATION / DEPTH TOP OF SCREEN: 85
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 15'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 100
ELEVATION / DEPTH BOTTOM OF HOLE: 103

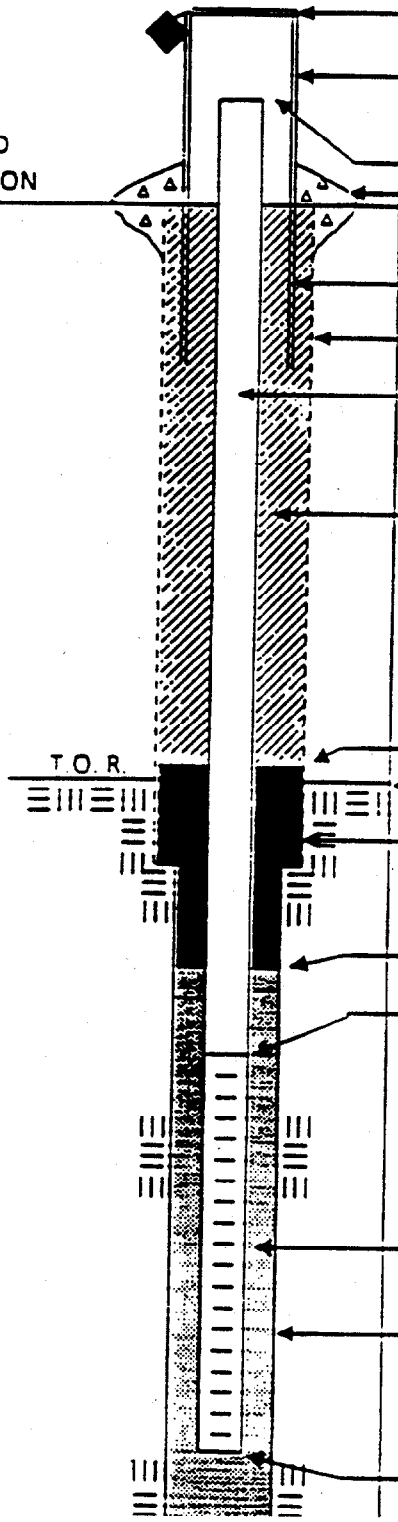
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-06D

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-06D
DATE 12/13/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 8
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 134
ELEVATION / DEPTH TOP OF SCREEN: 136
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 15'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 151

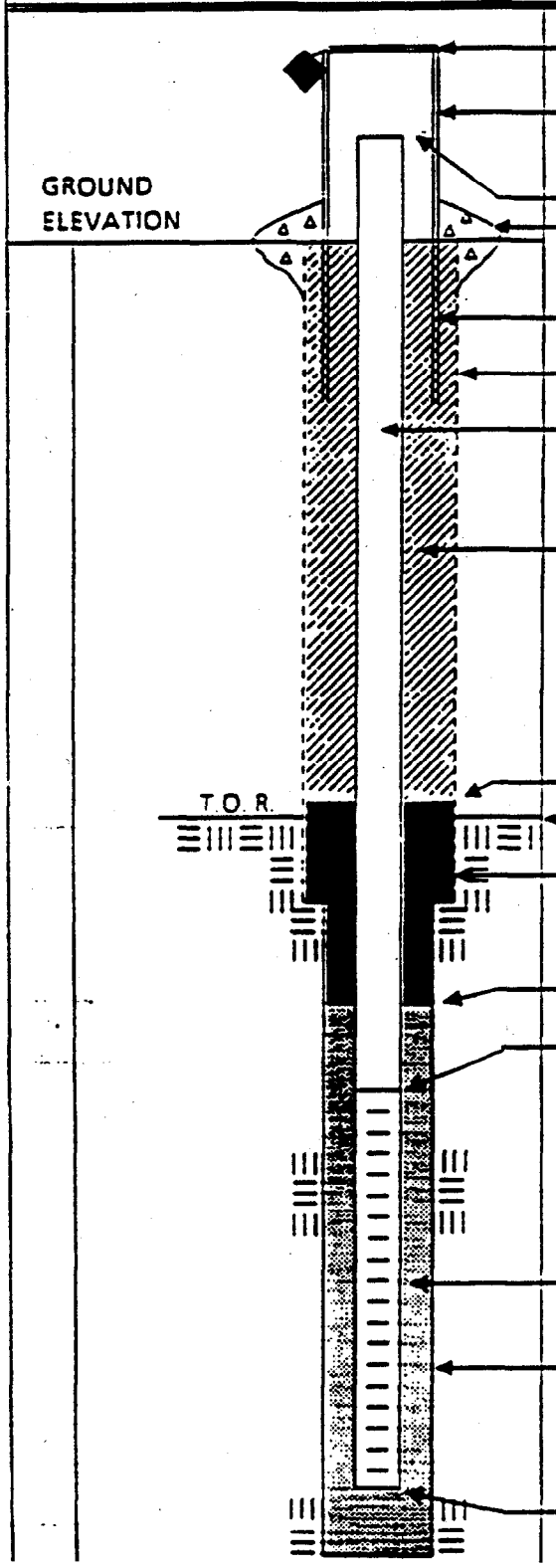
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-07S

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: NAWC Warminster
PROJECT NO.:
ELEVATION:
FIELD GEOLOGIST: D. Whalen
LOCATION:
BORING: HN-07S
DATE: 12/9/93

DRILLER: RAAB
DRILLING METHOD: AIR ROTARY
DEVELOPMENT METHOD: SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 5

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 29

ELEVATION / DEPTH TOP OF SCREEN: 35

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 10'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 45

ELEVATION / DEPTH BOTTOM OF HOLE: 45

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-07I

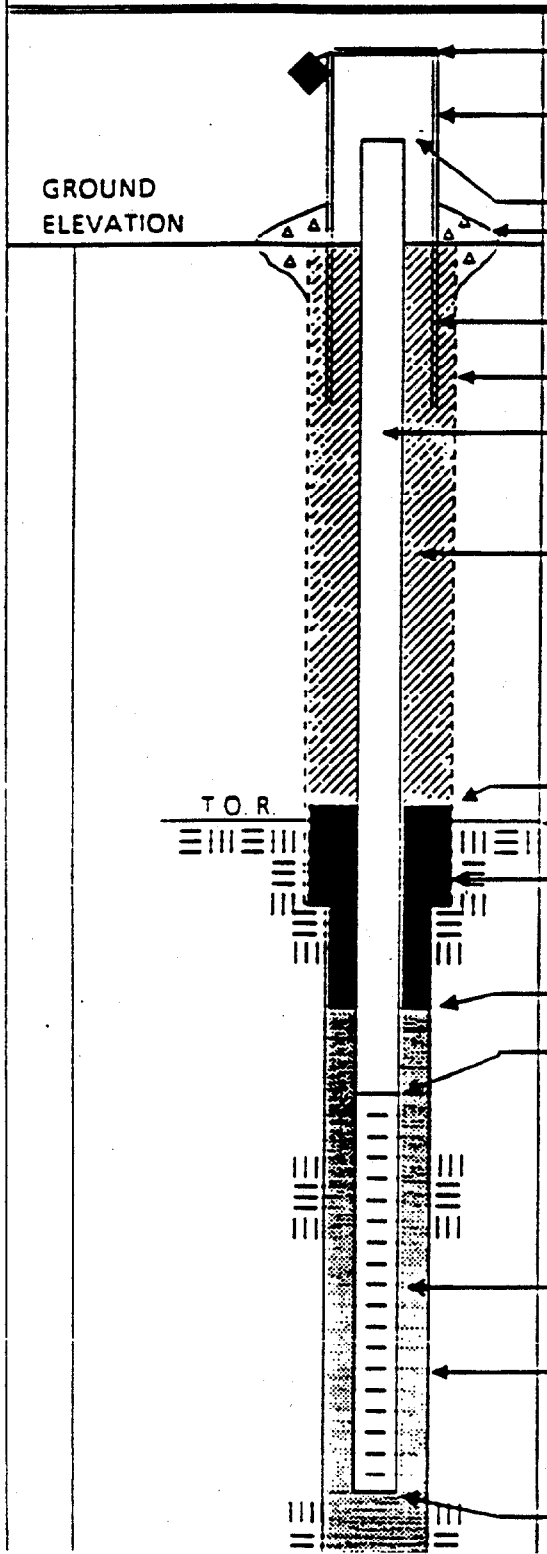
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT: NAWC Warminster
PROJECT NO.:
ELEVATION:
FIELD GEOLOGIST: D. Whalen

LOCATION:
BORING: HN-07I
DATE: 12/9/93

DRILLER: RAAB
DRILLING METHOD: AIR ROTARY
DEVELOPMENT METHOD: SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 5

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 64

ELEVATION / DEPTH TOP OF SCREEN: 69

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 10'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 79

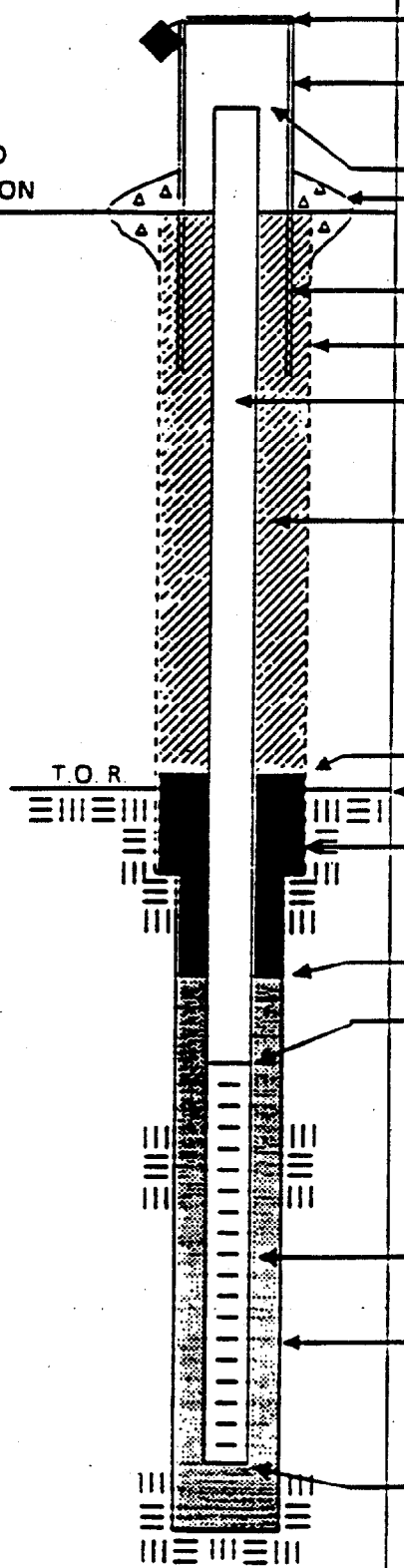
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-07D

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-07D
DATE 3/23/94

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite
ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 5
TYPE OF SEAL: Bentonite
ELEVATION / DEPTH TOP OF SAND: 144
ELEVATION / DEPTH TOP OF SCREEN: 149
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" X 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: NO. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 159
ELEVATION / DEPTH BOTTOM OF HOLE: 204
Backfill w/ bentonite to 165'

NUS CORPORATION
A Halliburton Company

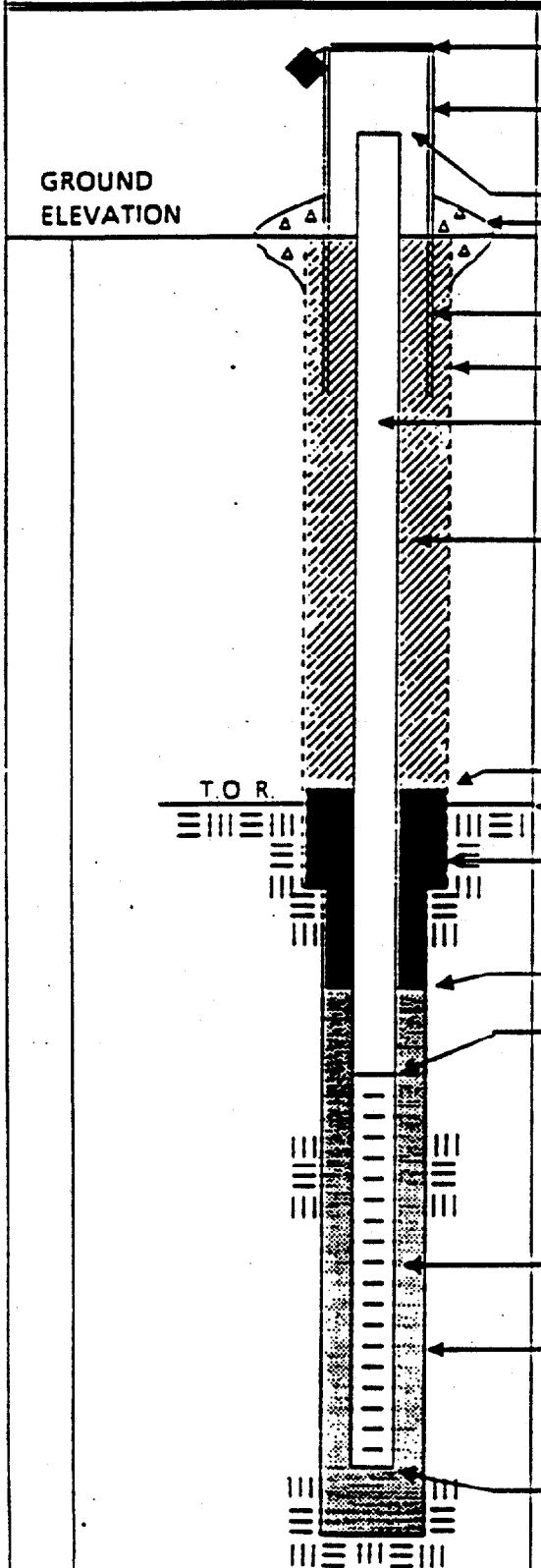
BORING NO.: HN-08I

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-08I
DATE 12/8/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 8
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 60
ELEVATION / DEPTH TOP OF SCREEN: 65
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 75
ELEVATION / DEPTH BOTTOM OF HOLE: 78

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-08D

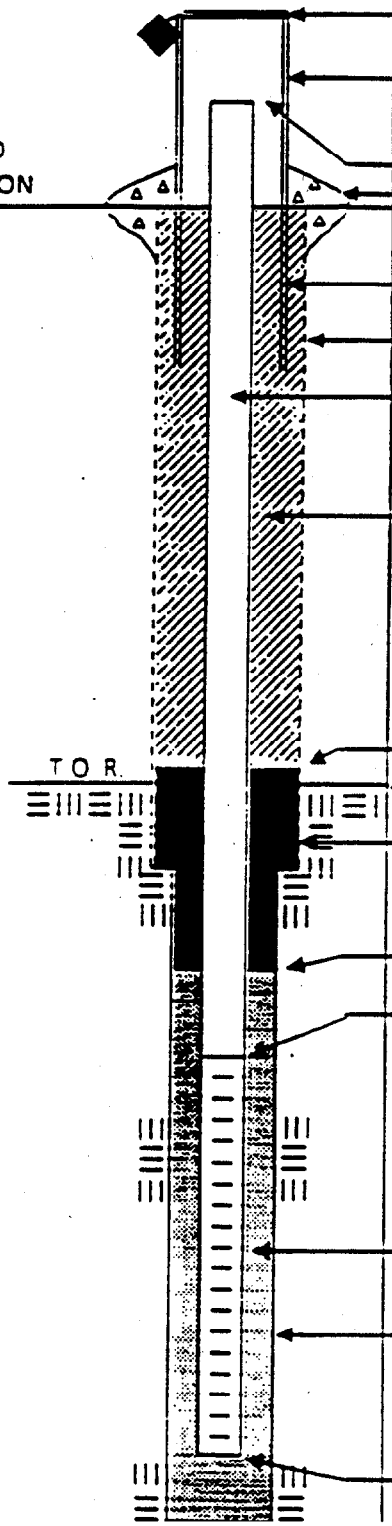
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-08D
DATE 12/16/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 8

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 157

ELEVATION / DEPTH TOP OF SCREEN: 162

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 15'

I.D. SCREEN: 4"

TYPE OF SAND PACK: NO. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 177

NUS CORPORATION
A Halliburton Company

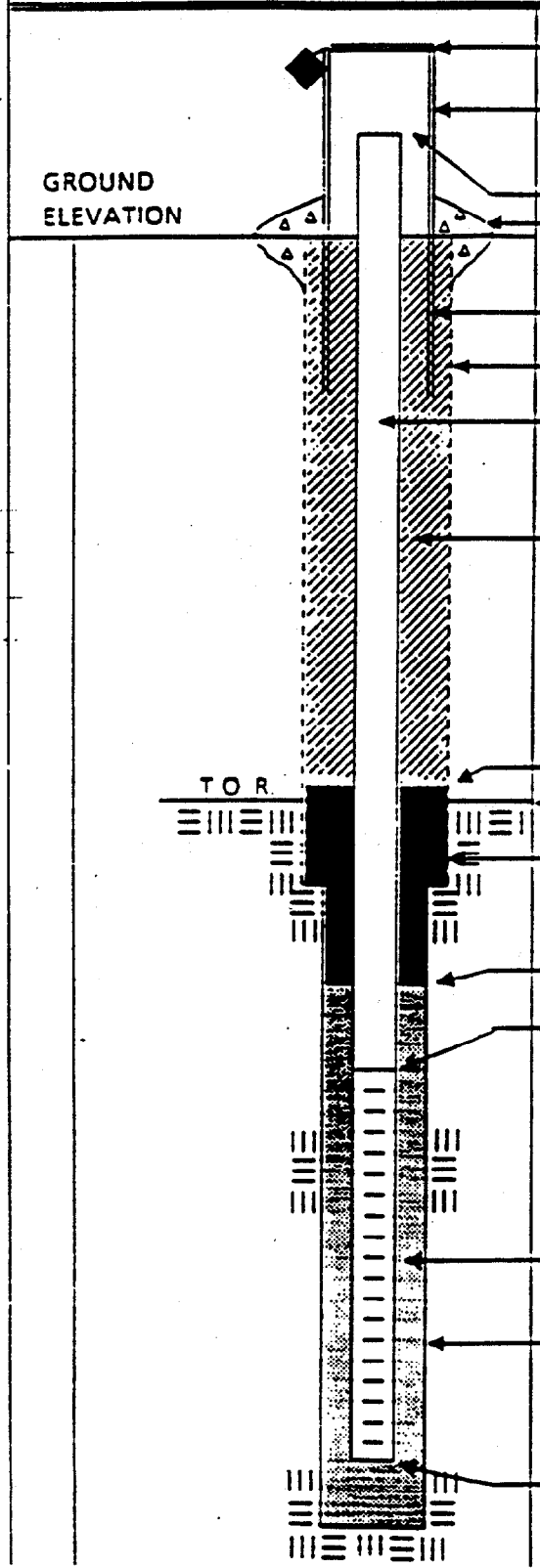
BORING NO.: HN-09 S

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-09 S
DATE 12/22/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: SCHED 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 8

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 29

ELEVATION / DEPTH TOP OF SCREEN: 36

TYPE OF SCREEN: SCHED 40 PVC

SLOT SIZE x LENGTH: 0.020" X 15'

I.D. SCREEN: 4"

TYPE OF SAND PACK: NO. 2 MORIE equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 51

ELEVATION / DEPTH BOTTOM OF HOLE: 52

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-09I

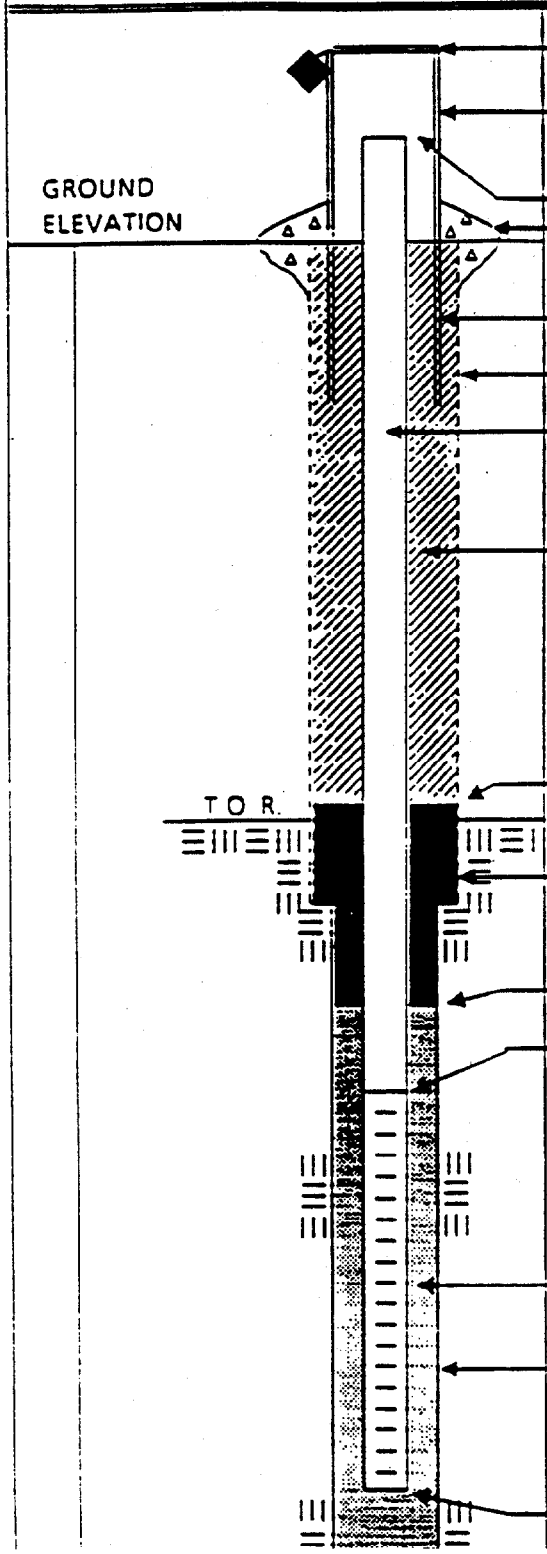
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-09I
DATE 12/22/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: SCHED 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 8

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 75

ELEVATION / DEPTH TOP OF SCREEN: 80

TYPE OF SCREEN: SCHED 40 PVC

SLOT SIZE x LENGTH: 0.020" x 15'

I.D. SCREEN: 4"

TYPE OF SAND PACK: NO. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 95

NUS CORPORATION
A Halliburton Company

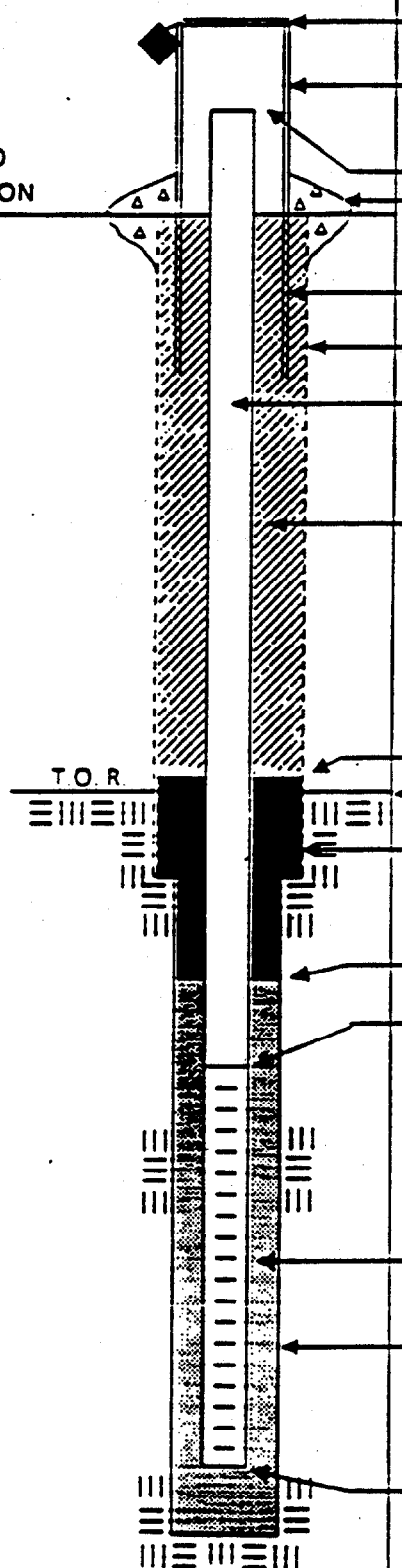
BORING NO.: HN-09D

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-09D
DATE 12/14/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 8
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 138
ELEVATION / DEPTH TOP OF SCREEN: 143
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 15'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 158
ELEVATION / DEPTH BOTTOM OF HOLE: 202
BACKfill w/ Bentonite to 161'

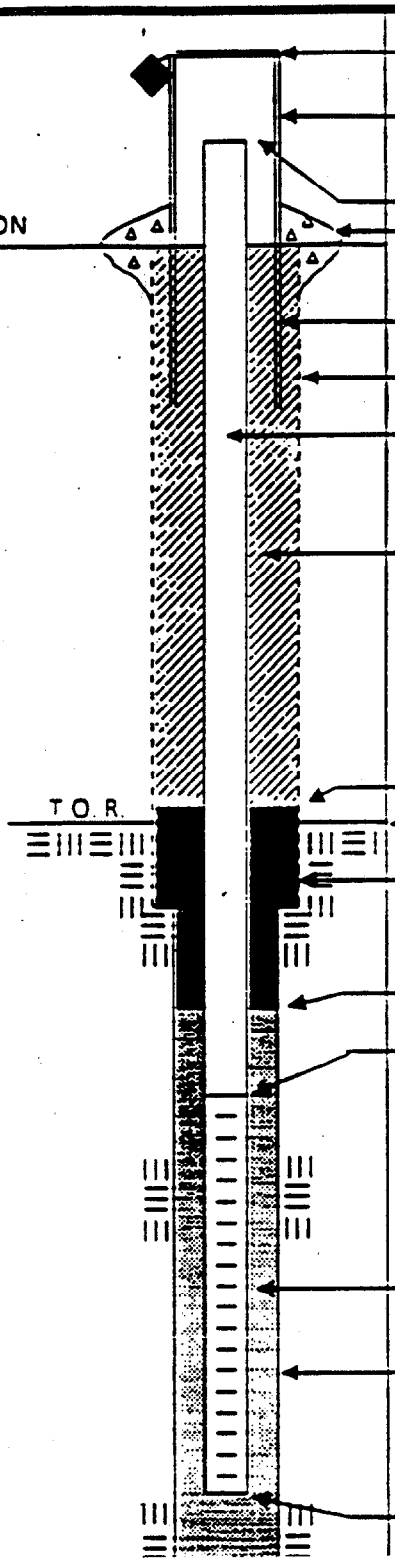
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-10S

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: NAWC WARMINSTER
PROJECT NO.:
ELEVATION:
FIELD GEOLOGIST: D. Whalen
LOCATION:
BORING: HN-10S
DATE: 12/20/93

DRILLER: RAAB
DRILLING METHOD: AIR ROTARY
DEVELOPMENT METHOD: SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 6
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 26
ELEVATION / DEPTH TOP OF SCREEN: 28
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" X 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 38

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-10I

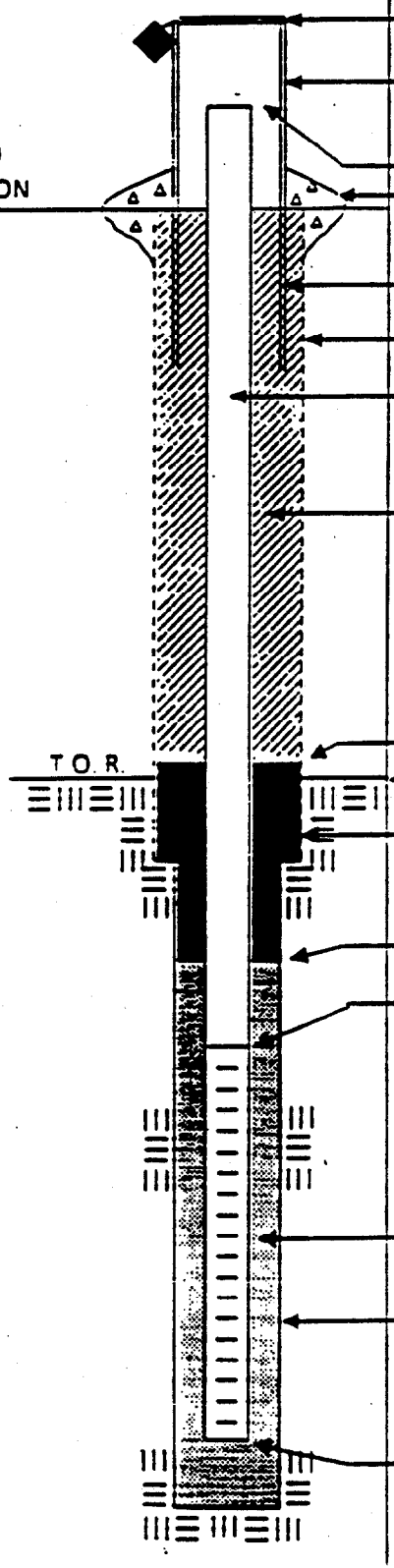
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-10I
DATE 12/20/93

DRILLER RAAB
DRILLING METHOD Air Rotary
DEVELOPMENT METHOD Sub Pump



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement Grout

I.D. OF SURFACE CASING: 8"

DIAMETER OF HOLE: 12"

RISER PIPE I.D.: 4"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 16

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 80

ELEVATION / DEPTH TOP OF SCREEN: 82

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 15'

I.D. SCREEN: 4"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 8"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 97

ELEVATION / DEPTH BOTTOM OF HOLE: 112

Backfill w/ bentonite to 101'

NUS CORPORATION
A Halliburton Company

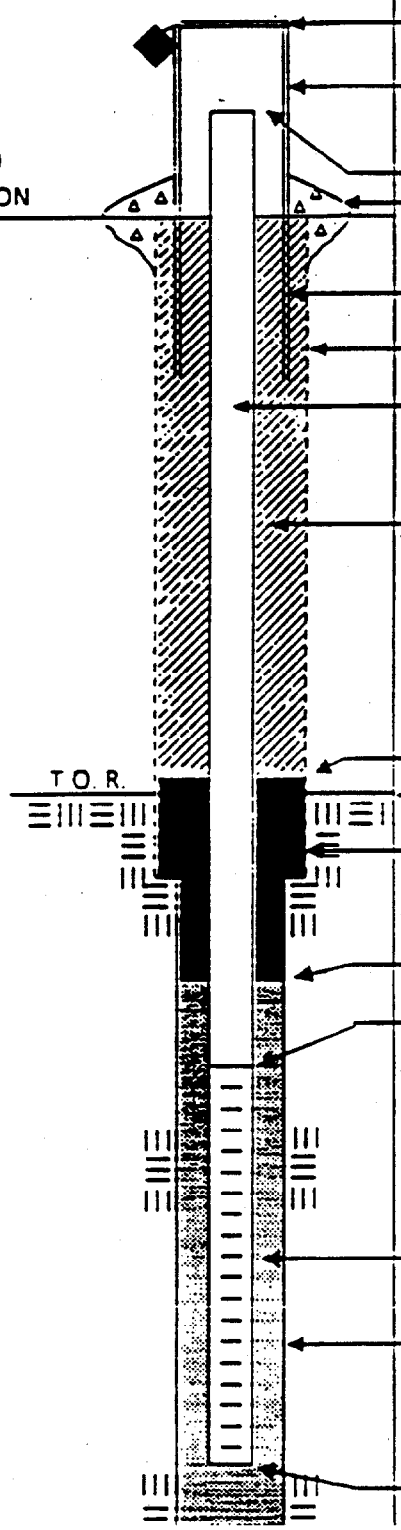
BORING NO.: HN-10D

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-10D
DATE 12/20/93

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Cement Grout
I.D. OF SURFACE CASING: 8"
DIAMETER OF HOLE: 12"
RISER PIPE I.D.: 4"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 6
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 225
ELEVATION / DEPTH TOP OF SCREEN: 229
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 4"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 8"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 239

Halliburton NUS CORPORATION

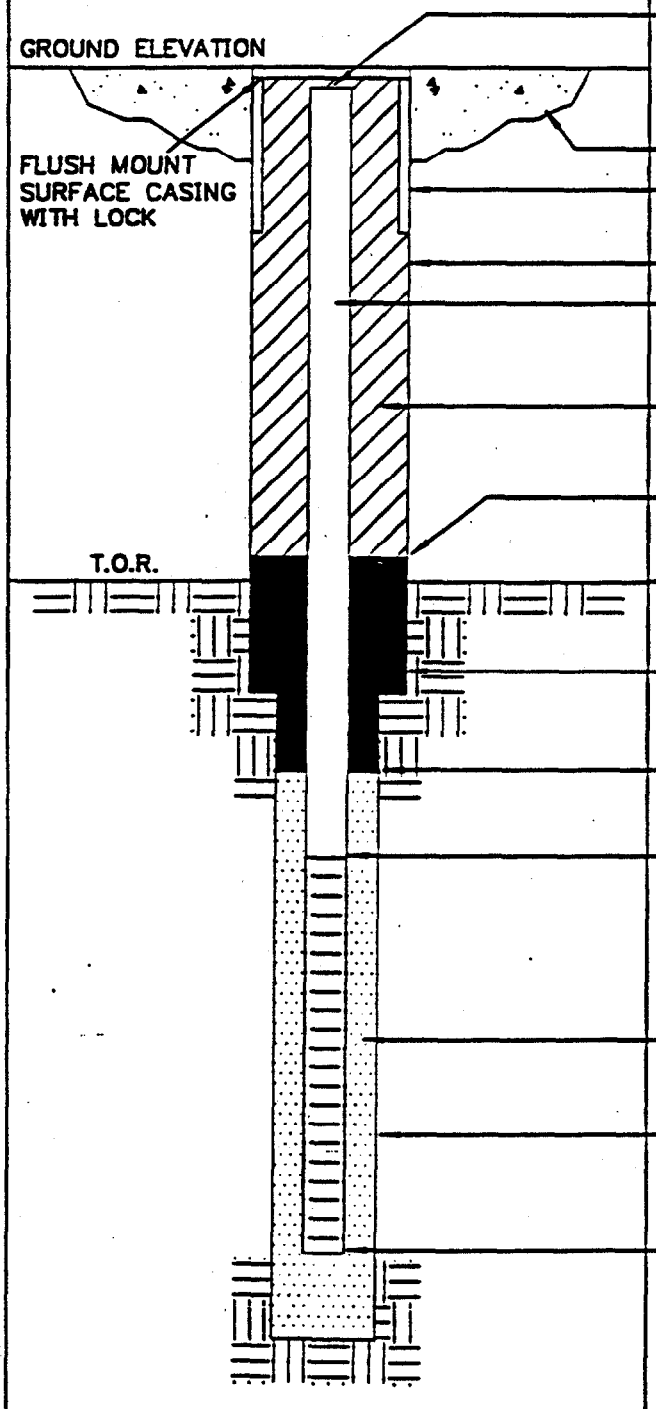
BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

BORING NO.: HN-35S
HN 35S & I constructed in same borehole

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-35S
DATE

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement

TYPE OF PROTECTIVE CASING: Steel
I.D. OF PROTECTIVE CASING: 6"

DIAMETER OF HOLE: 10"

RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION/DEPTH TOP OF SEAL:

ELEVATION/DEPTH TOP OF BEDROCK: 7

TYPE OF SEAL: Bentonite

ELEVATION/DEPTH TOP OF SAND: 35

ELEVATION/DEPTH TOP OF SCREEN 38
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" X 10'
I.D. SCREEN: 2"

TYPE OF SAND PACK: Pea Gravel

DIAMETER OF HOLE IN BEDROCK: 6"

ELEVATION/DEPTH BOTTOM SCREEN: 48
ELEVATION/DEPTH BOTTOM HOLE: 106

Sand pack extends to 52'
Bentonite seal to 87'
HN-35I constructed below.

ACAD. C:JEFF.DWG 06/14/94 TD

Halliburton NUS CORPORATION

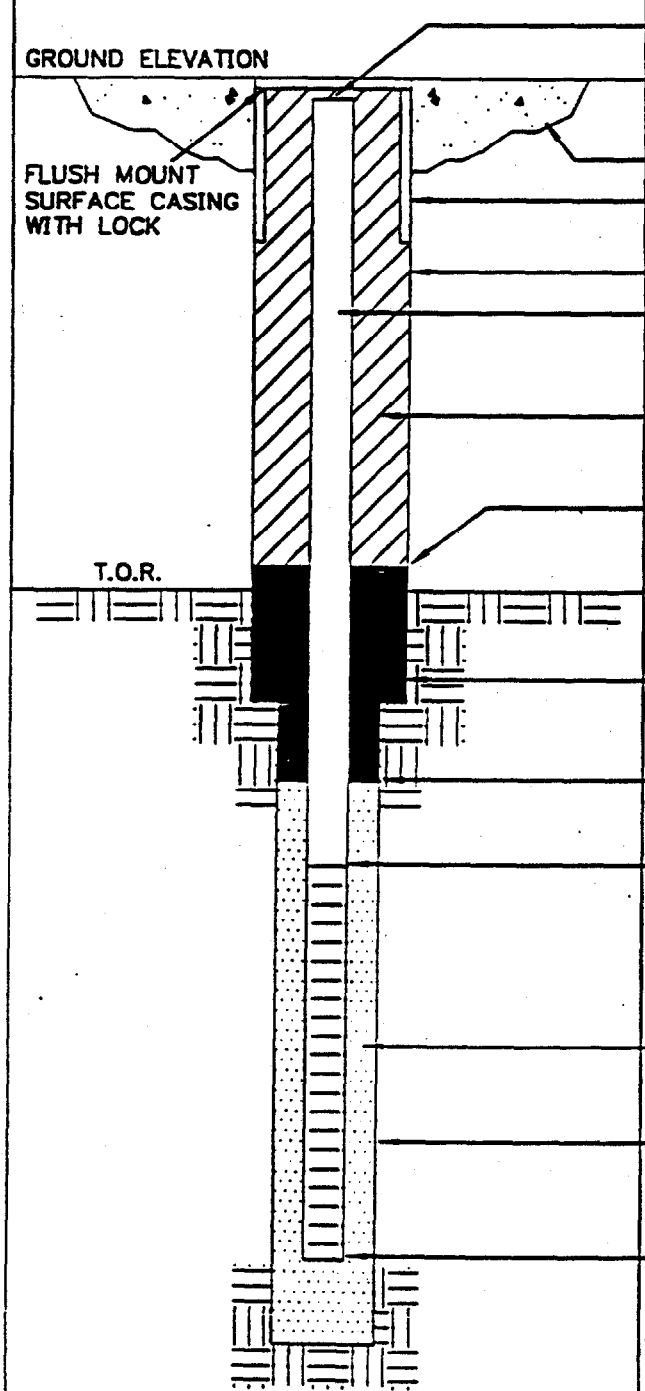
BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

BORING NO.: HN-35I
HN-35S & I constructed in same borehole

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-35I
DATE

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement

TYPE OF PROTECTIVE CASING: Steel
I.D. OF PROTECTIVE CASING: 6"

DIAMETER OF HOLE: 10"

RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION/DEPTH TOP OF SEAL: 87

ELEVATION/DEPTH TOP OF BEDROCK: 7

TYPE OF SEAL: Bentonite

ELEVATION/DEPTH TOP OF SAND: 87

ELEVATION/DEPTH TOP OF SCREEN: 91
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 2"

TYPE OF SAND PACK: Pea Gravel

DIAMETER OF HOLE IN BEDROCK: 6"

ELEVATION/DEPTH BOTTOM SCREEN: 101
ELEVATION/DEPTH BOTTOM HOLE: 106

Halliburton NUS CORPORATION

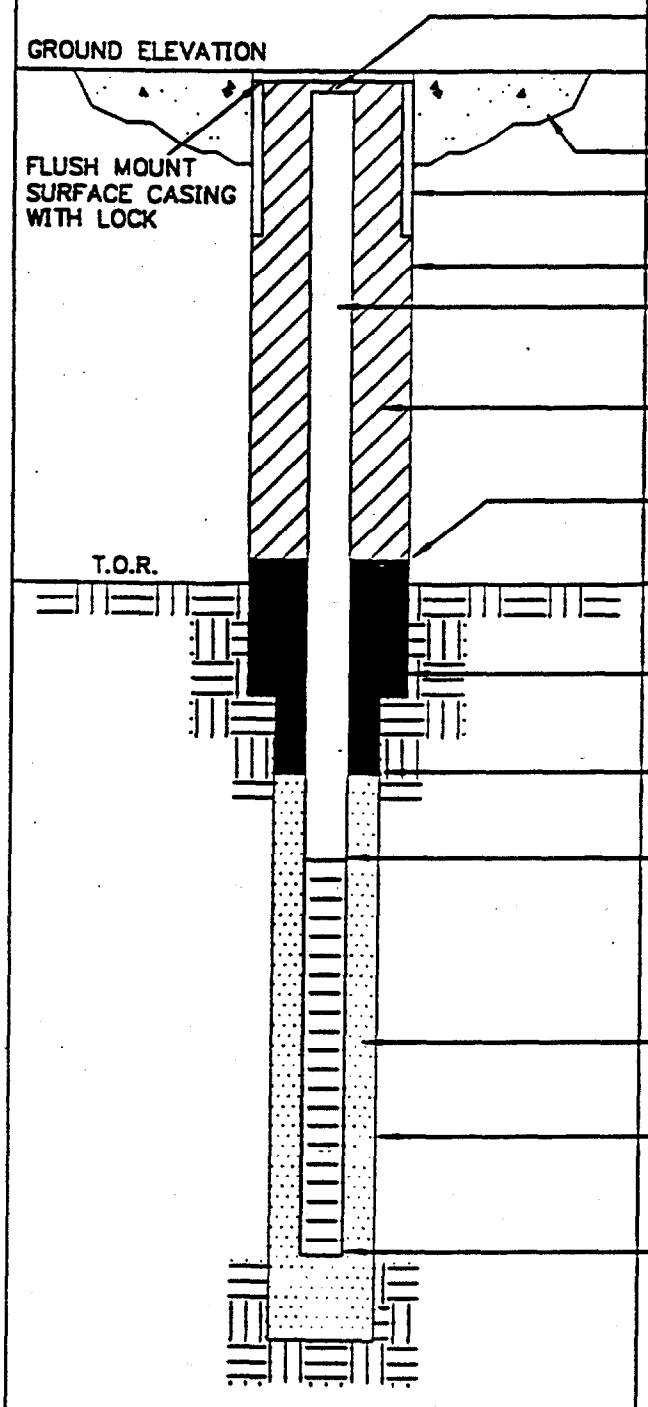
BORING NO.: HN-35D

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST P. NIMMER

LOCATION
BORING HN-35D
DATE 7/12/94

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Cement

TYPE OF PROTECTIVE CASING: Steel
I.D. OF PROTECTIVE CASING: 6"

DIAMETER OF HOLE: 10"

RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION/DEPTH TOP OF SEAL:

ELEVATION/DEPTH TOP OF BEDROCK: 7

TYPE OF SEAL: Bentonite

ELEVATION/DEPTH TOP OF SAND: 115

ELEVATION/DEPTH TOP OF SCREEN 120
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 2"

TYPE OF SAND PACK: No. 2 Morie equiv.

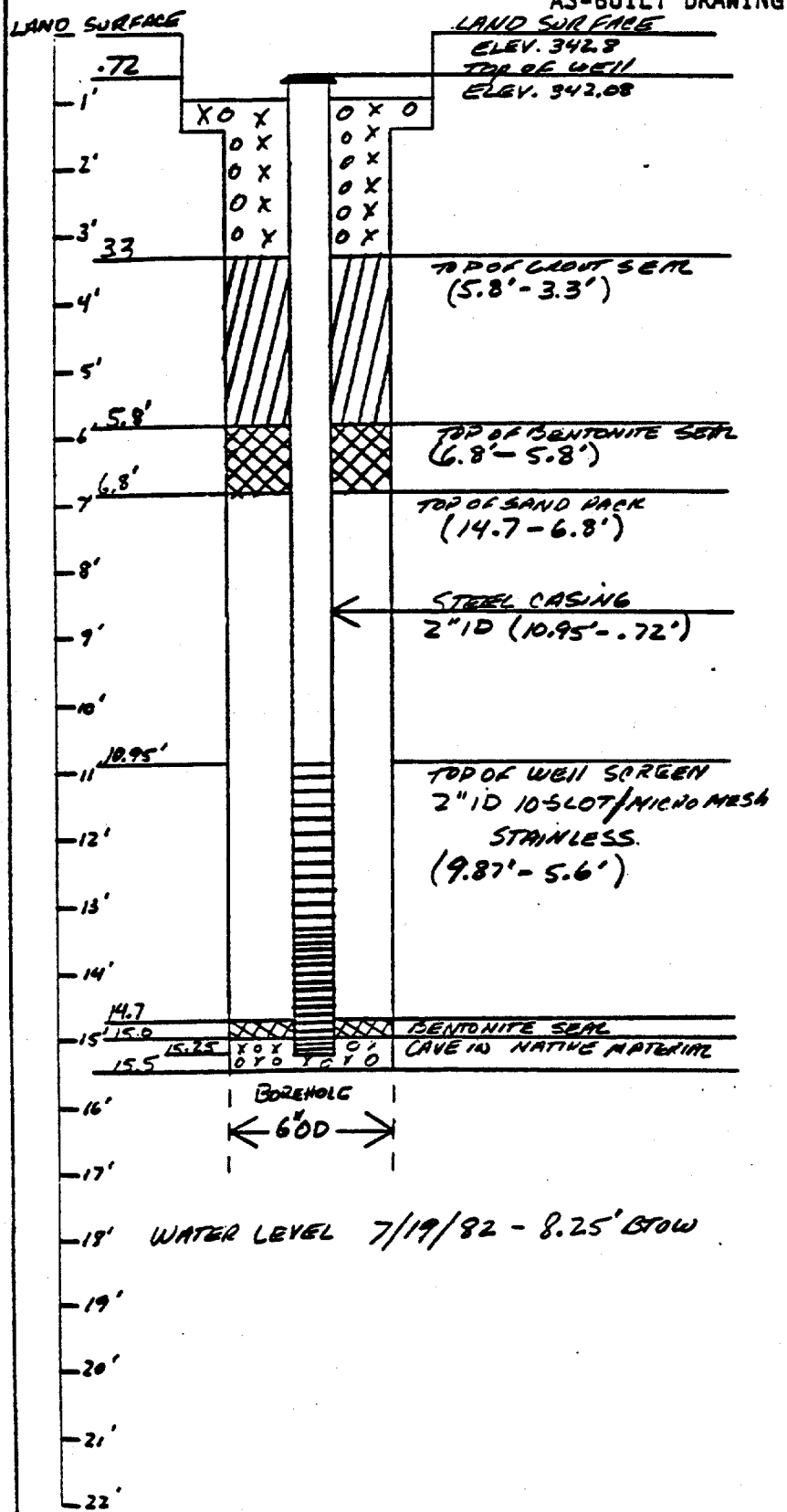
DIAMETER OF HOLE IN BEDROCK:

ELEVATION/DEPTH BOTTOM SCREEN: 130
ELEVATION/DEPTH BOTTOM HOLE: 152

Backfill w/ Bentonite to 135'

ACAD: C.JEFF.DWG 06/14/94 TD

AS-BUILT DRAWING



CHECKLIST

Land Surface Elevation 342.8

Casing Height Above L-S -.72'

Total Depth 15.5'

Borehole Diameter 6" O.D.

Casing Diameter 2" I.D.

~~Casing Thickness~~

Casing Lengths 10.23'

Screen Data

- Material STAINLESS
- Diameter 2" I.D.
- Slot Openings 10 SLOT/MM
- Settings 15.25'-10.95'

~~Centralizers~~

Grout Type PORTLAND

Gravel Pack SILICA.

~~K-Fittings~~

~~Packers~~

~~Cement Baskets~~

Rig Type MOBILE B-56

Driller LARRY CISLER - SCI

Supervisory Geologist ED TOKARSKI - JRB

Well No. DG-9 (HN-36X)

Project NADC-WARMINSTER, PA

Location N. OF HOUSING ALONG FENCE.

S. OF SITE #6. DOWNGRAD. SITE #6.

Date Drilled 7/17/82

Prepared By: ED TOKARSKI 10/6/82

Scale: AS SHOWN

198-600/03

NUS CORPORATION
A Halliburton Company

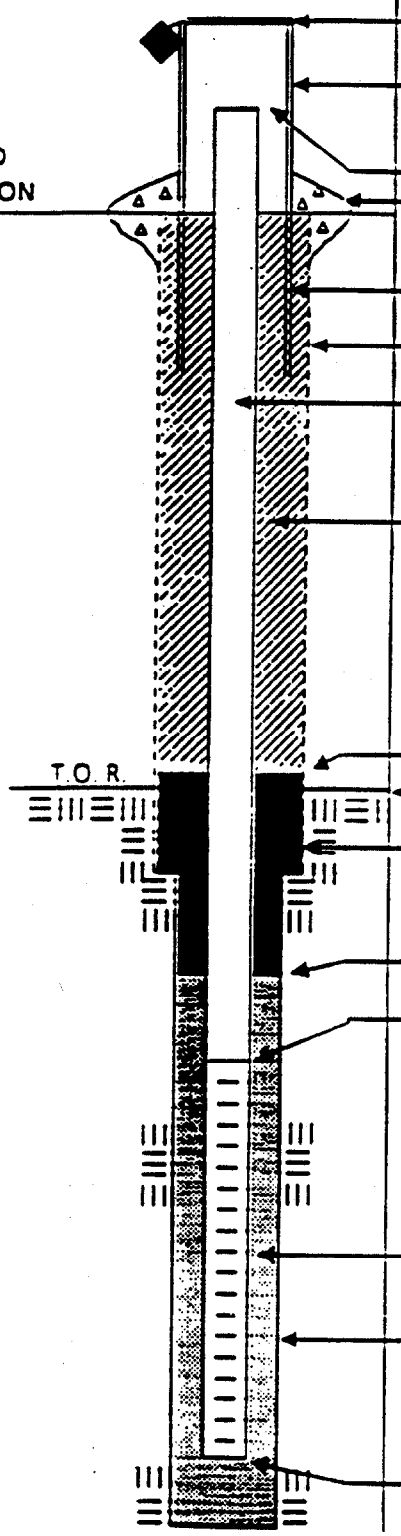
BORING NO.: HN-36I1

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST P. NIMMER
LOCATION
BORING HN-36I1
DATE 7/13/94

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



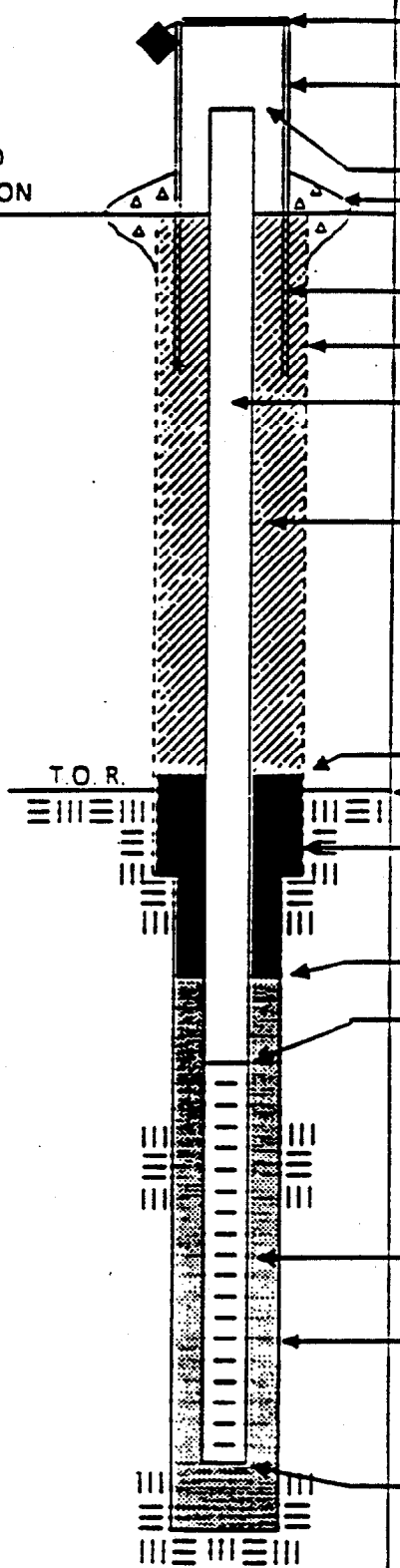
ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL:
I.D. OF SURFACE CASING: 6"
DIAMETER OF HOLE: 10"
RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: SCHED 40 PVC
TYPE OF BACKFILL: BENTONITE
ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 8
TYPE OF SEAL: BENTONITE
ELEVATION / DEPTH TOP OF SAND: 82
ELEVATION / DEPTH TOP OF SCREEN: 86
TYPE OF SCREEN: SCHED 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 2"
TYPE OF SAND PACK: NO. 2 MORIE EQUIV.
DIAMETER OF HOLE IN BEDROCK: 6"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 96

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-36I2
HN-36I2 & HN-36D constructed in same borehole

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: NAWC Warminster
PROJECT NO.:
ELEVATION:
FIELD GEOLOGIST: P. Nimmer
LOCATION:
BORING: HN-36I2
DATE: 6/17/94
DRILLER: RAAB
DRILLING METHOD: AIR ROTARY
DEVELOPMENT METHOD: SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL:
I.D. OF SURFACE CASING: 6"
DIAMETER OF HOLE: 10"
RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: SCHED 40 PVC
TYPE OF BACKFILL: Bentonite
ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 8
TYPE OF SEAL: Bentonite
ELEVATION / DEPTH TOP OF SAND: 101
ELEVATION / DEPTH TOP OF SCREEN: 104
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 2"
TYPE OF SAND PACK: NO. 2 Morie EQUIV.
DIAMETER OF HOLE IN BEDROCK: 6"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 114
ELEVATION / DEPTH BOTTOM OF HOLE: 151
SAND PACK extends to 115'

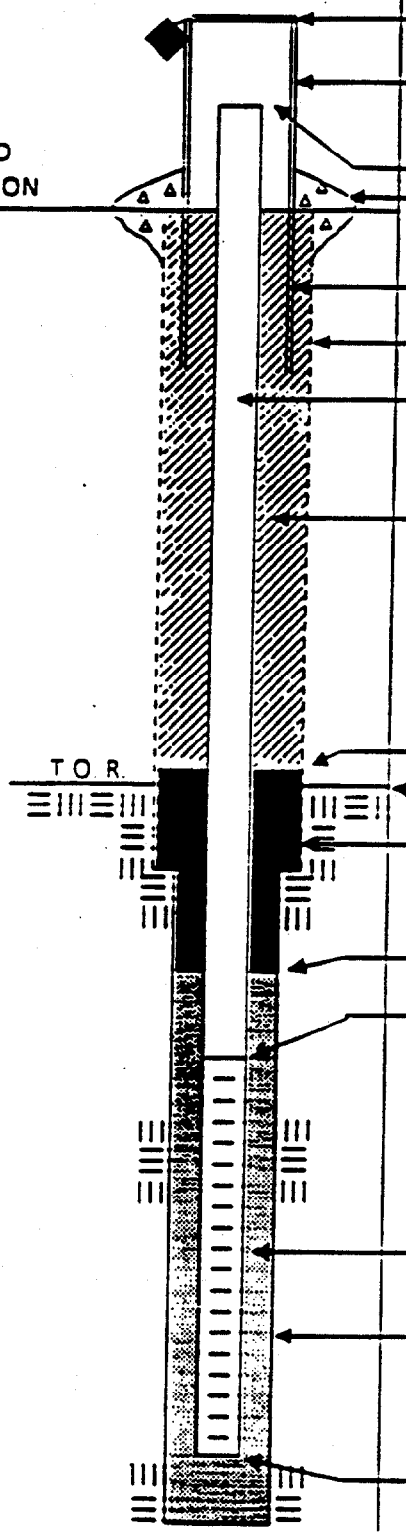
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-36D
HN-36I2 & HN-36D constructed in same borehole

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

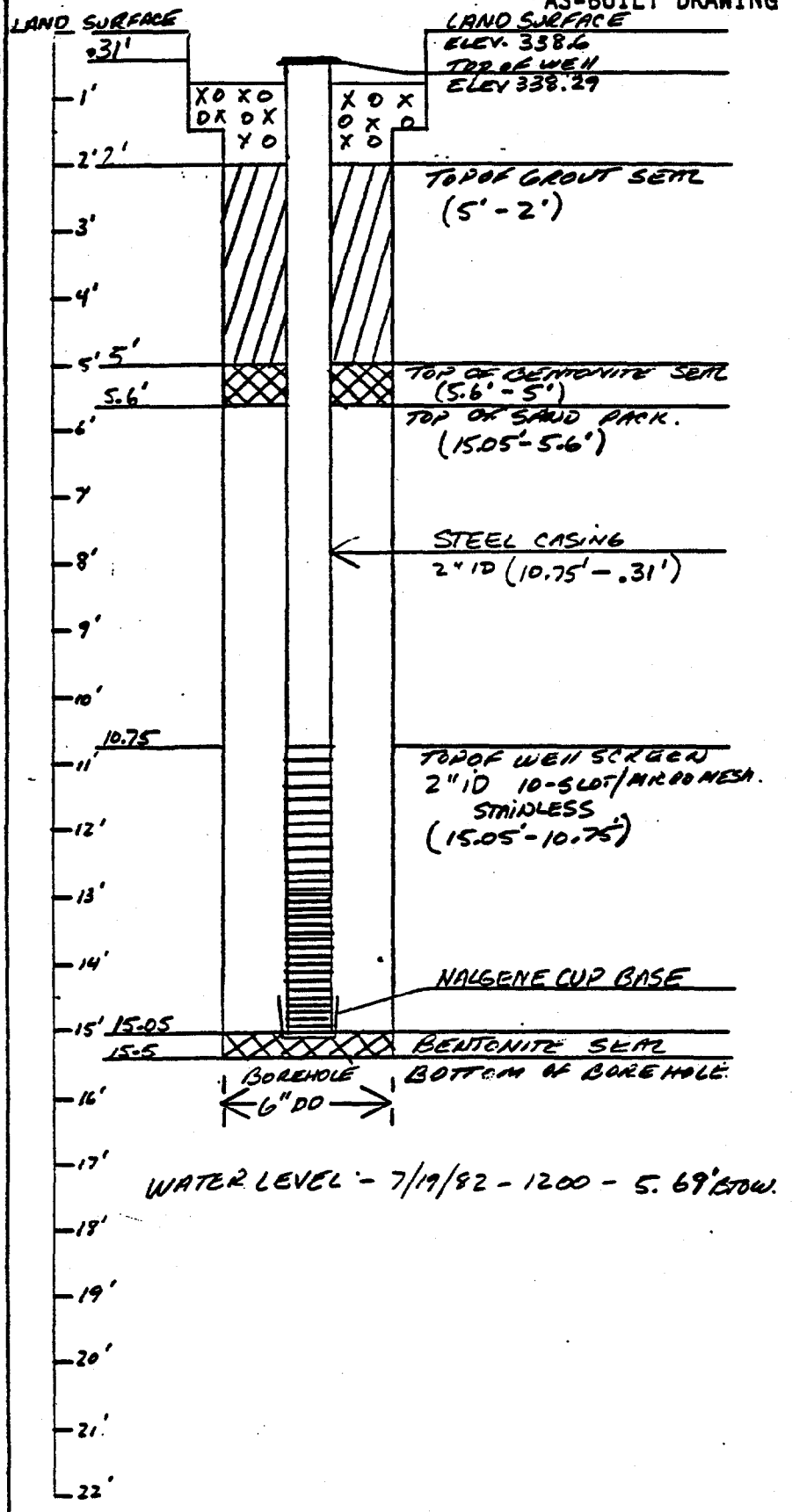
PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST P. Nimmer
LOCATION
BORING HN-36D
DATE 6/17/94

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL:
I.D. OF SURFACE CASING: 6"
DIAMETER OF HOLE: 10"
RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite
ELEVATION / DEPTH TOP OF SEAL: 133
ELEVATION / DEPTH TOP OF BEDROCK: 8
TYPE OF SEAL: Bentonite
ELEVATION / DEPTH TOP OF SAND: 133
ELEVATION / DEPTH TOP OF SCREEN: 135
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 2"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 6"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 145
151

AS-BUILT DRAWING



CHECKLIST

Land Surface Elevation 338.6

Casing Height Above L-S -.31'

Total Depth 15.5'

Borehole Diameter 6" O.D.

Casing Diameter 2" I.D.

~~Casing Thickness~~

Casing Lengths 10.4

Screen Data

- Material STAINLESS
- Diameter 2" I.D.
- Slot Openings 10 SLOT
- Settings 15.05 - 10.75

~~Centralizers~~

Grout Type PORTLAND

Gravel Pack SILICA.

~~K-Fittings~~

~~Packers~~

~~Cement Baskets~~

Rig Type MOBILE B-56

Driller LARRY CISLER - SCI

Supervisory Geologist ED TOKARSKI - JRB.

Well No. D6-7 (HN-37X)

Project NADC - WARMINSTER, PA

Location DOWNGRADIENT SITE #7, SOUTH OF AIRFIELD ALONG PATH BETWEEN FENCE AND RUNWAY

Date DRILLED 7/19/82

Prepared By: ED TOKARSKI 10/6/82

Scale: AS SHOWN

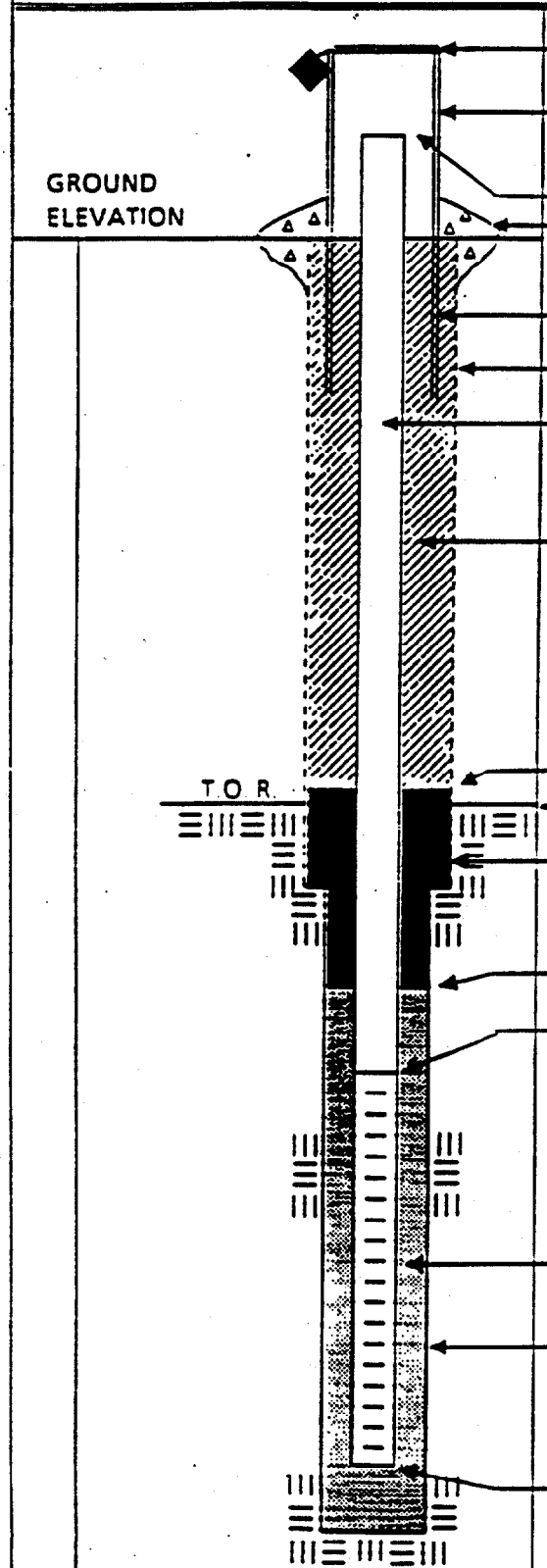
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-37S
HN-37S & HN-37I constructed in same borehole

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST P. Nimmer
LOCATION
BORING HN-37S
DATE 6/17/94

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Bentonite
I.D. OF SURFACE CASING: 6"
DIAMETER OF HOLE: 10"
RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 9
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 75
ELEVATION / DEPTH TOP OF SCREEN: 80
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 20'
I.D. SCREEN: 2"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 6"
CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 100
ELEVATION / DEPTH BOTTOM OF HOLE: 159

SAND PACK EXTENDS TO 103'

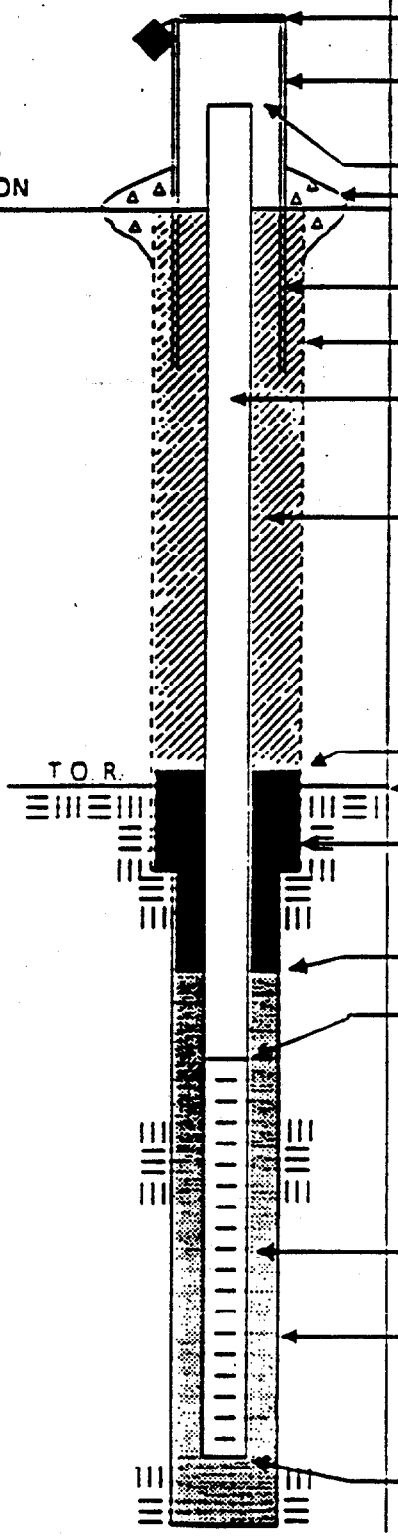
NUS CORPORATION
A Halliburton Company

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

BORING NO.: HN-37I
HN-37S + HN-37I constructed same borehole

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST P. Nimmer
LOCATION
BORING HN-37I
DATE 6/17/94

DRILLER RAAB
DRILLING METHOD Air Rotary
DEVELOPMENT METHOD Sub Pump



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Bentonite
I.D. OF SURFACE CASING: 6"
DIAMETER OF HOLE: 10"
RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL: 103
ELEVATION / DEPTH TOP OF BEDROCK: 9
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 116
ELEVATION / DEPTH TOP OF SCREEN: 119
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 15'
I.D. SCREEN: 2"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK:
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 134
159

NUS CORPORATION
A Halliburton Company

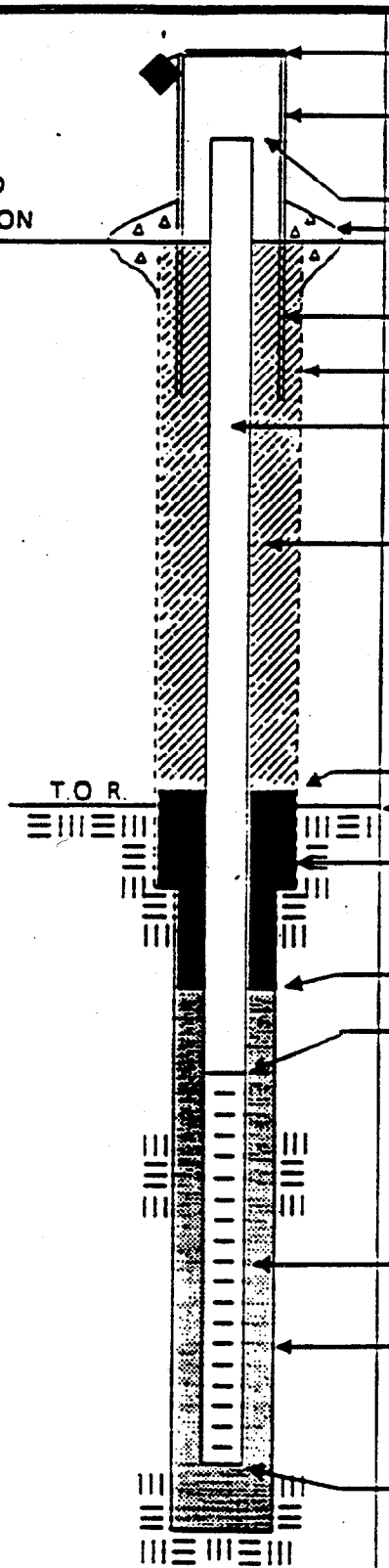
BORING NO.: HN-38

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen
LOCATION
BORING HN-38
DATE 6/16/94

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Bentonite

I.D. OF SURFACE CASING: 6"

DIAMETER OF HOLE: 10"

RISER PIPE I.D.: 2"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 8

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 97

ELEVATION / DEPTH TOP OF SCREEN: 101

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 10'

I.D. SCREEN: 2"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 6"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 111

ELEVATION / DEPTH BOTTOM OF HOLE: 119

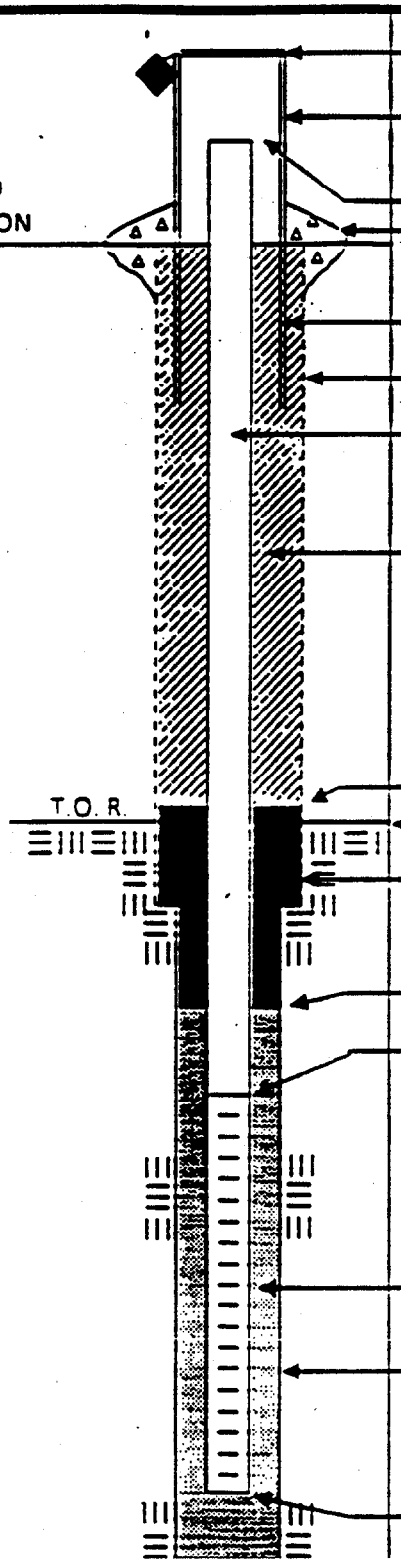
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-39

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: NAWC Warminster
PROJECT NO.:
ELEVATION:
FIELD GEOLOGIST: P. Nimmer
LOCATION:
BORING: HN-39
DATE: 6/17/94

DRILLER: RAAB
DRILLING METHOD: AIR ROTARY
DEVELOPMENT METHOD: SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Bentonite
I.D. OF SURFACE CASING: 6"
DIAMETER OF HOLE: 10"
RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 8
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 125
ELEVATION / DEPTH TOP OF SCREEN: 129
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 20'
I.D. SCREEN: 2"
TYPE OF SAND PACK: NO. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 6"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 149

NUS CORPORATION
A Halliburton Company

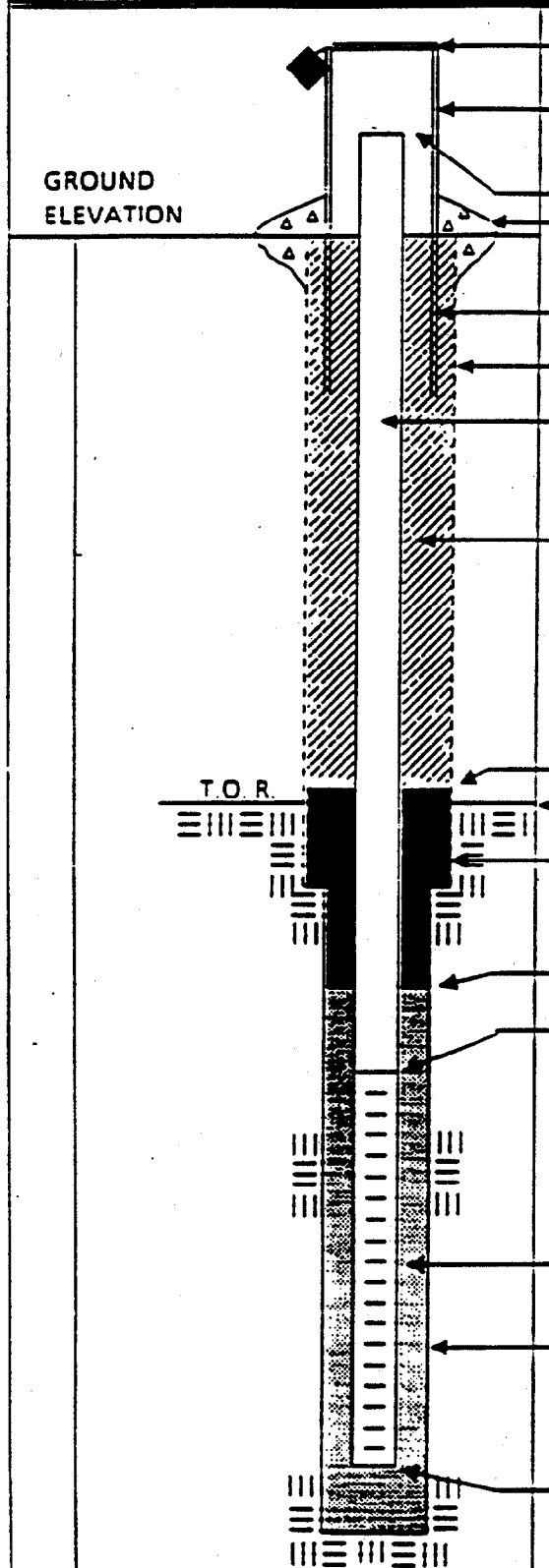
BORING NO.: HN-40S

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC WARMINSTER
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-40S
DATE 6/9/94

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Bentonite

I.D. OF SURFACE CASING: 6"

DIAMETER OF HOLE: 10"

RISER PIPE I.D.: 2"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 9

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 55

ELEVATION / DEPTH TOP OF SCREEN: 59

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" X 10'

I.D. SCREEN: 2"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 6"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 69

ELEVATION / DEPTH BOTTOM OF HOLE: 69

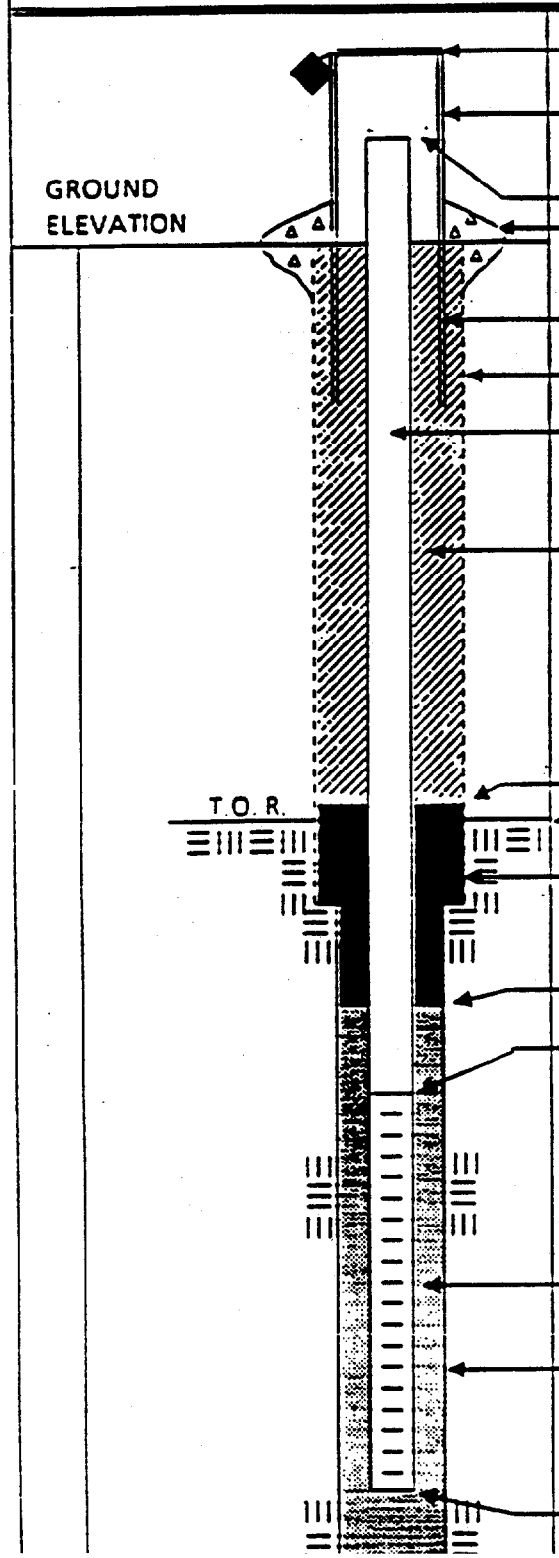
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-40I

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST P. NIMMER
LOCATION
BORING HN-40I
DATE 6/17/94

DRILLER
DRILLING METHOD
DEVELOPMENT METHOD



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Bentonite
I.D. OF SURFACE CASING: 6"
DIAMETER OF HOLE: 10"
RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 9
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 88
ELEVATION / DEPTH TOP OF SCREEN: 94
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 15'
I.D. SCREEN: 2"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 6"
CORE / REAM:
ELEVATION / DEPTH BOTTOM SCREEN: 109

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-40D

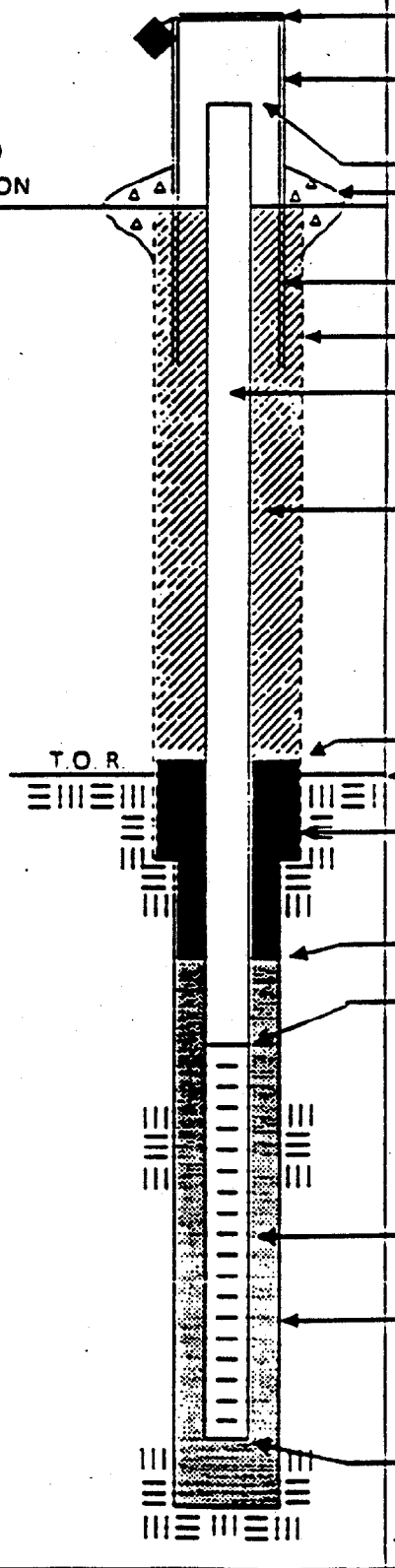
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST P. Nimmer

LOCATION
BORING HN-40D
DATE 6/16/94

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Bentonite

I.D. OF SURFACE CASING: 6"

DIAMETER OF HOLE: 10"

RISER PIPE I.D.: 2"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 9

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 120

ELEVATION / DEPTH TOP OF SCREEN: 123

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 20'

I.D. SCREEN: 2"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 6"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 143

ELEVATION / DEPTH BOTTOM OF HOLE: 161

BACKFILL w/ Bentonite TO 148'

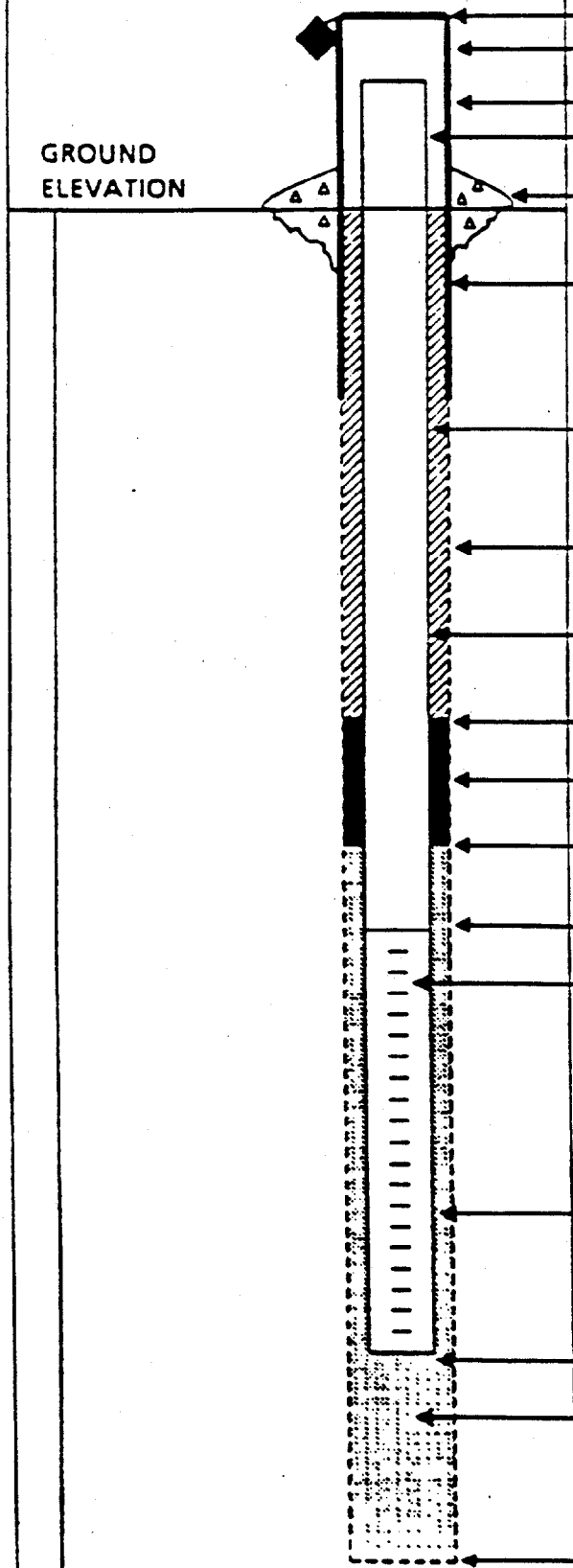
HALLIBURTON NUS
Environmental Corporation

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-415
DATE 6/9/94

DRILLER Raab
DRILLING METHOD air hamm
DEVELOPMENT METHOD Submersible Pum



ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE:

STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE :

TYPE OF SURFACE SEAL: bentonite

I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: Steel
Depth: 19'

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 6"

TYPE OF BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL:

TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 41'

ELEVATION / DEPTH TOP OF SCREEN: 44'

TYPE OF SCREEN: schedule 40 PVC

SLOT SIZE x LENGTH: 0.02" x 10'

I.D. OF SCREEN: 2"

TYPE OF SAND PACK: no. 2

ELEVATION / DEPTH BOTTOM OF SCREEN: 54'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 5
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A

ELEVATION / DEPTH OF HOLE: 54'

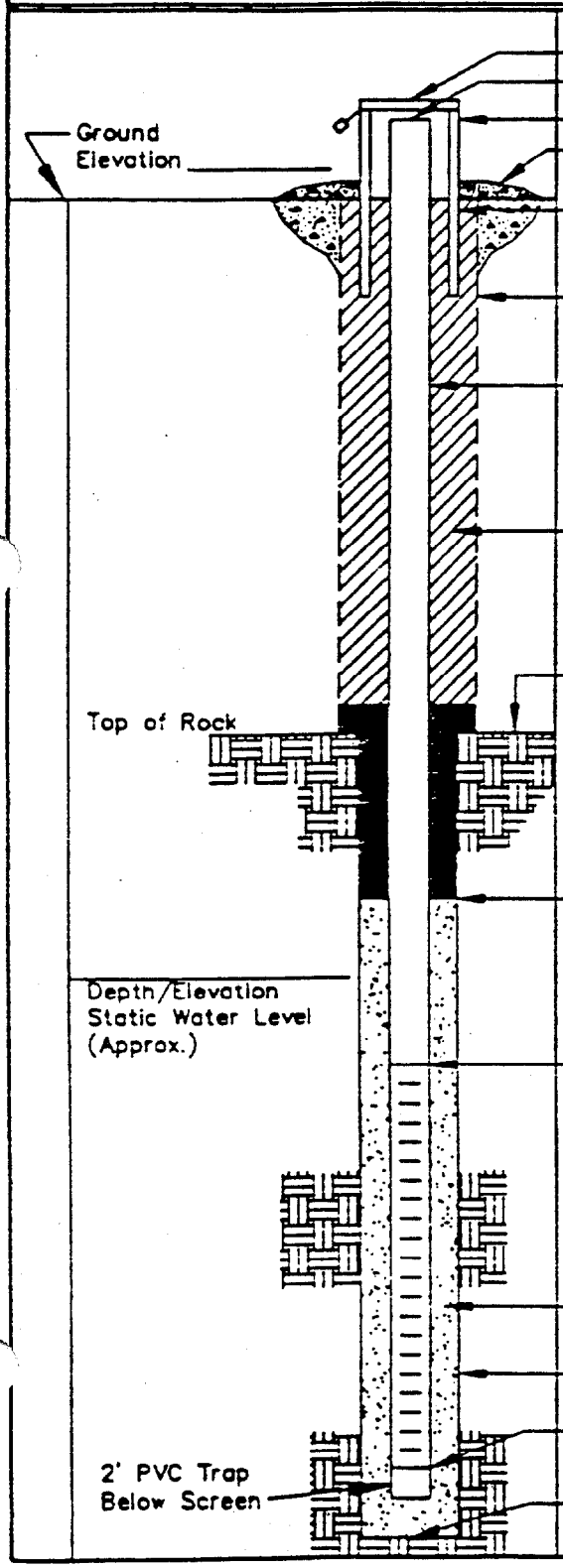
NUS CORPORATION

WELL NO.: HN-41I

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT: WARMINSTER
LOCATION: AREA "C"
DRILLER: RAAB
PROJECT NO.: 1412
BORING:
DRILLING METHOD: AIR HAMMER
ELEVATION:
DATE: 6/16/94
DEVELOPMENT METHOD: Submersiable Pump
FIELD GEOLOGIST: P. NIMMER



ELEVATION OF TOP OF SURFACE CASING: 1.9' /
ELEVATION TOP OF RISER: 1.5' /
STICK UP OF CASING ABOVE GROUND SURFACE: 1.9'
TYPE OF SURFACE SEAL: BENTONITE 3' to 19'
TYPE OF PROTECTIVE CASING: Steel
I.D. OF PROTECTIVE CASING: 6" ø
DIAMETER OF HOLE: 10" ø HOLE 0' to 19'
TYPE OF RISER PIPE: Sch. 40 PVC +1.5' to 78'
RISER PIPE I.D.: 2" ø
TYPE OF BACKFILL/SEAL: BENTONITE to 78'
DEPTH/ELEVATION TOP OF BEDROCK: 7' /
DEPTH/ELEVATION TOP OF SAND: 72.8' /
DEPTH/ELEVATION TOP OF SCREEN: 78' /
TYPE OF SCREEN: Sch. 40 PVC
SLOT SIZE x LENGTH: 0.02 x 15 ft
TYPE OF SAND PACK: #2 SAND
DIAMETER OF HOLE IN BEDROCK: 6" ø HOLE 19' to 101'
DEPTH/ELEVATION BOTTOM OF SCREEN: 93' /
DEPTH/ELEVATION BOTTOM OF SAND: 93' /
DEPTH/ELEVATION BOTTOM OF HOLE: 101' /
BACKFILL MATERIAL BELOW SAND: BENTONITE 93' to 101'

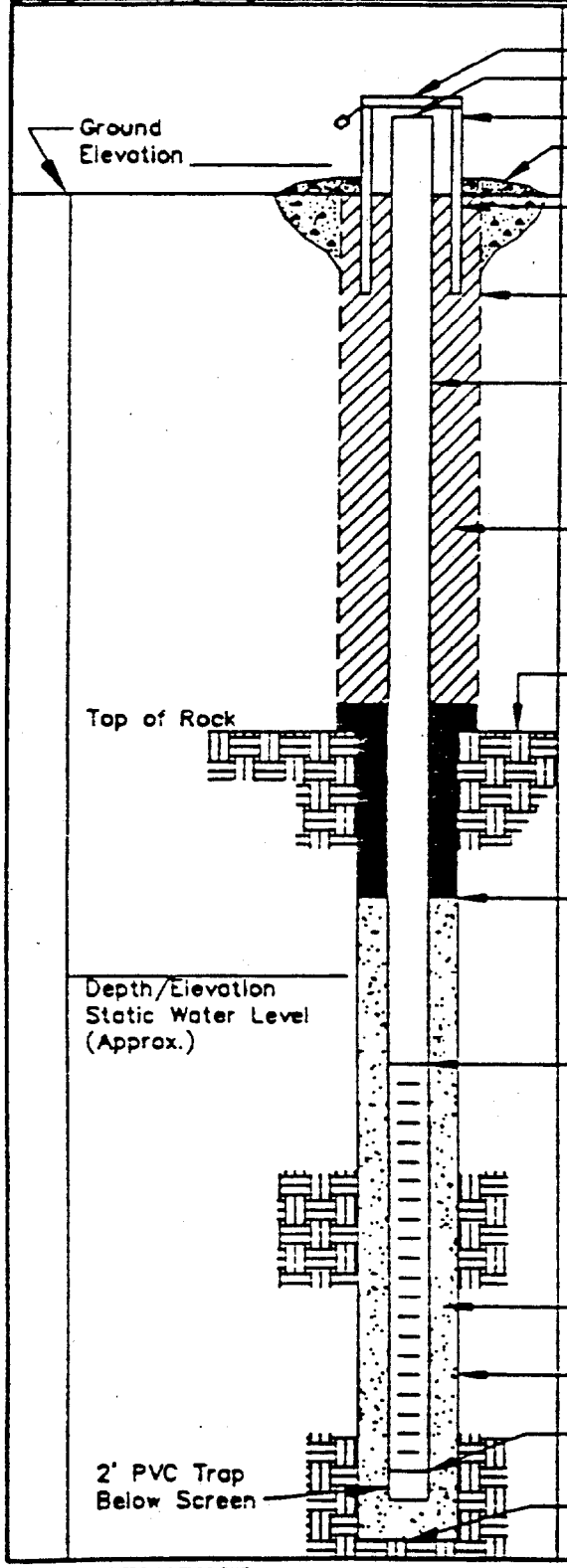
ACFILE L:\70\GEOL\BEDROC.DWG

NUS CORPORATION

WELL NO.: HN-41D

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: WARMINSTER
LOCATION: AREA "C"
DRILLER: RAAB
PROJECT NO.: 1412
BORING:
DRILLING METHOD: AIR HAMMER
ELEVATION:
DATE: 6/16/94
DEVELOPMENT METHOD: Submersible Pump
FIELD GEOLOGIST: P. NIMMER



ELEVATION OF TOP OF SURFACE CASING:
ELEVATION TOP OF RISER: 1.6'
STICK UP OF CASING ABOVE GROUND SURFACE: 2.3'
TYPE OF SURFACE SEAL: BENTONITE 3' to 19'
TYPE OF PROTECTIVE CASING: STEEL CASING
I.D. OF PROTECTIVE CASING: 6" Ø +2.3' to 19'
DIAMETER OF HOLE: 10" Ø 0' to 19'
TYPE OF RISER PIPE: Sch. 40 PVC +1.6' to 161'
RISER PIPE I.D.: 2" Ø
TYPE OF BACKFILL/SEAL: BENTONITE ~~1~~ TO 176
DEPTH/ELEVATION TOP OF BEDROCK: 7' /
DEPTH/ELEVATION TOP OF SAND: 151.5 /
DEPTH/ELEVATION TOP OF SCREEN: 161' /
TYPE OF SCREEN: Sch. 40 PVC
SLOT SIZE x LENGTH: 0.02 x 15 ft
TYPE OF SAND PACK: #2 SAND
DIAMETER OF HOLE IN BEDROCK: 6" Ø 19' to 176'
DEPTH/ELEVATION BOTTOM OF SCREEN: 176' /
DEPTH/ELEVATION BOTTOM OF SAND: 176' /
DEPTH/ELEVATION BOTTOM OF HOLE: 176' /
BACKFILL MATERIAL BELOW SAND: NONE

ACFILE: L670\GEOL\BEDR2.DWG

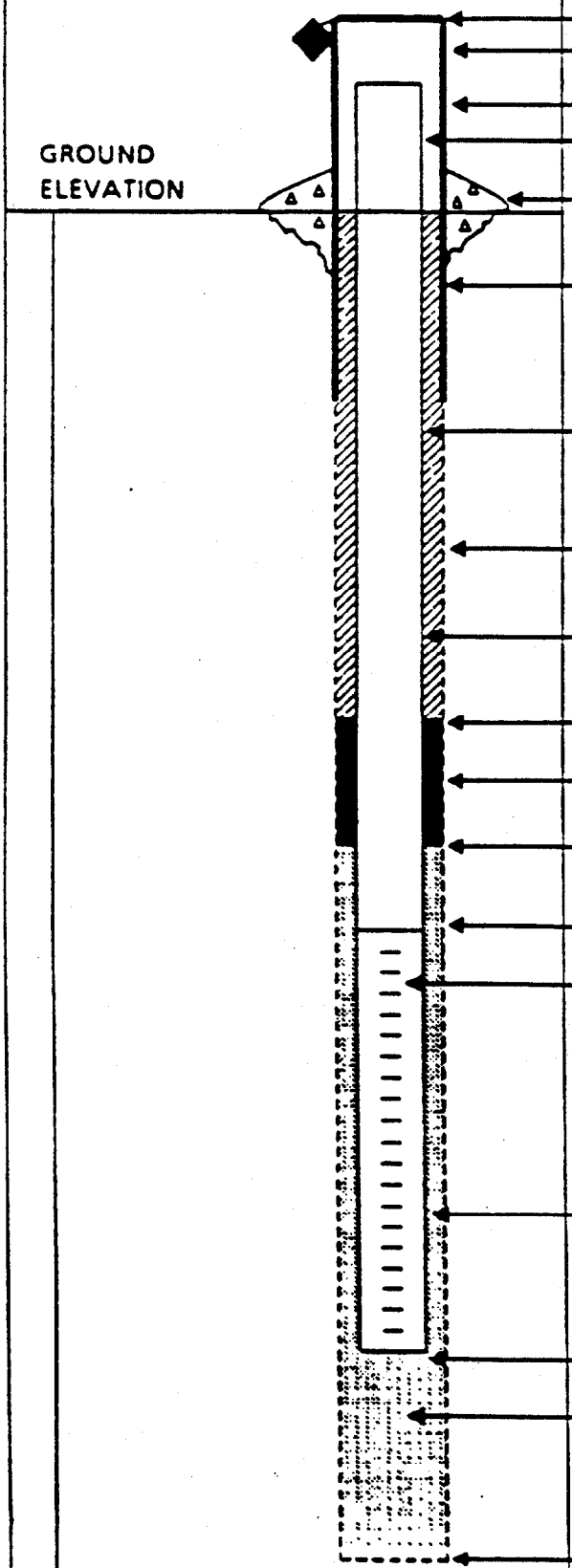
HALLIBURTON NUS
Environmental Corporation

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION former catapult area
BORING HN-435
DATE 7/19/94

DRILLER Raab
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE :
TYPE OF SURFACE SEAL: bentonite
I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC
BOREHOLE DIAMETER: 6"
TYPE OF BACKFILL: bentonite
ELEVATION / DEPTH TOP OF SEAL:
TYPE OF SEAL: bentonite
DEPTH TOP OF SAND PACK: 43'
ELEVATION / DEPTH TOP OF SCREEN: 49'
TYPE OF SCREEN: sched. 40 PVC
SLOT SIZE x LENGTH: 0.02" x 15'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: no. 2
ELEVATION / DEPTH BOTTOM OF SCREEN: 64'
ELEVATION / DEPTH BOTTOM OF SAND PACK: 64'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A
ELEVATION / DEPTH OF HOLE: 64'

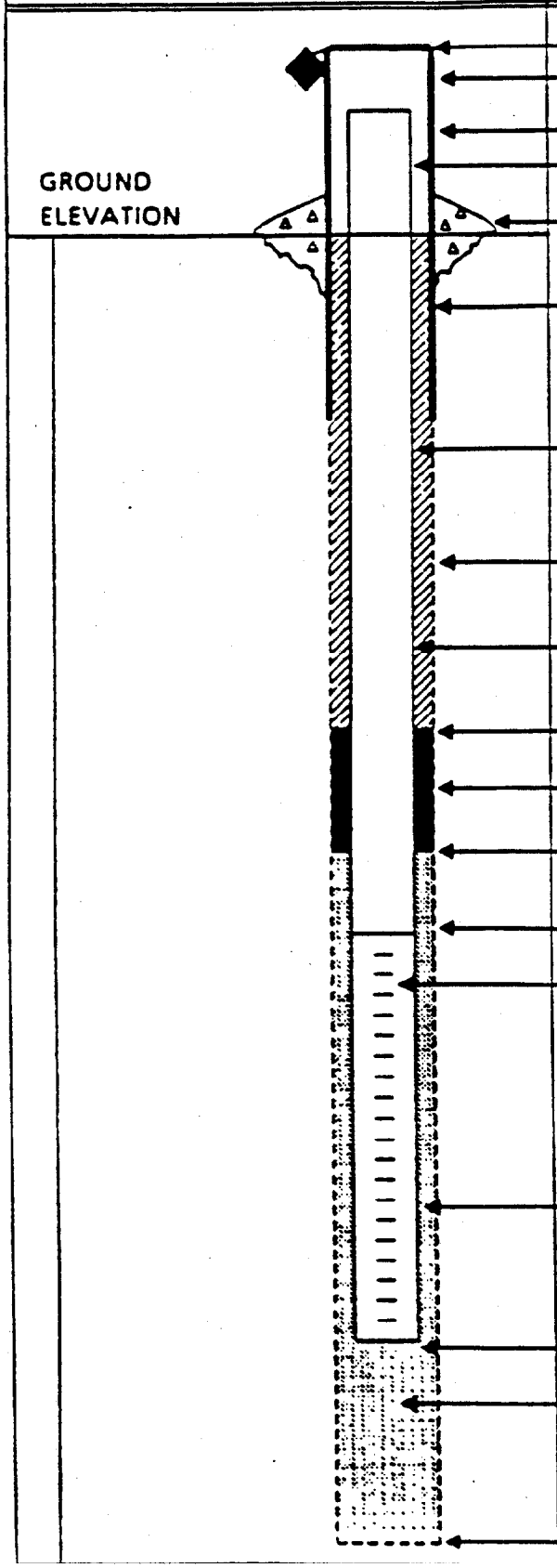
HALLIBURTON NUS
Environmental Corporation

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION former catapult area
BORING HN-43 I
DATE 7/19/94

DRILLER Raab
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE :
TYPE OF SURFACE SEAL: bentonite
I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 pvc
BOREHOLE DIAMETER: 6"
TYPE OF BACKFILL: bentonite
ELEVATION / DEPTH TOP OF SEAL:
TYPE OF SEAL: bentonite
DEPTH TOP OF SAND PACK: 90'
ELEVATION / DEPTH TOP OF SCREEN: 94'
TYPE OF SCREEN: schedule 40 PVC
SLOT SIZE x LENGTH: 0.02" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: no. 2
ELEVATION / DEPTH BOTTOM OF SCREEN: 104'
ELEVATION / DEPTH BOTTOM OF SAND PACK: 104'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A
ELEVATION / DEPTH OF HOLE: 104'

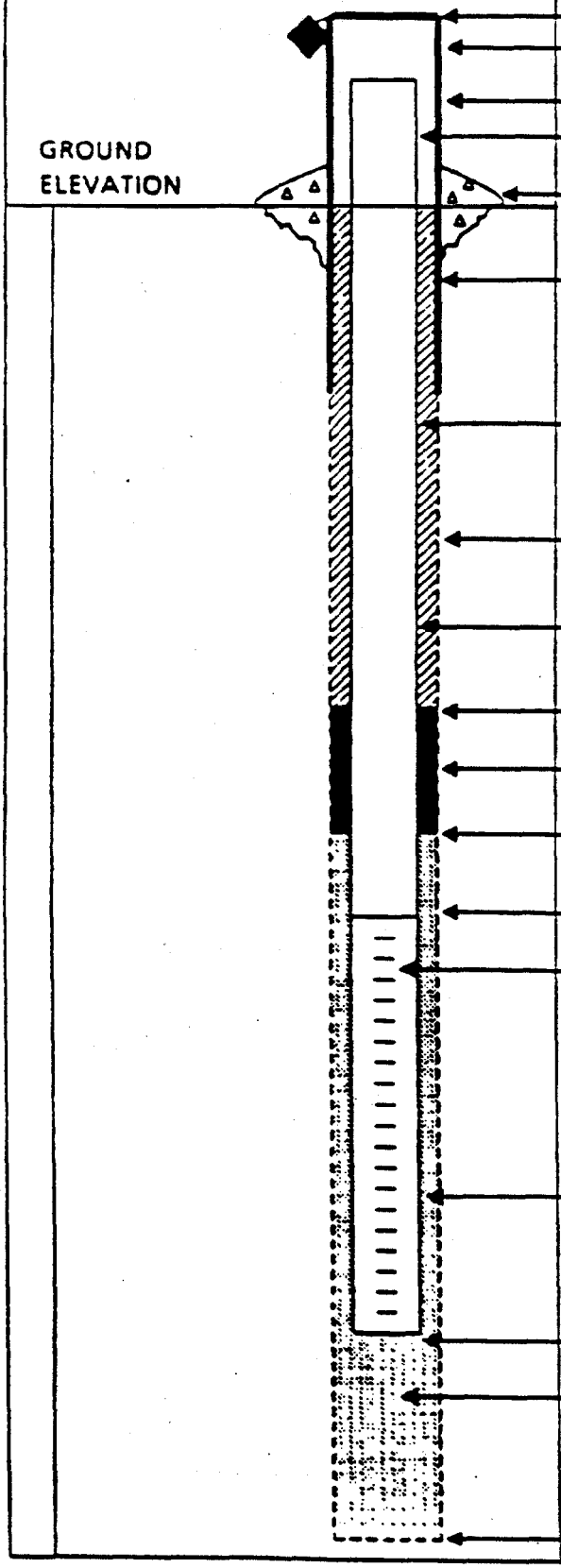
HALLIBURTON NUS
Environmental Corporation

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION
FIELD GEOLOGIST R. Whalen

LOCATION former catapult area
BORING HN-43D
DATE 7/19/94

DRILLER Koab
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE :
TYPE OF SURFACE SEAL: bentonite
I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC
BOREHOLE DIAMETER: 6"
TYPE OF BACKFILL: bentonite
ELEVATION / DEPTH TOP OF SEAL:
TYPE OF SEAL: bentonite
DEPTH TOP OF SAND PACK: 117'
ELEVATION / DEPTH TOP OF SCREEN: 119'
TYPE OF SCREEN: schedule 40 PVC
SLOT SIZE x LENGTH: 0.02" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: no. 2
ELEVATION / DEPTH BOTTOM OF SCREEN: 129'
ELEVATION / DEPTH BOTTOM OF SAND PACK: 135'
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite
ELEVATION / DEPTH OF HOLE: 151'

NUS CORPORATION
A Halliburton Company

BORING NO.: HN-49S

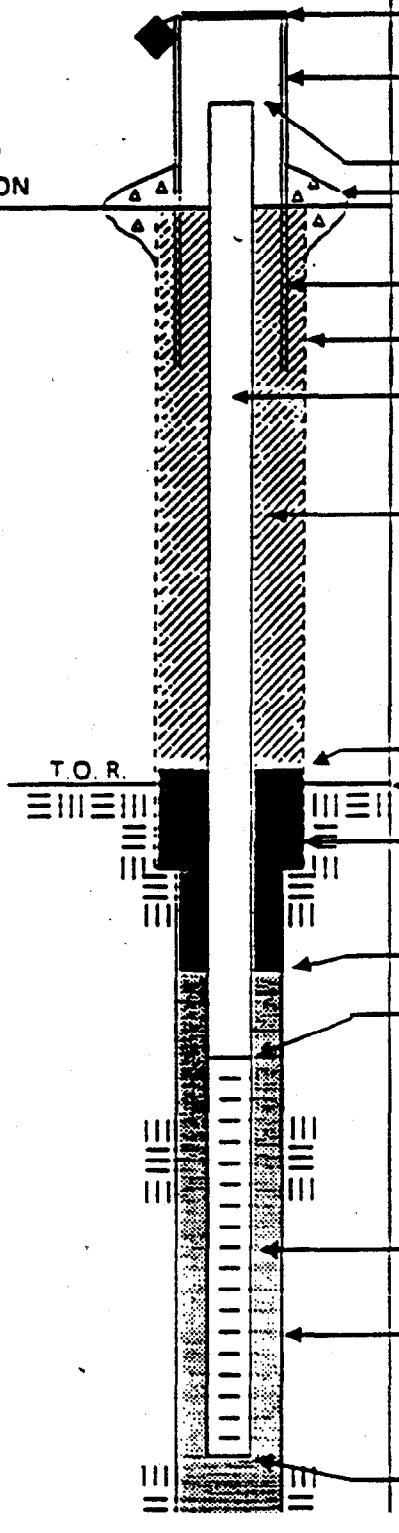
BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-49S
DATE

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Bentonite

I.D. OF SURFACE CASING: 6"

DIAMETER OF HOLE: 10"

RISER PIPE I.D.: 2"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 12

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 36

ELEVATION / DEPTH TOP OF SCREEN: 40

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 10'

I.D. SCREEN: 2"

TYPE OF SAND PACK: No. 2 Morie equiv.

DIAMETER OF HOLE IN BEDROCK: 6"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 50

NUS CORPORATION
A Halliburton Company

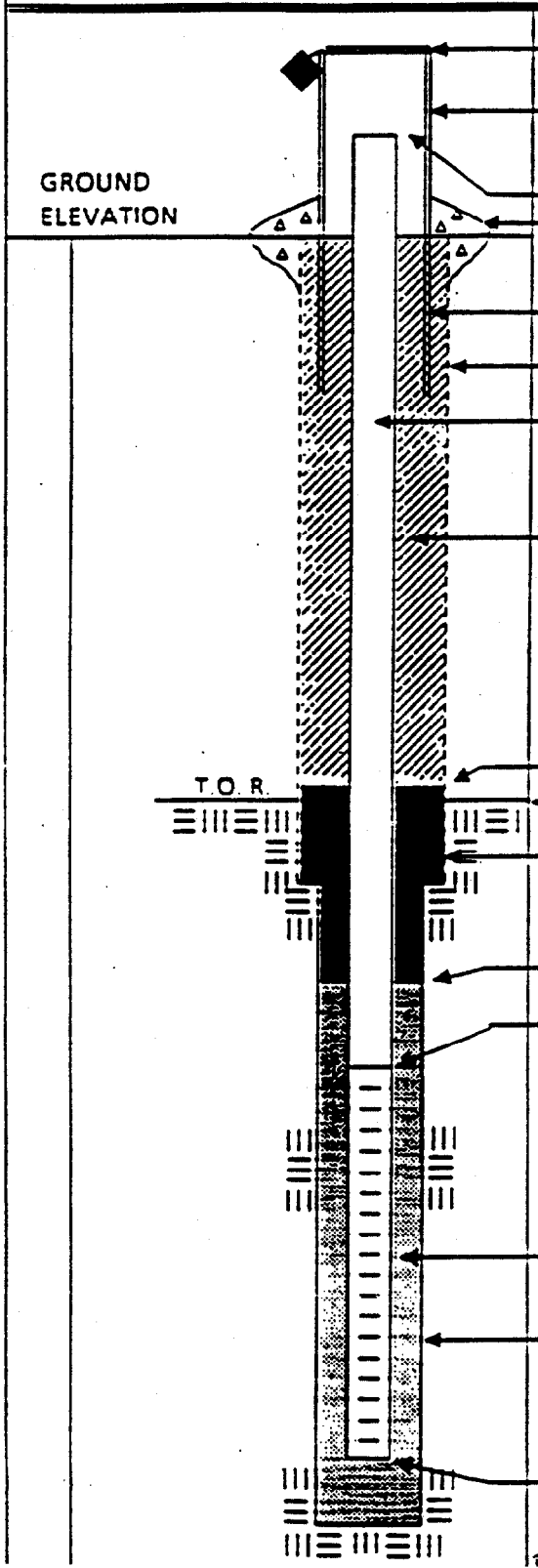
BORING NO.: HN-49I

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT NAWC Warminster
PROJECT NO.
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING HN-49I
DATE

DRILLER RAAB
DRILLING METHOD AIR ROTARY
DEVELOPMENT METHOD SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:
STICK UP OF CASING ABOVE GROUND SURFACE:
ELEVATION TOP OF RISER:
TYPE OF SURFACE SEAL: Bentonite
I.D. OF SURFACE CASING: 6"
DIAMETER OF HOLE: 10"
RISER PIPE I.D.: 2"
TYPE OF RISER PIPE: Sched 40 PVC
TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:
ELEVATION / DEPTH TOP OF BEDROCK: 12
TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 55
ELEVATION / DEPTH TOP OF SCREEN: 60
TYPE OF SCREEN: Sched 40 PVC
SLOT SIZE x LENGTH: 0.020" x 10'
I.D. SCREEN: 2"
TYPE OF SAND PACK: No. 2 Morie equiv.
DIAMETER OF HOLE IN BEDROCK: 6"
CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 70
ELEVATION / DEPTH BOTTOM OF HOLE: 100

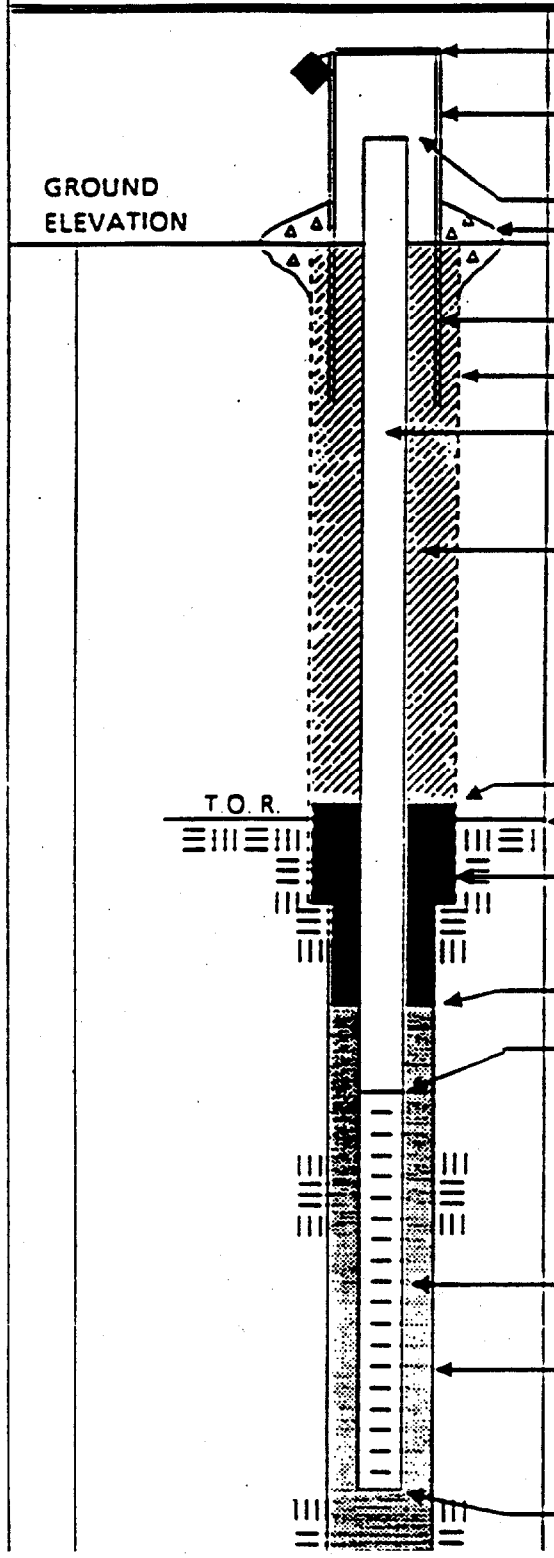
NUS CORPORATION
A Halliburton Company

BORING NO.: HN-49D

BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: NAWC Warminster
PROJECT NO.:
ELEVATION:
FIELD GEOLOGIST: D. Whalen
LOCATION:
BORING: HN-49D
DATE: 10/26/94

DRILLER: RAAB
DRILLING METHOD: AIR ROTARY
DEVELOPMENT METHOD: SUB PUMP



ELEVATION OF TOP OF SURFACE CASING:

STICK UP OF CASING ABOVE GROUND SURFACE:

ELEVATION TOP OF RISER:

TYPE OF SURFACE SEAL: Bentonite

I.D. OF SURFACE CASING: 6"

DIAMETER OF HOLE: 10"

RISER PIPE I.D.: 2"

TYPE OF RISER PIPE: Sched 40 PVC

TYPE OF BACKFILL: Bentonite

ELEVATION / DEPTH TOP OF SEAL:

ELEVATION / DEPTH TOP OF BEDROCK: 12

TYPE OF SEAL: Bentonite

ELEVATION / DEPTH TOP OF SAND: 118

ELEVATION / DEPTH TOP OF SCREEN: 121

TYPE OF SCREEN: Sched 40 PVC

SLOT SIZE x LENGTH: 0.020" x 10'

I.D. SCREEN: 2"

TYPE OF SAND PACK: NO. 2 Morie Equiv.

DIAMETER OF HOLE IN BEDROCK: 6"

CORE / REAM:

ELEVATION / DEPTH BOTTOM SCREEN: 131

HALLIBURTON NUS
Environmental Corporation

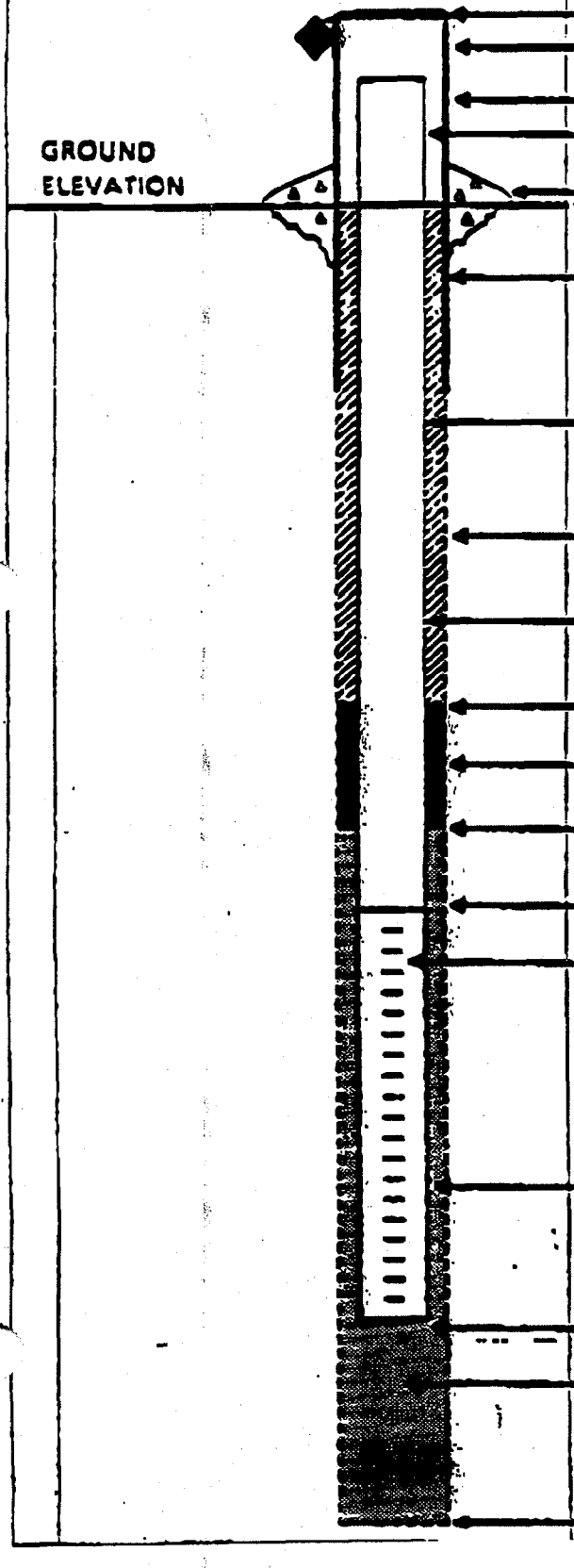
BORING NO _____

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION _____
FIELD GEOLOGIST V. Shiekera

LOCATION _____
BORING HN-61 S
DATE 12/21/95

DRILLER Raab
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____

STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____

TYPE OF SURFACE SEAL: bentonite

I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 6"

TYPE OF BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL: 1.5'

TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 81'

ELEVATION / DEPTH TOP OF SCREEN: 84'

TYPE OF SCREEN: schedule 40 PVC

SLOT SIZE x LENGTH: 0.02" x 10'

I.D. OF SCREEN: 2"

TYPE OF SAND PACK: no. 2

ELEVATION / DEPTH BOTTOM OF SCREEN: 94'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 95.5'

TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite

ELEVATION / DEPTH OF HOLE: 142.5'

HALLIBURTON NUS
Environmental Corporation

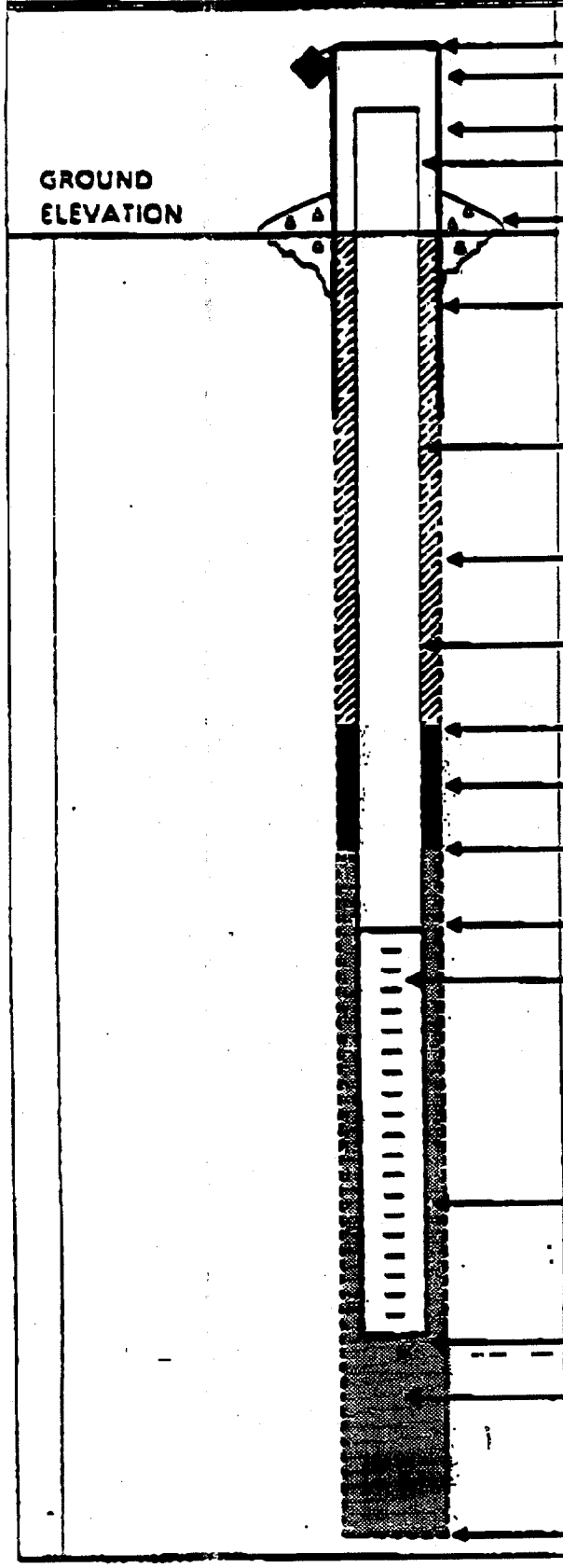
BORING NO. _____

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO 1412
ELEVATION _____
FIELD GEOLOGIST V. Shickora

LOCATION _____
BORING HN-61-IZ
DATE 12/21/95.

DRILLER Raab
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____
TYPE OF SURFACE SEAL: bentonite
I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC
BOREHOLE DIAMETER: 6"
TYPE OF BACKFILL: bentonite
ELEVATION / DEPTH TOP OF SEAL: 6'
TYPE OF SEAL: bentonite
DEPTH TOP OF SAND PACK: 110'
ELEVATION / DEPTH TOP OF SCREEN: 112.5
TYPE OF SCREEN: schedule 40 PVC
SLOT SIZE x LENGTH: 0.02" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: no. 2
ELEVATION / DEPTH BOTTOM OF SCREEN: 122.5
ELEVATION / DEPTH BOTTOM OF SAND PACK: 124.5
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite
ELEVATION / DEPTH OF HOLE: 142

HALLIBURTON NUS
Environmental Corporation

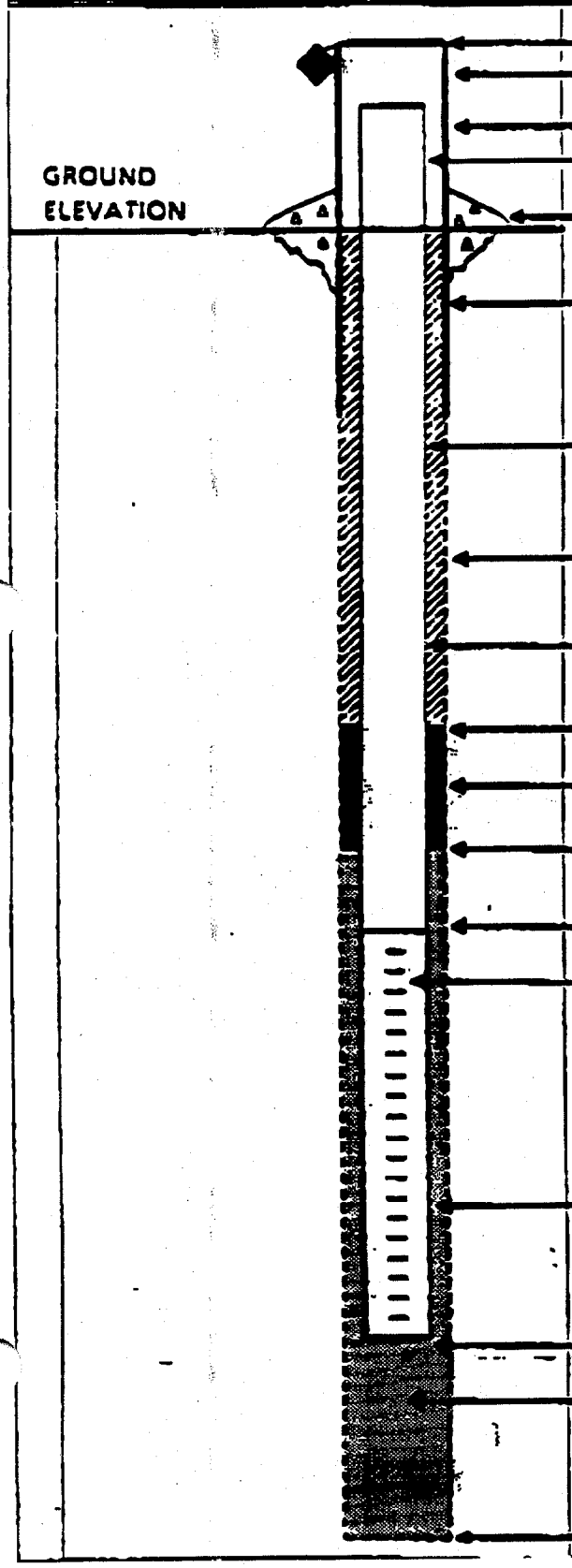
BORING NO _____

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION _____
FIELD GEOLOGIST Vince Shickora

LOCATION _____
BORING HN-625
DATE 12/21/96

DRILLER Reab
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE : _____

TYPE OF SURFACE SEAL: bentonite

I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 6"

TYPE OF BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL: 6'

TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 35'

ELEVATION / DEPTH TOP OF SCREEN: 38'

TYPE OF SCREEN: schedule 40 PVC

SLOT SIZE x LENGTH: 0.02" x 10'

I.D. OF SCREEN: 2"

TYPE OF SAND PACK: no. 2

ELEVATION / DEPTH BOTTOM OF SCREEN: 48'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 50'

TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite

ELEVATION / DEPTH OF HOLE: 57.2'

HALLIBURTON NUS
Environmental Corporation

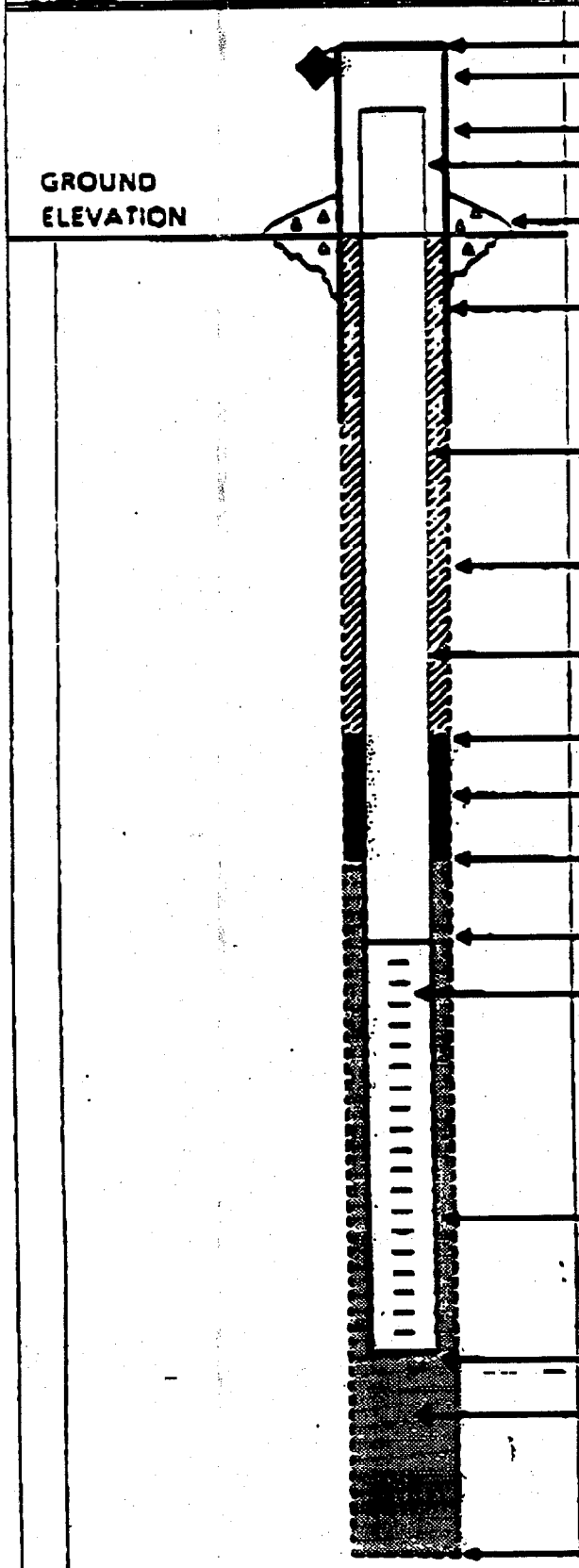
BORING NO. _____

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION _____
FIELD GEOLOGIST V. Shickera

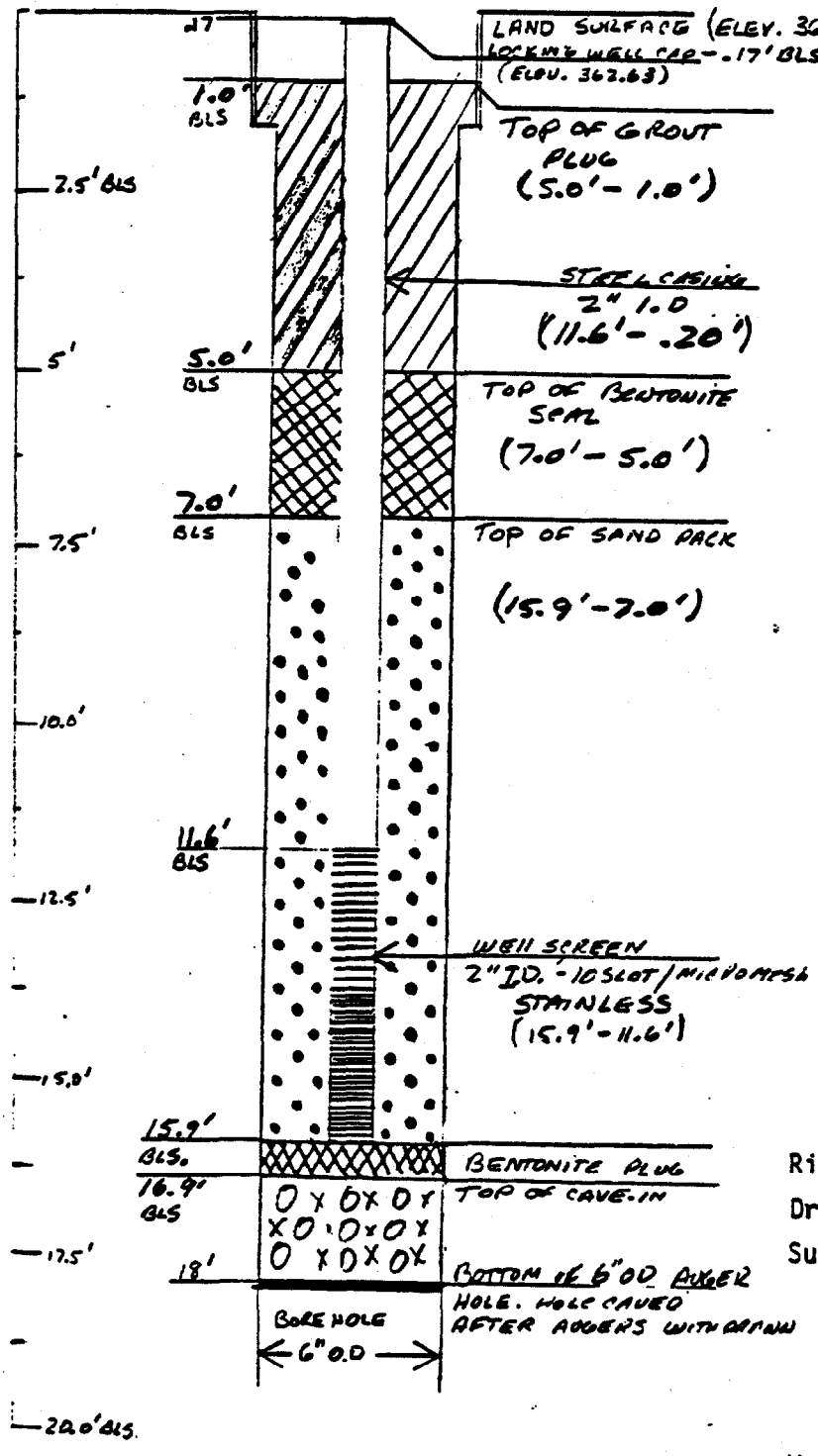
LOCATION _____
BORING HN-62I
DATE 12/21/95

DRILLER Raab
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____
TYPE OF SURFACE SEAL: bentonite
I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC
BOREHOLE DIAMETER: 6"
TYPE OF BACKFILL: bentonite
ELEVATION / DEPTH TOP OF SEAL: 6'
TYPE OF SEAL: bentonite
DEPTH TOP OF SAND PACK: 70.5'
ELEVATION / DEPTH TOP OF SCREEN: 73'
TYPE OF SCREEN: schedule 40 PVC
SLOT SIZE x LENGTH: 0.02" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: no. 2
ELEVATION / DEPTH BOTTOM OF SCREEN: 83'
ELEVATION / DEPTH BOTTOM OF SAND PACK: 85.5
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite
ELEVATION / DEPTH OF HOLE: 140'

AS-BUILT DRAWING



CHECKLIST

Land Surface Elevation 362.8'

Casing Height Above L-S -.17'

Total Depth BORE HOLE (OPEN) 15.9

Borehole Diameter 6" OD

Casing Diameter 2" ID

Casing Thickness N/A

Casing Lengths 8.4'

Screen Data

- Material STAINLESS
- Diameter 2" ID
- Slot Openings 10 SLOT/MM.
- Settings 11.6' - 15.9' BLS

Centralizers NONE

Grout Type Portland

Gravel Pack [illegible]

K-Fittings NONE

Packers NONE

Cement Baskets NONE

Rig Type MOBILE B-56.

Driller LARRY CISLER - SCI

Supervisory Geologist ED TOKARSKI - JRB.

Well No. BG-1 (HN63-X)

Project NADC - WARMINSTER

Location SOUTH OF AIRFIELD - UPGRAD. OF SITE #6.

Date DRILLED 7/17/82

Prepared By: E TOKARSKI 10/4/82

Scale: 1 INCH = 2.5 FEET

JRB-600/03-b

HALLIBURTON NUS
Environmental Corporation

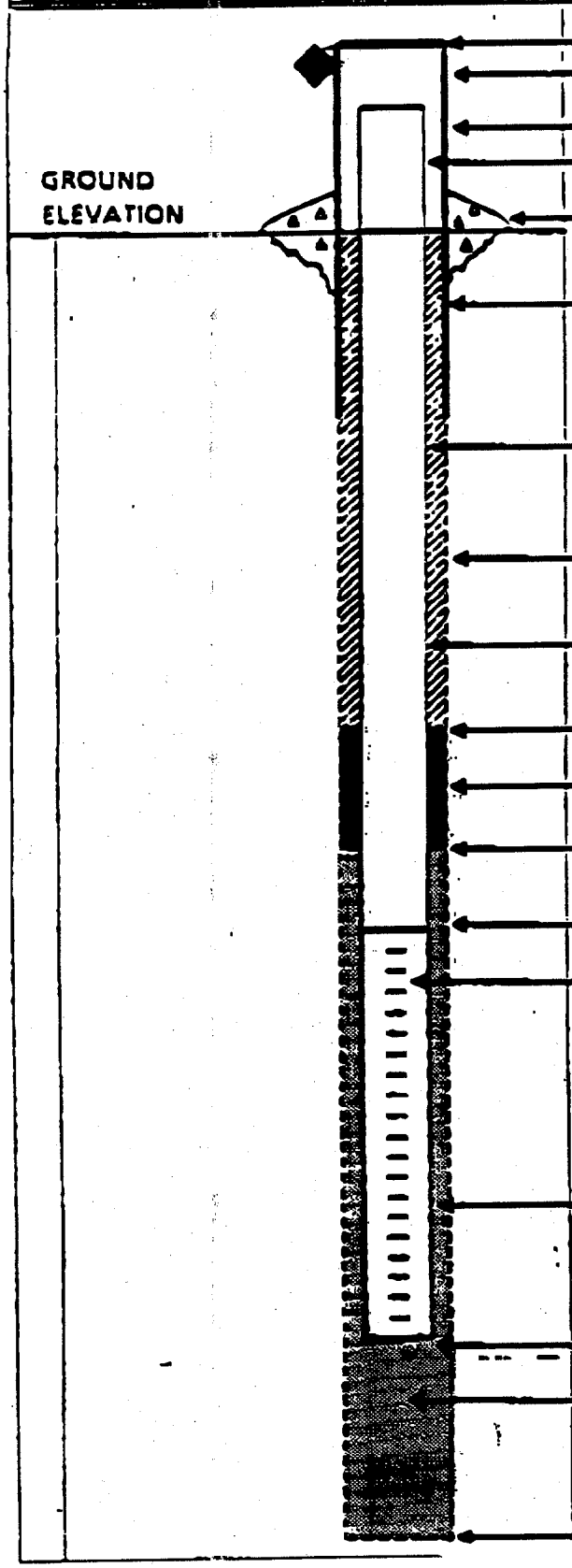
BORING NO _____

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION _____
FIELD GEOLOGIST C. Meyer

LOCATION _____
BORING HN-635
DATE 4/26/96

DRILLER Reed
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC
BOREHOLE DIAMETER: 6"
TYPE OF BACKFILL: bentonite
ELEVATION / DEPTH TOP OF SEAL: 5'
TYPE OF SEAL: bentonite
DEPTH TOP OF SAND PACK: 27'
ELEVATION / DEPTH TOP OF SCREEN: 31'
TYPE OF SCREEN: schedule 40 PVC
SLOT SIZE x LENGTH: 0.02" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: no. 2
ELEVATION / DEPTH BOTTOM OF SCREEN: 41'
ELEVATION / DEPTH BOTTOM OF SAND PACK: 46'
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite
ELEVATION / DEPTH OF HOLE: 54'

HALLIBURTON NUS
Environmental Corporation

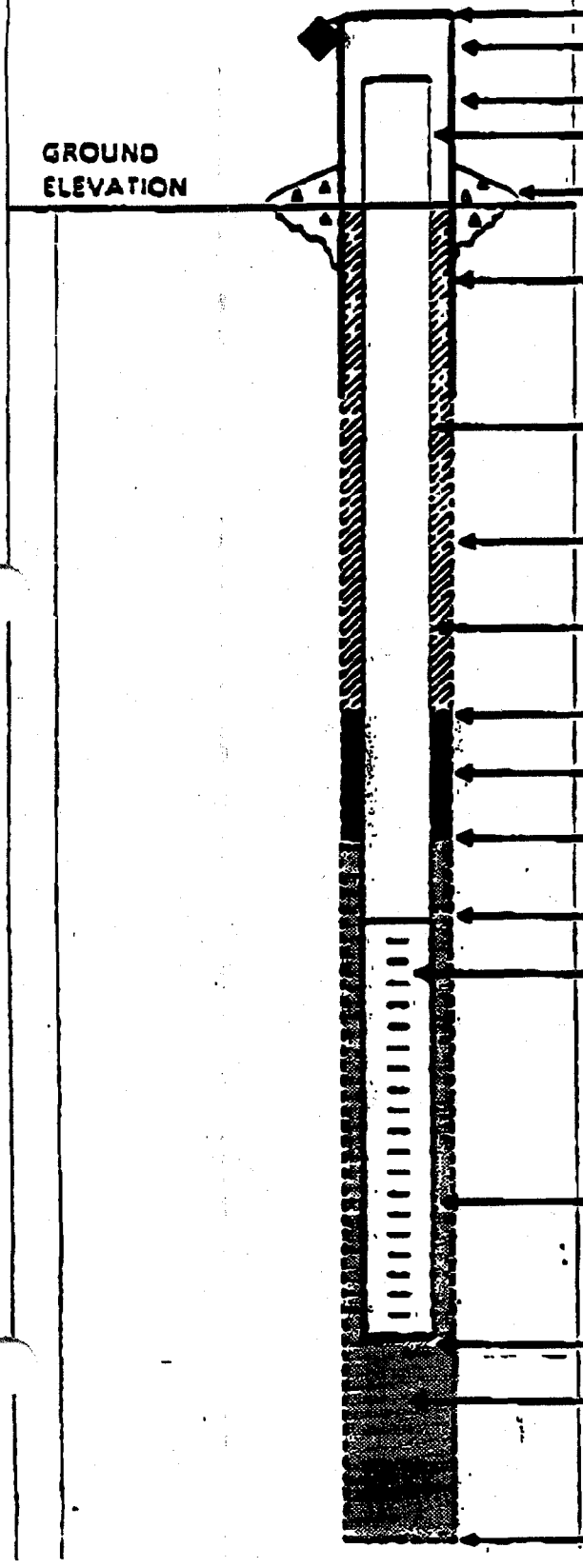
BORING NO _____

MONITORING WELL SHEET

PROJECT NAWC Warminster
PROJECT NO. 1412
ELEVATION _____
FIELD GEOLOGIST C. Meyer

LOCATION _____
BORING HN-645
DATE 4/26/96

DRILLER Reed
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC
BOREHOLE DIAMETER: 6"
TYPE OF BACKFILL: bentonite
ELEVATION / DEPTH TOP OF SEAL: 6'
TYPE OF SEAL: bentonite
DEPTH TOP OF SAND PACK: 29'
ELEVATION / DEPTH TOP OF SCREEN: 33'
TYPE OF SCREEN: schedule 40 PVC
SLOT SIZE x LENGTH: 0.02" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: no. 2
ELEVATION / DEPTH BOTTOM OF SCREEN: 48'
ELEVATION / DEPTH BOTTOM OF SAND PACK: 50'
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite
ELEVATION / DEPTH OF HOLE: 104'

HALLIBURTON NUS
Environmental Corporation

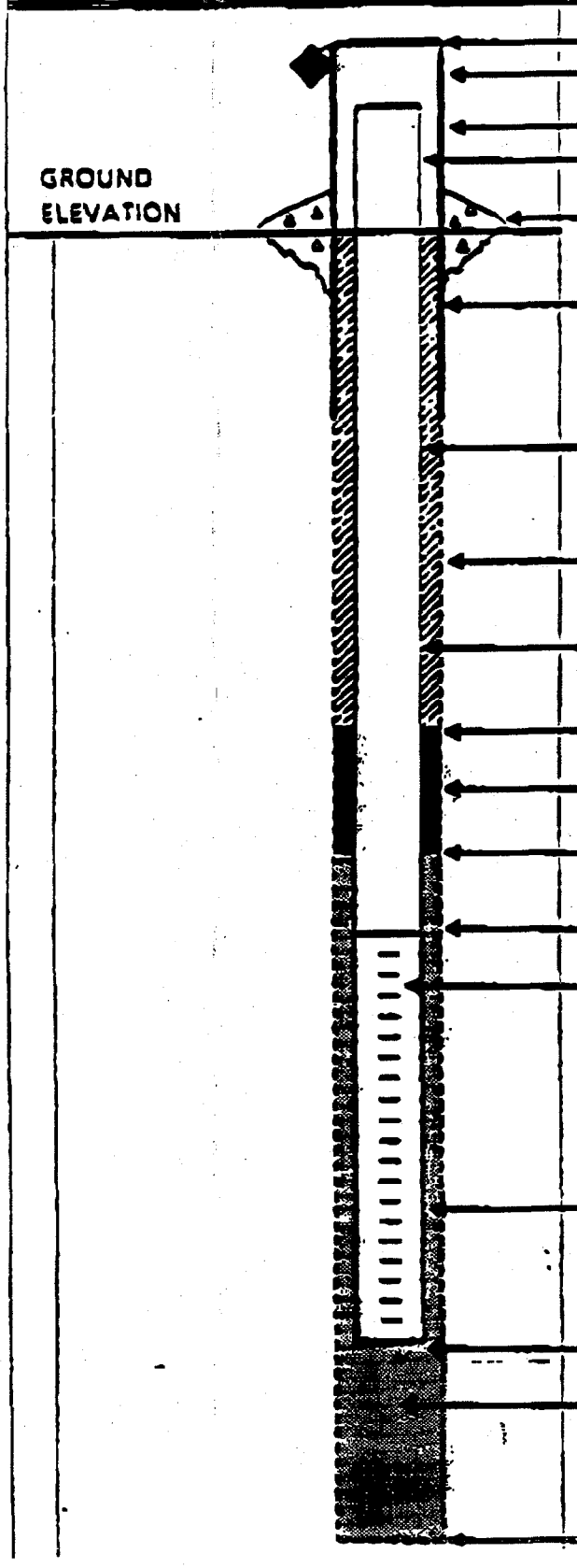
BORING NO _____

MONITORING WELL SHEET

PROJECT NAVC Warminster
PROJECT NO. 1412
ELEVATION _____
FIELD GEOLOGIST C. Meyer

LOCATION _____
BORING HN-64I
DATE 4/26/96

DRILLER Rack
DRILLING METHOD air hammer
DEVELOPMENT METHOD submersible pump



ELEVATION OF TOP OF SURFACE CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____
STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE: _____
TYPE OF SURFACE SEAL: bentonite
I.D. OF SURFACE CASING: 6"
TYPE OF SURFACE CASING: steel
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC
BOREHOLE DIAMETER: 6"
TYPE OF BACKFILL: bentonite
ELEVATION / DEPTH TOP OF SEAL: 5'
TYPE OF SEAL: bentonite
DEPTH TOP OF SAND PACK: 82'
ELEVATION / DEPTH TOP OF SCREEN: 89'
TYPE OF SCREEN: schedule 40 PVC
SLOT SIZE x LENGTH: 0.02" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: no. 2
ELEVATION / DEPTH BOTTOM OF SCREEN: 99'
ELEVATION / DEPTH BOTTOM OF SAND PACK: 104'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A
ELEVATION / DEPTH OF HOLE: 104'

BROWN & ROOT ENVIRONMENTAL

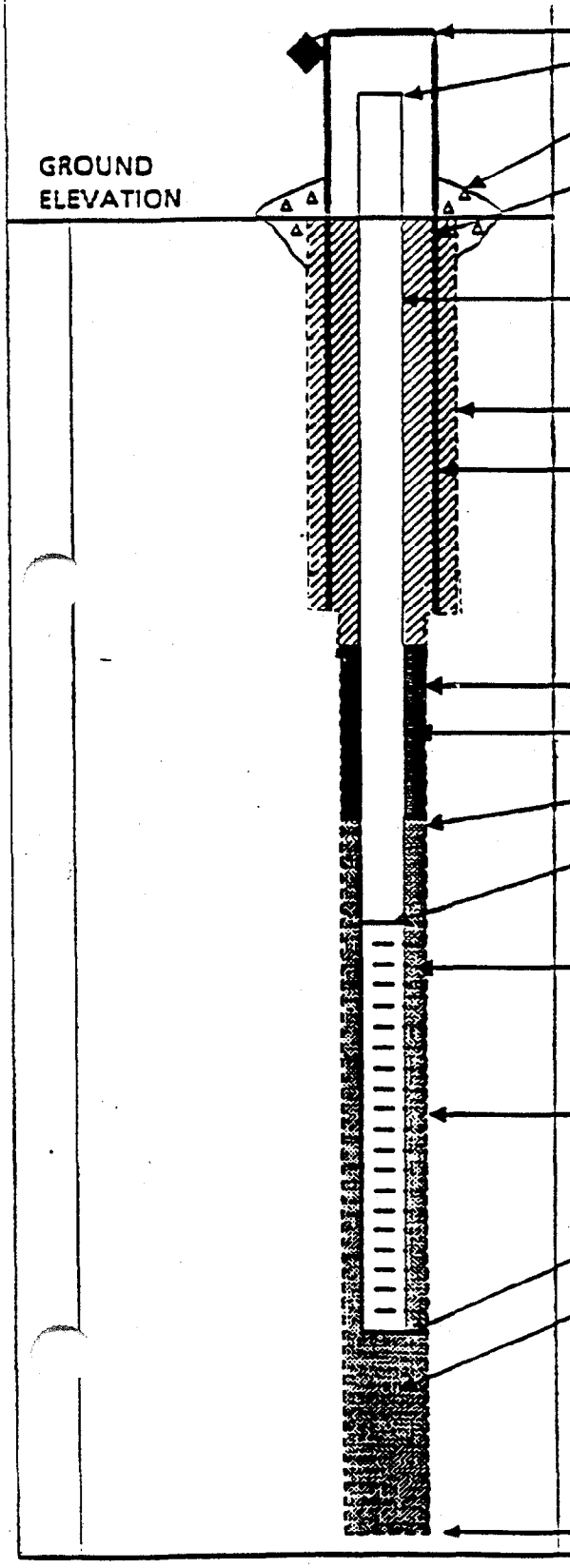
BORING NO. 7601-U.S.-017

MONITORING WELL SHEET

PROJECT: Warminster
PROJECT NO.: 7606
ELEVATION:
FIELD GEOLOGIST: D. Whalen

LOCATION:
BORING: HN 84S
DATE: 5/26/98

DRILLER: Raab
DRILLING METHOD: air hammer
DEVELOPMENT METHOD: submersible pump



ELEVATION OF TOP OF PERM. CASING :
ELEVATION OF TOP OF RISER PIPE:

TYPE OF SURFACE SEAL: bentonite

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6"
TYPE OF CASING & BACKFILL: steel / bentonite

ELEVATION / DEPTH TOP OF SEAL: 2'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 36'

ELEVATION/DEPTH TOP OF SCREEN: 39'
TYPE OF SCREEN: schedule 40 PVC
0.02" slot size

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 49'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 51'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A

ELEVATION / DEPTH OF HOLE: 51'

BORING NO. _____

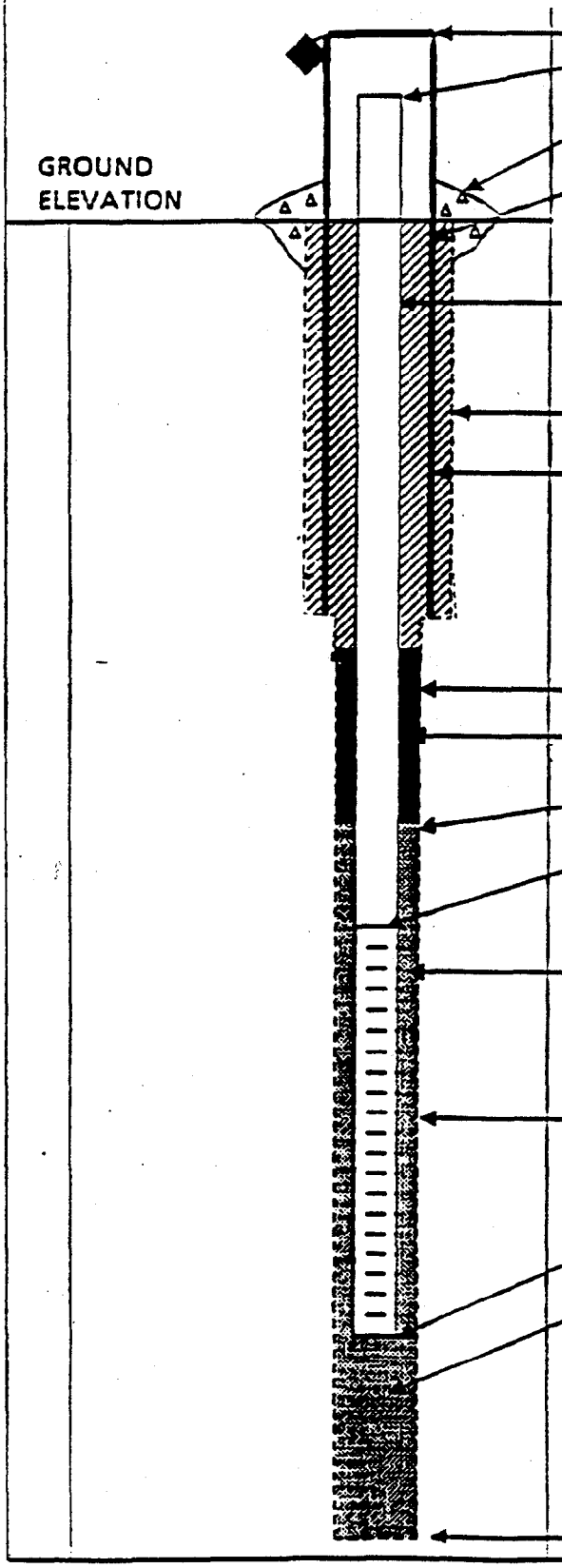
BROWN & ROOT ENVIRONMENTAL

MONITORING WELL SHEET

PROJECT: Warminster
PROJECT NO.: 7606
ELEVATION: _____
FIELD GEOLOGIST: D. Whalen

LOCATION: _____
BORING: HN 84I
DATE: 5/26/98

DRILLER: Raab
DRILLING METHOD: air hammer
DEVELOPMENT METHOD: submersible pump



ELEVATION OF TOP OF PERM. CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: bentonite

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 pvc

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6" steel
TYPE OF CASING & BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL: 2'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 107.5'

ELEVATION/DEPTH TOP OF SCREEN: 110'
TYPE OF SCREEN: schedule 40 PVC

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 120'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 120'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A

ELEVATION / DEPTH OF HOLE: 120'

BORING NO. _____

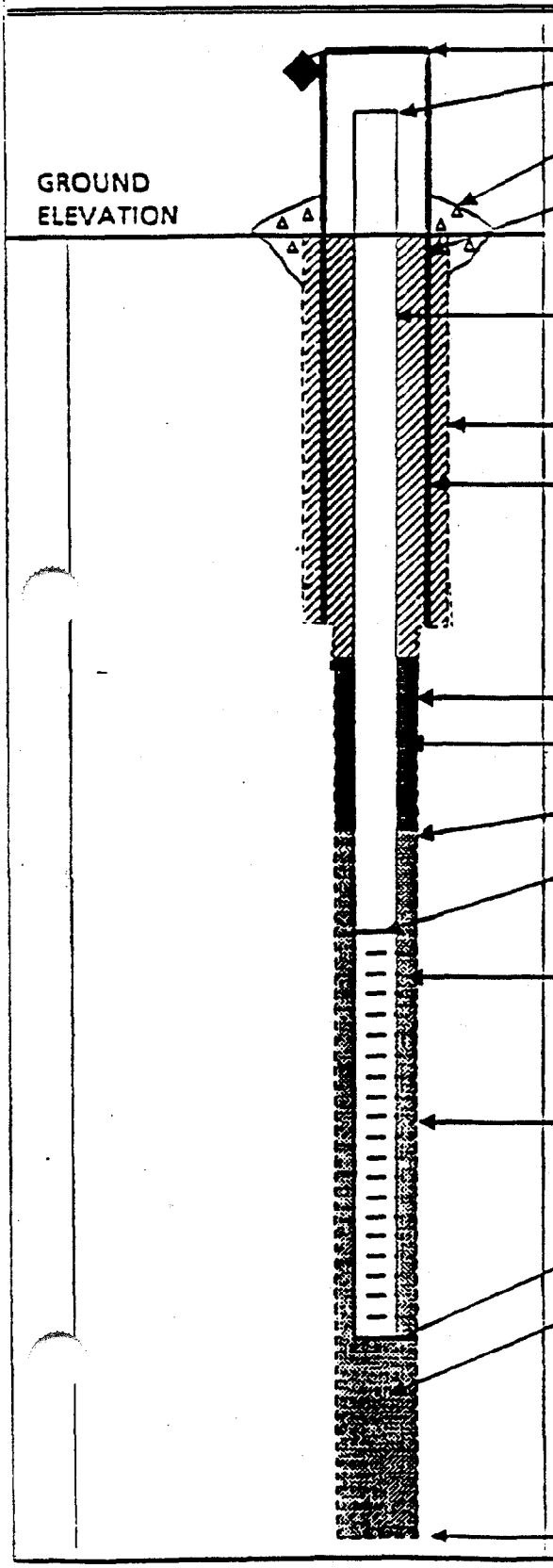
BROWN & ROOT ENVIRONMENTAL

MONITORING WELL SHEET

PROJECT Warminster
PROJECT NO. 7606
ELEVATION
FIELD GEOLOGIST D. Whalen

LOCATION
BORING #N855
DATE 5/26/98

DRILLER Raab
DRILLING METHOD air hammer
DEVELOPMENT METHOD Submersible pump



ELEVATION OF TOP OF PERM. CASING :
ELEVATION OF TOP OF RISER PIPE:

TYPE OF SURFACE SEAL: bentonite

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6" steel
TYPE OF CASING & BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL: 2'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 19

ELEVATION/DEPTH TOP OF SCREEN: 19.5
TYPE OF SCREEN: schedule 40 PVC .02" slot size

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 29.5'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 34'
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite

ELEVATION / DEPTH OF HOLE: 43'

BORING NO. _____

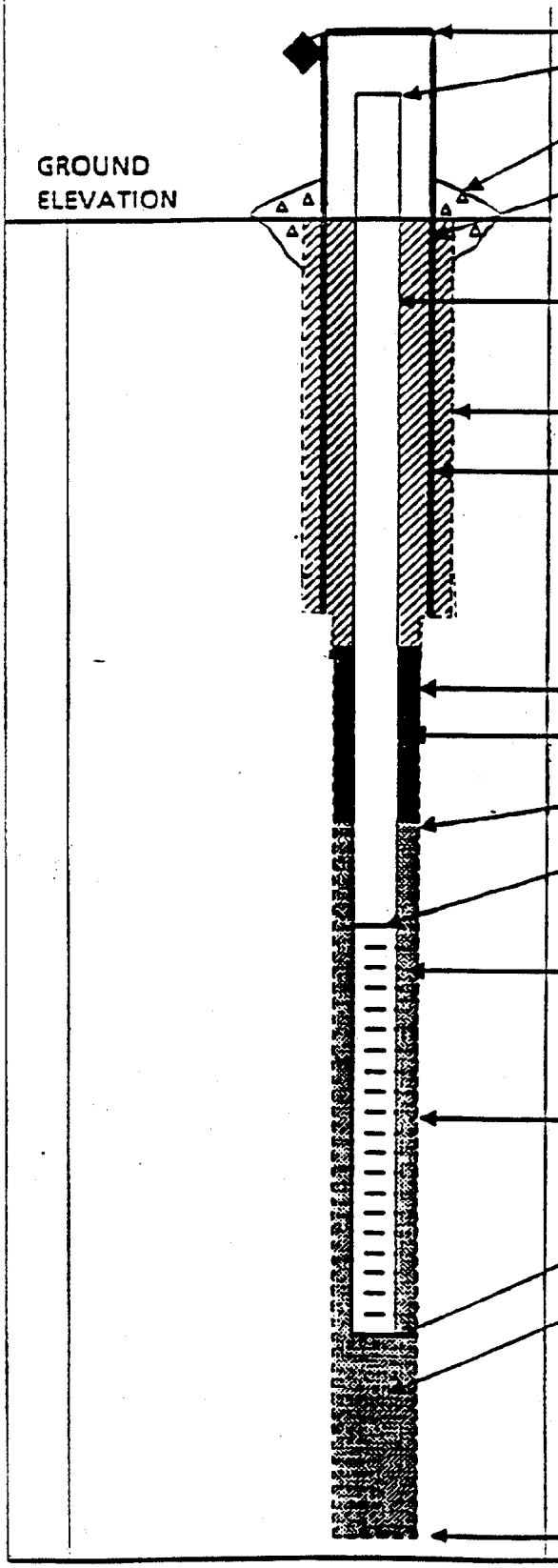
BROWN & ROOT ENVIRONMENTAL

MONITORING WELL SHEET

PROJECT: Warminster
PROJECT NO.: 7606
ELEVATION: _____
FIELD GEOLOGIST: D. Whalen

LOCATION: _____
BORING: HN 85 I
DATE: 5/26/98

DRILLER: Kaab
DRILLING METHOD: air hammer
DEVELOPMENT METHOD: submersible pump



ELEVATION OF TOP OF PERM. CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: bentonite

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6"
TYPE OF CASING & BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL: 2'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 72

ELEVATION/DEPTH TOP OF SCREEN: 74.5
TYPE OF SCREEN: schedule 40 PVC
0.02" slot size

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 84.5

ELEVATION / DEPTH BOTTOM OF SAND PACK: 85.5'
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite

ELEVATION / DEPTH OF HOLE: 94'

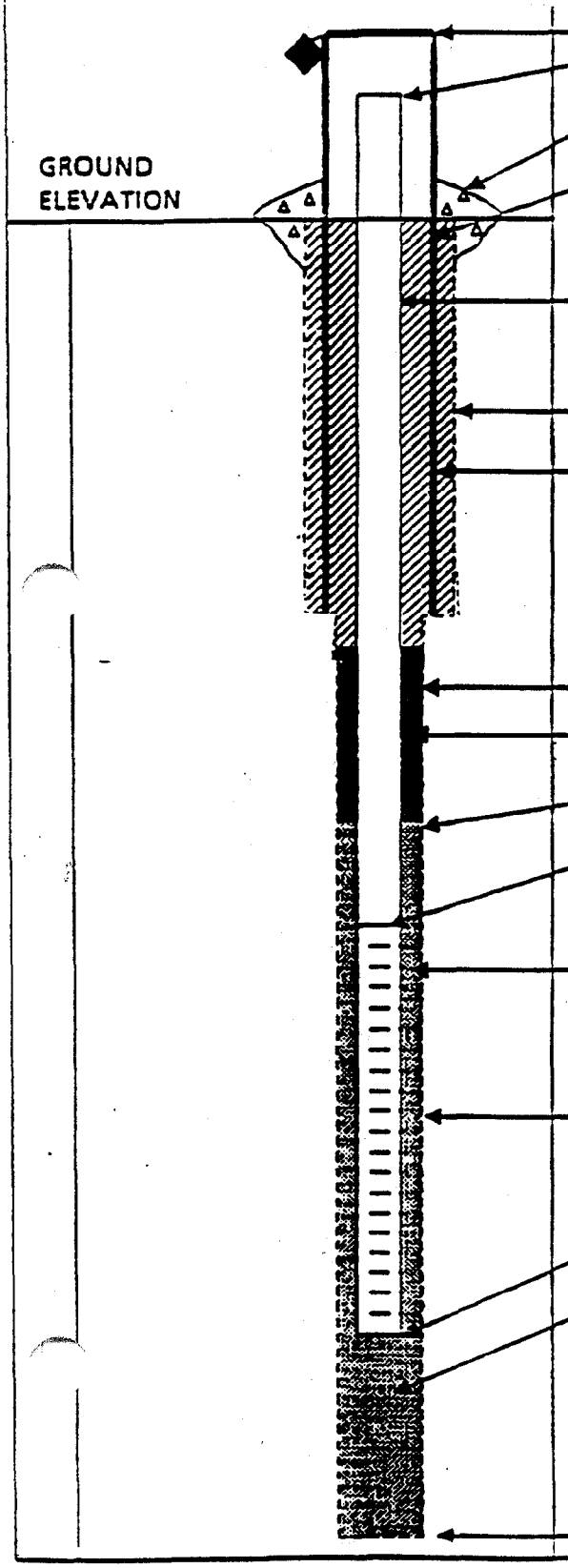
BORING NO.: _____

BROWN & ROOT ENVIRONMENTAL

MONITORING WELL SHEET

PROJECT: Warminster
PROJECT NO.: 7606
ELEVATION: _____
FIELD GEOLOGIST: D. Whalen
LOCATION: _____
BORING: HN 865
DATE: 5/28/98

DRILLER: Raab
DRILLING METHOD: air hammer
DEVELOPMENT METHOD: submersible pump



ELEVATION OF TOP OF PERM. CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: bentonite

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6" steel
TYPE OF CASING & BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL: 2'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 34.5'

ELEVATION/DEPTH TOP OF SCREEN: 38.5'
TYPE OF SCREEN: schedule 40 PVC

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 48.5

ELEVATION / DEPTH BOTTOM OF SAND PACK: 52'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A

ELEVATION / DEPTH OF HOLE: 52'

BORING NO. _____

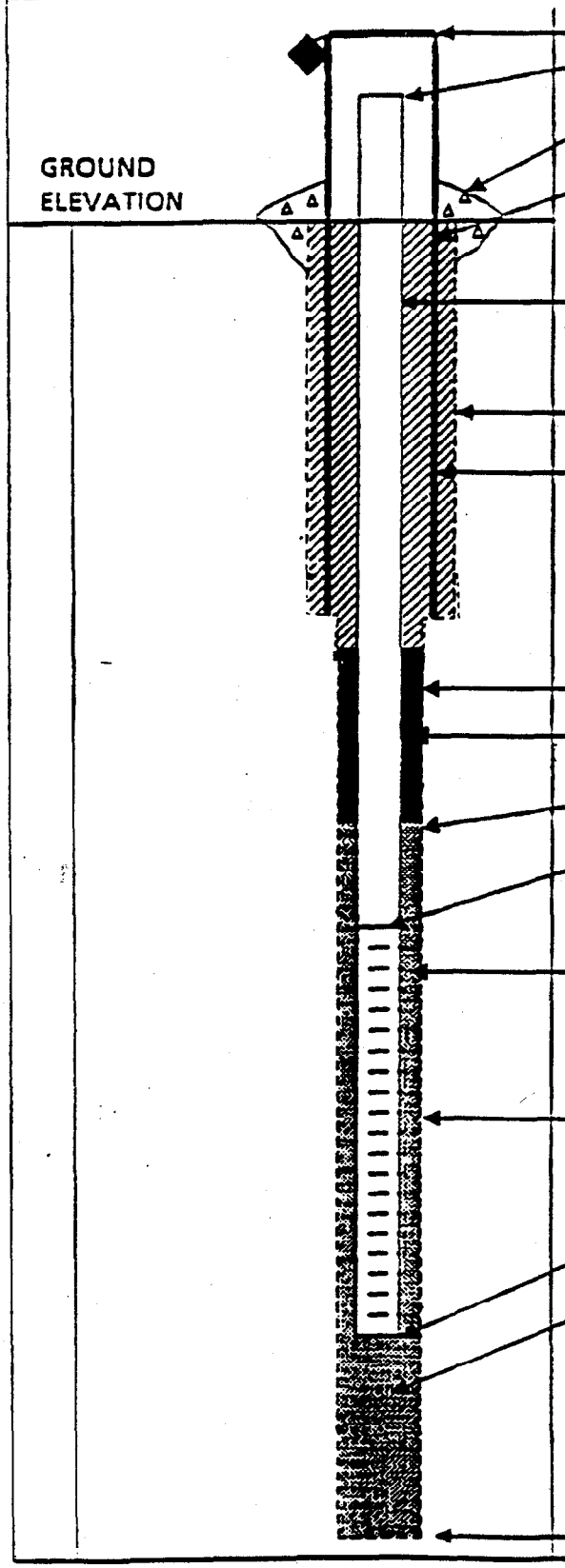
BROWN & ROOT ENVIRONMENTAL

MONITORING WELL SHEET

PROJECT: Warminster
PROJECT NO.: 7606
ELEVATION: _____
FIELD GEOLOGIST: D. Whalen

LOCATION: _____
BORING: HN 86 I
DATE: 5/26/98

DRILLER: Raab
DRILLING METHOD: air hammer
DEVELOPMENT METHOD: submersible pump



ELEVATION OF TOP OF PERM. CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: bentonite

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: _____

PERM. CASING I.D. 6" steel
TYPE OF CASING & BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL: 2'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 72'

ELEVATION/DEPTH TOP OF SCREEN: 75'
TYPE OF SCREEN: schedule 40 PVC
0.02" slot size

TYPE OF SAND PACK: no. 2

BOREHOLE DIA. BELOW CASING: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: 85'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 86
TYPE OF BACKFILL BELOW OBSERVATION WELL: bentonite

ELEVATION / DEPTH OF HOLE: 102

BORING NO.: _____

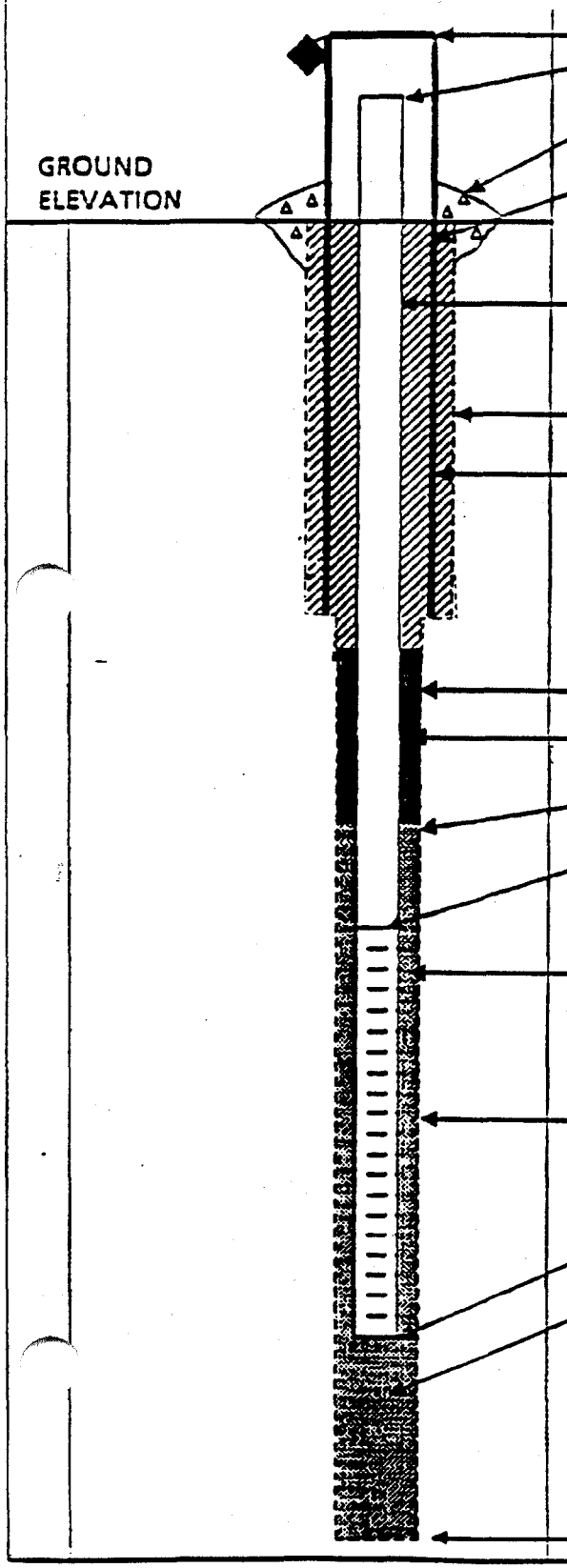
BROWN & ROOT ENVIRONMENTAL

MONITORING WELL SHEET

PROJECT: Warminster
PROJECT NO.: 7606
ELEVATION: _____
FIELD GEOLOGIST: D. Whalen

LOCATION: _____
BORING: HN 875
DATE: 5/26/98

DRILLER: Raab
DRILLING METHOD: air hammer
DEVELOPMENT METHOD: submersible pump



ELEVATION OF TOP OF PERM. CASING: _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: bentonite

I.D. OF PERM. CASING: 6"
TYPE OF SURFACE CASING: steel

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: schedule 40 PVC

BOREHOLE DIAMETER: 10"

PERM. CASING I.D. 6" steel
TYPE OF CASING & BACKFILL: bentonite

ELEVATION / DEPTH TOP OF SEAL: 2'
TYPE OF SEAL: bentonite

DEPTH TOP OF SAND PACK: 46.5'

ELEVATION/DEPTH TOP OF SCREEN: 49'
TYPE OF SCREEN: schedule 40 PVC
0.02" slot size

TYPE OF SAND PACK: no. 2

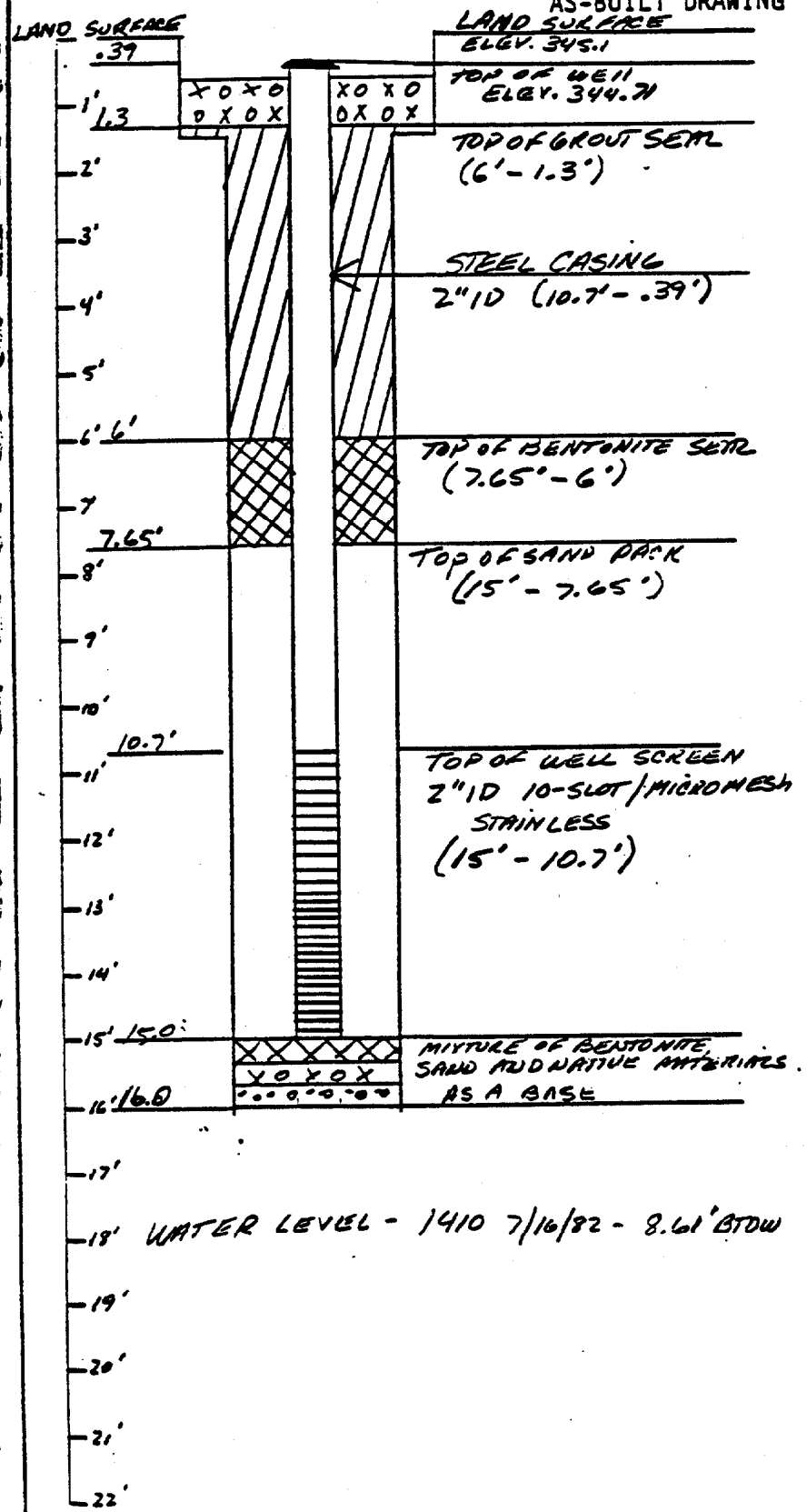
BOREHOLE DIA. BELOW CASING: 6"

ELEVATION / DEPTH BOTTOM OF SCREEN: 59'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 62'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A

ELEVATION / DEPTH OF HOLE: 62'

AS-BUILT DRAWING



CHECKLIST

Land Surface Elevation 345.1

Casing Height Above L-S -.39

Total Depth 16.1'

Borehole Diameter 6" O.D.

Casing Diameter 2" I.D.

~~Casing Thickness~~

Casing Lengths 10.31'

Screen Data

- Material STAINLESS
- Diameter 2" I.D.
- Slot Openings 10 SLOT/MM
- Settings 15'-10.7'

~~Centralizers~~

Grout Type PORTLAND

Gravel Pack SILICA.

~~K-Fittings~~

~~Packers~~

~~Cement Baskets~~

Rig Type MOBILE B-56

Driller LARRY CISLER - SCI

Supervisory Geologist ED TOKARSKI - JRB.

Well No. DG-10

Project NADC - WARMINSTER, PA

Location EAST WELL DG-9. N. OF HOUSING DOWNGRADIENT OF SITE #6.

Date DRILLED 7/16/82

Prepared By: ED TOKARSKI 10/6/82

Scale: AS SHOWN

JRB-600/03-b

APPENDIX B

SUMMARY OF ANALYTICAL RESULTS

APPENDIX B.1

SUMMARY OF SHALLOW ZONE ANALYTICAL RESULTS

ANALYTIC ATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-DG-17 06/11/98 16.5-38	W-DG-19 06/18/98 21.75-47	W-HN-01S 06/10/98 18.5-37	W-HN-020 06/15/98 W-HN-020-DUP 6.2-13.2	W-HN-020-DUP 06/15/98 W-HN-020 6.2-13.2	W-HN-02S 06/12/98 W-HN-02S-DUP 15-33	W-HN-02S-DUP 06/12/98 W-HN-02S 15-33
INORGANICS							
Aluminum	NA	37.4 B	71.3 B	13 B	36.4 B	NA	NA
Antimony	NA	1.8 U	1.8 U	1.8 U	1.8 U	NA	NA
Arsenic	NA	2.4	2.1 U	2.1 U	2.1 U	NA	NA
Barium	NA	238	4.6	51	48.2	NA	NA
Beryllium	NA	0.2 U	0.2 U	0.2 U	0.2 U	NA	NA
Cadmium	NA	0.3 U	0.3 U	0.3 U	0.3 U	NA	NA
Calcium	NA	60900	7120	38400	36100	NA	NA
Chromium	NA	0.8 U	2.8	1.3	1.6	NA	NA
Cobalt	NA	0.4 U	0.4 U	0.4 U	0.44	NA	NA
Copper	NA	3.3 B	0.93 B	1.6 B	1.5 B	NA	NA
Cyanide	NA	10 U	10 UL	10 UL	10 UL	NA	NA
Iron	NA	12.5 U	212	12.5 UL	93.3 B	NA	NA
Lead	NA	1.7 UJ	1.7 UJ	1.7 UJ	1.7 UJ	NA	NA
Magnesium	NA	17700	3120	18200	17200	NA	NA
Manganese	NA	8.5	21.4	1 B	2.4 B	NA	NA
Mercury	NA	0.1 U	0.1 UL	0.1 U	0.1 U	NA	NA
Nickel	NA	0.8	3.3	1.6 B	2.3 B	NA	NA
Potassium	NA	1330 J	708 B	1520 J	1510 J	NA	NA
Selenium	NA	2.2 U	1.6 UJ	2.2 U	2.2 U	NA	NA
Silver	NA	0.7 U	0.7 U	0.7 U	0.7 U	NA	NA
Sodium	NA	12700	7360	17500	17700	NA	NA
Thallium	NA	3.1 UL	3.1 UL	3.1 UL	3.1 UL	NA	NA
Vanadium	NA	0.6 U	0.6 U	0.6 U	0.6 U	NA	NA
Zinc	NA	10.8 B	1.6 B	4.7 B	9.9 B	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-DG-17 06/11/98 16.5-38	W-DG-19 06/18/98 21.75-47	W-HN-01S 06/10/98 18.5-37	W-HN-020 06/15/98 W-HN-020-DUP 6.2-13.2	W-HN-020-DUP 06/15/98 W-HN-020 6.2-13.2	W-HN-02S 06/12/98 W-HN-02S-DUP 15-33	W-HN-02S-DUP 06/12/98 W-HN-02S 15-33
SEMIVOLATILES							
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA	NA
2-Chlorophenol	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	NA	NA	NA	NA
2-Nitroaniline	NA	NA	NA	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA	NA
3-Nitroaniline	NA	NA	NA	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA	NA
4-Chloroaniline	NA	NA	NA	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA	NA	NA	NA
Benz(a)anthracene	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA

ANALYTIC ATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-DG-17 06/11/98 16.5-38	W-DG-19 06/18/98 21.75-47	W-HN-01S 06/10/98 18.5-37	W-HN-020 06/15/98 W-HN-020-DUP 6.2-13.2	W-HN-020-DUP 06/15/98 W-HN-020 6.2-13.2	W-HN-02S 06/12/98 W-HN-02S-DUP 15-33	W-HN-02S-DUP 06/12/98 W-HN-02S 15-33
SEMIVOLATILES							
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	NA	NA	NA	NA	NA	NA	NA
Carbazole	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA	NA	NA	NA
Dimethylphthalate	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA	NA
Hexachlorobenzene	NA	NA	NA	NA	NA	NA	NA
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA
Isophorone	NA	NA	NA	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	NA	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA	NA	NA
Nitrobenzene	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA
Phenol	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-DG-17 06/11/98 16.5-38	W-DG-19 06/18/98 21.75-47	W-HN-01S 06/10/98 18.5-37	W-HN-020 06/15/98 W-HN-020-DUP 6.2-13.2	W-HN-020-DUP 06/15/98 W-HN-020 6.2-13.2	W-HN-02S 06/12/98 W-HN-02S-DUP 15-33	W-HN-02S-DUP 06/12/98 W-HN-02S 15-33
VOLATILES							
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 UR	5 U	5 U	5 UR	5 UR	5 UR	5 UR
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U

ANALYTIC. ATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-DG-17 06/11/98 16.5-38	W-DG-19 06/18/98 21.75-47	W-HN-01S 06/10/98 18.5-37	W-HN-020 06/15/98 W-HN-020-DUP 6.2-13.2	W-HN-020-DUP 06/15/98 W-HN-020 6.2-13.2	W-HN-02S 06/12/98 W-HN-02S-DUP 15-33	W-HN-02S-DUP 06/12/98 W-HN-02S 15-33
VOLATILES							
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methylene Chloride	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	1 U	2	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U	1 U
PESTICIDES/PCBS							
4,4'-DDD	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA	NA	NA	NA
Alpha-BHC	NA	NA	NA	NA	NA	NA	NA
Alpha-Chlordane	NA	NA	NA	NA	NA	NA	NA
Aroclor-1016	NA	NA	NA	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	NA	NA	NA	NA
Aroclor-1242	NA	NA	NA	NA	NA	NA	NA
Aroclor-1248	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254	NA	NA	NA	NA	NA	NA	NA
Aroclor-1260	NA	NA	NA	NA	NA	NA	NA
Beta-BHC	NA	NA	NA	NA	NA	NA	NA
Delta-BHC	NA	NA	NA	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA	NA	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID:	W-DG-17	W-DG-19	W-HN-01S	W-HN-020	W-HN-020-DUP	W-HN-02S	W-HN-02S-DUP
Sample Date:	06/11/98	06/18/98	06/10/98	06/15/98	06/15/98	06/12/98	06/12/98
Duplicate:				W-HN-020-DUP	W-HN-020	W-HN-02S-DUP	W-HN-02S
Screen:	16.5-38	21.75-47	18.5-37	6.2-13.2	6.2-13.2	15-33	15-33
PESTICIDES/PCBS							
Endosulfan Sulfate	NA	NA	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA	NA	NA
Endrin Aldehyde	NA	NA	NA	NA	NA	NA	NA
Endrin Ketone	NA	NA	NA	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	NA	NA	NA	NA	NA	NA
Gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA
Heptachlor Epoxide	NA	NA	NA	NA	NA	NA	NA
Methoxychlor	NA	NA	NA	NA	NA	NA	NA
Toxaphene	NA	NA	NA	NA	NA	NA	NA

ANALYTIC. ATABASE
SHALLOW WELLS

Sample ID:	W-HN-03S	W-HN-05S	W-HN-10S	W-HN-290	W-HN-29S	W-HN-29X	W-HN-35S	W-HN-36S
Sample Date:	06/16/98	06/10/98	06/23/98	06/24/98	06/23/98	06/23/98	06/15/98	06/11/98
Duplicate:								
Screen:	17.6-32	36-55	26-40		?	?	35-48	22-27
INORGANICS								
Aluminum	NA	NA	NA	NA	NA	NA	NA	340 K
Antimony	NA	NA	NA	NA	NA	NA	NA	1.8 U
Arsenic	NA	NA	NA	NA	NA	NA	NA	2.1 U
Barium	NA	NA	NA	NA	NA	NA	NA	193
Beryllium	NA	NA	NA	NA	NA	NA	NA	0.2 U
Cadmium	NA	NA	NA	NA	NA	NA	NA	0.3 U
Calcium	NA	NA	NA	NA	NA	NA	NA	41300
Chromium	NA	NA	NA	NA	NA	NA	NA	2.4
Cobalt	NA	NA	NA	NA	NA	NA	NA	2
Copper	NA	NA	NA	NA	NA	NA	NA	1.1 B
Cyanide	NA	NA	NA	NA	NA	NA	NA	10 UL
Iron	NA	NA	NA	NA	NA	NA	NA	210
Lead	NA	NA	NA	NA	NA	NA	NA	2.4 J
Magnesium	NA	NA	NA	NA	NA	NA	NA	14300
Manganese	NA	NA	NA	NA	NA	NA	NA	69.8
Mercury	NA	NA	NA	NA	NA	NA	NA	0.1 UL
Nickel	NA	NA	NA	NA	NA	NA	NA	7.1
Potassium	NA	NA	NA	NA	NA	NA	NA	2290 J
Selenium	NA	NA	NA	NA	NA	NA	NA	1.6 UJ
Silver	NA	NA	NA	NA	NA	NA	NA	0.7 U
Sodium	NA	NA	NA	NA	NA	NA	NA	20700
Thallium	NA	NA	NA	NA	NA	NA	NA	3.1 UL
Vanadium	NA	NA	NA	NA	NA	NA	NA	0.6 U
Zinc	NA	NA	NA	NA	NA	NA	NA	4 B

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-03S 06/16/98 17.6-32	W-HN-05S 06/10/98 36-55	W-HN-10S 06/23/98 26-40	W-HN-290 06/24/98	W-HN-29S 06/23/98 ?	W-HN-29X 06/23/98 ?	W-HN-35S 06/15/98 35-48	W-HN-36S 06/11/98 22-27
SEMIVOLATILES								
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA	NA	NA
2-Chlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA	NA	NA
3-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benz(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA

ANALYTIC ATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-03S 06/16/98 17.6-32	W-HN-05S 06/10/98 36-55	W-HN-10S 06/23/98 26-40	W-HN-290 06/24/98	W-HN-29S 06/23/98 ?	W-HN-29X 06/23/98 ?	W-HN-35S 06/15/98 35-48	W-HN-36S 06/11/98 22-27
SEMIVOLATILES								
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Dimethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Isophorone	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA	NA	NA	NA
Nitrobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-03S 06/16/98 17.6-32	W-HN-05S 06/10/98 36-55	W-HN-10S 06/23/98 26-40	W-HN-290 06/24/98	W-HN-29S 06/23/98 ?	W-HN-29X 06/23/98 ?	W-HN-35S 06/15/98 35-48	W-HN-36S 06/11/98 22-27
VOLATILES								
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	2	1 U	1 U	1 U	1 U	1 U	1	2
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 UR	5 U	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U

ANALYTIC ATABASE
SHALLOW WELLS

Sample ID:	W-HN-03S	W-HN-05S	W-HN-10S	W-HN-290	W-HN-29S	W-HN-29X	W-HN-35S	W-HN-36S
Sample Date:	06/16/98	06/10/98	06/23/98	06/24/98	06/23/98	06/23/98	06/15/98	06/11/98
Duplicate:								
Screen:	17.6-32	36-55	26-40		?	?	35-48	22-27
VOLATILES								
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methylene Chloride	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	2	1 U	1 U	1 U	1 U	1 U	3	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	7	1 U	1 U	1 U	1 U	1 U	3	5 B
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
PESTICIDES/PCBS								
4,4'-DDD	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1016	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1242	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1248	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1260	NA	NA	NA	NA	NA	NA	NA	NA
Beta-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Delta-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA	NA	NA	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID:	W-HN-03S	W-HN-05S	W-HN-10S	W-HN-290	W-HN-29S	W-HN-29X	W-HN-35S	W-HN-36S
Sample Date:	06/16/98	06/10/98	06/23/98	06/24/98	06/23/98	06/23/98	06/15/98	06/11/98
Duplicate:								
Screen:	17.6-32	36-55	26-40		?	?	35-48	22-27
PESTICIDES/PCBS								
Endosulfan Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Aldehyde	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Ketone	NA	NA	NA	NA	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	NA	NA	NA	NA	NA	NA	NA
Gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor Epoxide	NA	NA	NA	NA	NA	NA	NA	NA
Methoxychlor	NA	NA	NA	NA	NA	NA	NA	NA
Toxaphene	NA	NA	NA	NA	NA	NA	NA	NA

ANALYTIC ATABASE
SHALLOW WELLS

Sample ID:	W-HN-37S	W-HN-38S	W-HN-38X	W-HN-38X-F	W-HN-39S	W-HN-39X	W-HN-41S	W-HN-43S
Sample Date:	06/16/98	06/16/98	06/18/98	06/18/98	06/19/98	06/22/98	06/22/98	06/22/98
Duplicate:								
Screen:	21-41	25-35	2-7	2-7	18-50	2-7	41-54	43-64
INORGANICS								
Aluminum	NA	NA	NA	43 B	70.8 B	502	NA	NA
Antimony	NA	NA	NA	1.8 U	1.8 U	1.8 U	NA	NA
Arsenic	NA	NA	NA	2.1 U	2.1 U	2.1 U	NA	NA
Barium	NA	NA	NA	35	114	30.3	NA	NA
Beryllium	NA	NA	NA	0.2 U	0.2 U	0.21	NA	NA
Cadmium	NA	NA	NA	0.3 U	0.3 U	0.3 U	NA	NA
Calcium	NA	NA	NA	5740	27000	3750	NA	NA
Chromium	NA	NA	NA	1.5	1	2.4	NA	NA
Cobalt	NA	NA	NA	0.4 U	0.96	0.4 U	NA	NA
Copper	NA	NA	NA	2.6 B	2.2 B	1.7 B	NA	NA
Cyanide	NA	NA	NA	10 U	10 U	10 U	NA	NA
Iron	NA	NA	NA	27.4 B	23.5 L	561 L	NA	NA
Lead	NA	NA	NA	1.7 UJ	2.1	10.2	NA	NA
Magnesium	NA	NA	NA	2290	10700	1460	NA	NA
Manganese	NA	NA	NA	2.9 B	14.3	5.6	NA	NA
Mercury	NA	NA	NA	0.1 U	0.1 U	0.1 U	NA	NA
Nickel	NA	NA	NA	1.9	1.6 B	1.9 B	NA	NA
Potassium	NA	NA	NA	799 J	1060	2660	NA	NA
Selenium	NA	NA	NA	2.2 U	2.2 U	2.2 U	NA	NA
Silver	NA	NA	NA	0.7 U	0.7 U	0.7 U	NA	NA
Sodium	NA	NA	NA	6300	10700	32300	NA	NA
Thallium	NA	NA	NA	3.1 UL	3.1 UL	3.1 UL	NA	NA
Vanadium	NA	NA	NA	0.6 U	0.6 U	0.7 B	NA	NA
Zinc	NA	NA	NA	17.9 B	5.8 B	8.8 B	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-37S 06/16/98 21-41	W-HN-38S 06/16/98 25-35	W-HN-38X 06/18/98 2-7	W-HN-38X-F 06/18/98 2-7	W-HN-39S 06/19/98 18-50	W-HN-39X 06/22/98 2-7	W-HN-41S 06/22/98 41-54	W-HN-43S 06/22/98 43-64
SEMIVOLATILES								
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA	NA	NA
2-Chlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA	NA	NA
3-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benz(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA

ANALYTIC. TABASE
SHALLOw WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-37S 06/16/98 21-41	W-HN-38S 06/16/98 25-35	W-HN-38X 06/18/98 2-7	W-HN-38X-F 06/18/98 2-7	W-HN-39S 06/19/98 18-50	W-HN-39X 06/22/98 2-7	W-HN-41S 06/22/98 41-54	W-HN-43S 06/22/98 43-64
SEMIVOLATILES								
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Dimethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Isophorone	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA	NA	NA	NA
Nitrobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-37S 06/16/98 21-41	W-HN-38S 06/16/98 25-35	W-HN-38X 06/18/98 2-7	W-HN-38X-F 06/18/98 2-7	W-HN-39S 06/19/98 18-50	W-HN-39X 06/22/98 2-7	W-HN-41S 06/22/98 41-54	W-HN-43S 06/22/98 43-64
VOLATILES								
1,1,1-Trichloroethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2-Dichloroethene (trans)	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	NA	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 UR	5 UR	5 U	NA	5 U	5 UR	5 U	5 UR
4-Methyl-2-pentanone	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	NA	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Carbon Disulfide	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U

ANALYTIC ATABASE
SHALLOW WELLS

Sample ID:	W-HN-37S	W-HN-38S	W-HN-38X	W-HN-38X-F	W-HN-39S	W-HN-39X	W-HN-41S	W-HN-43S
Sample Date:	06/16/98	06/16/98	06/18/98	06/18/98	06/19/98	06/22/98	06/22/98	06/22/98
Duplicate:								
Screen:	21-41	25-35	2-7	2-7	18-50	2-7	41-54	43-64
VOLATILES								
cis-1,3-Dichloropropene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Methylene Chloride	2 U	2 U	2 U	NA	2 U	2 U	2 U	2 U
Styrene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Trichloroethene	1	1 U	1 U	NA	1 U	1 U	1 U	1 U
Vinyl Chloride	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	NA	1 U	1 U	1 U	1 U
PESTICIDES/PCBS								
4,4'-DDD	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1016	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1242	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1248	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1260	NA	NA	NA	NA	NA	NA	NA	NA
Beta-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Delta-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA	NA	NA	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID:	W-HN-37S	W-HN-38S	W-HN-38X	W-HN-38X-F	W-HN-39S	W-HN-39X	W-HN-41S	W-HN-43S
Sample Date:	06/16/98	06/16/98	06/18/98	06/18/98	06/19/98	06/22/98	06/22/98	06/22/98
Duplicate:								
Screen:	21-41	25-35	2-7	2-7	18-50	2-7	41-54	43-64
PESTICIDES/PCBS								
Endosulfan Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Aldehyde	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Ketone	NA	NA	NA	NA	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	NA	NA	NA	NA	NA	NA	NA
Gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor Epoxide	NA	NA	NA	NA	NA	NA	NA	NA
Methoxychlor	NA	NA	NA	NA	NA	NA	NA	NA
Toxaphene	NA	NA	NA	NA	NA	NA	NA	NA

ANALYTI( )ATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-63S 06/19/98 27-46	W-HN-640 06/11/98 W-HN-640-DUP 29-50	W-HN-640-DUP 06/11/98 W-HN-640 29-50	W-HN-85S 06/18/98 TBD	W-HN-86S 06/19/98 TBD	W-HN-87S 06/19/98 TBD	W-MW-HN15S 08/19/98 ?
INORGANICS							
Aluminum	NA	209 B	355 K	NA	NA	502	NA
Antimony	NA	1.8 U	1.8 U	NA	NA	1.8 U	NA
Arsenic	NA	2.1 U	2.1 U	NA	NA	2.6 B	NA
Barium	NA	159	197	NA	NA	160	NA
Beryllium	NA	0.2 U	0.2 U	NA	NA	0.2 U	NA
Cadmium	NA	0.3 U	0.3 U	NA	NA	0.55	NA
Calcium	NA	67000	70500	NA	NA	33200	NA
Chromium	NA	4.6	6.7	NA	NA	3	NA
Cobalt	NA	7.6	10.7	NA	NA	0.64	NA
Copper	NA	2 B	2.4 B	NA	NA	4.2 B	NA
Cyanide	NA	10 UL	10 UL	NA	NA	10 U	NA
Iron	NA	344	627	NA	NA	696	NA
Lead	NA	1.7 UJ	1.7 UJ	NA	NA	16.6	NA
Magnesium	NA	23400	24600	NA	NA	15600	NA
Manganese	NA	1120	1320	NA	NA	111	NA
Mercury	NA	0.1 UL	0.1 UL	NA	NA	0.1 U	NA
Nickel	NA	8.8	9.2	NA	NA	3.6	NA
Potassium	NA	1260 J	1330 J	NA	NA	916	NA
Selenium	NA	1.6 UJ	1.6 J	NA	NA	2.2 U	NA
Silver	NA	0.7 U	0.7 U	NA	NA	0.7 U	NA
Sodium	NA	12300	13000	NA	NA	11100	NA
Thallium	NA	3.1 UL	3.1 UL	NA	NA	3.1 UL	NA
Vanadium	NA	0.6 U	0.6 U	NA	NA	0.6 U	NA
Zinc	NA	6.7 B	5.8 B	NA	NA	22.4 B	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-63S 06/19/98 27-46	W-HN-640 06/11/98 W-HN-640-DUP 29-50	W-HN-640-DUP 06/11/98 W-HN-640 29-50	W-HN-85S 06/18/98 TBD	W-HN-86S 06/19/98 TBD	W-HN-87S 06/19/98 TBD	W-MW-HN15S 08/19/98 ?
SEMIVOLATILES							
2,2'-Oxybis(1-chloropropane)	NA	10 U	10 U	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	24 U	24 U	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	10 U	10 U	NA	NA	NA	NA
2,4-Dichlorophenol	NA	10 U	10 U	NA	NA	NA	NA
2,4-Dimethylphenol	NA	10 U	10 U	NA	NA	NA	NA
2,4-Dinitrophenol	NA	24 U	24 U	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	10 U	10 U	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	10 U	10 U	NA	NA	NA	NA
2-Chloronaphthalene	NA	10 U	10 U	NA	NA	NA	NA
2-Chlorophenol	NA	10 U	10 U	NA	NA	NA	NA
2-Methylnaphthalene	NA	10 U	10 U	NA	NA	NA	NA
2-Methylphenol	NA	10 U	10 U	NA	NA	NA	NA
2-Nitroaniline	NA	24 U	24 U	NA	NA	NA	NA
2-Nitrophenol	NA	10 U	10 U	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	10 U	10 U	NA	NA	NA	NA
3-Nitroaniline	NA	24 U	24 U	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	24 U	24 U	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	10 U	10 U	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	10 U	10 U	NA	NA	NA	NA
4-Chloroaniline	NA	10 U	10 U	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	10 U	10 U	NA	NA	NA	NA
4-Methylphenol	NA	10 U	10 U	NA	NA	NA	NA
4-Nitroaniline	NA	24 U	24 U	NA	NA	NA	NA
4-Nitrophenol	NA	24 U	24 U	NA	NA	NA	NA
Acenaphthene	NA	10 U	10 U	NA	NA	NA	NA
Acenaphthylene	NA	10 U	10 U	NA	NA	NA	NA
Anthracene	NA	10 U	10 U	NA	NA	NA	NA
Benz(a)anthracene	NA	10 U	10 U	NA	NA	NA	NA
Benzo(a)pyrene	NA	10 U	10 U	NA	NA	NA	NA

ANALYTIC ATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-63S 06/19/98 27-46	W-HN-640 06/11/98 W-HN-640-DUP 29-50	W-HN-640-DUP 06/11/98 W-HN-640 29-50	W-HN-85S 06/18/98 TBD	W-HN-86S 06/19/98 TBD	W-HN-87S 06/19/98 TBD	W-MW-HN15S 08/19/98 ?
SEMIVOLATILES							
Benzo(b)fluoranthene	NA	10 U	10 U	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	10 U	10 U	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	10 U	10 U	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	10 U	10 U	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	10 U	10 U	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	1 B	2 B	NA	NA	NA	NA
Butylbenzylphthalate	NA	10 U	10 U	NA	NA	NA	NA
Carbazole	NA	10 U	10 U	NA	NA	NA	NA
Chrysene	NA	10 U	10 U	NA	NA	NA	NA
Di-n-butylphthalate	NA	10 U	10 U	NA	NA	NA	NA
Di-n-octylphthalate	NA	10 U	10 U	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	10 U	10 U	NA	NA	NA	NA
Dibenzofuran	NA	10 U	10 U	NA	NA	NA	NA
Diethylphthalate	NA	10 U	10 U	NA	NA	NA	NA
Dimethylphthalate	NA	10 U	10 U	NA	NA	NA	NA
Fluoranthene	NA	10 U	10 U	NA	NA	NA	NA
Fluorene	NA	10 U	10 U	NA	NA	NA	NA
Hexachlorobenzene	NA	10 U	10 U	NA	NA	NA	NA
Hexachlorobutadiene	NA	10 U	10 U	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	10 U	10 U	NA	NA	NA	NA
Hexachloroethane	NA	10 U	10 U	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	10 U	10 U	NA	NA	NA	NA
Isophorone	NA	10 U	10 U	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	10 U	10 U	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	10 U	10 U	NA	NA	NA	NA
Naphthalene	NA	10 U	10 U	NA	NA	NA	NA
Nitrobenzene	NA	10 U	10 U	NA	NA	NA	NA
Pentachlorophenol	NA	24 U	24 U	NA	NA	NA	NA
Phenanthrene	NA	10 U	10 U	NA	NA	NA	NA
Phenol	NA	10 U	10 U	NA	NA	NA	NA
Pyrene	NA	10 U	10 U	NA	NA	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-63S 06/19/98 27-46	W-HN-640 06/11/98 W-HN-640-DUP 29-50	W-HN-640-DUP 06/11/98 W-HN-640 29-50	W-HN-85S 06/18/98 TBD	W-HN-86S 06/19/98 TBD	W-HN-87S 06/19/98 TBD	W-MW-HN15S 08/19/98 ?
VOLATILES							
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U	4 B	5	1 U	1 U	1 U	5
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 U	5 UR	5 UR	5 U	5 U	5 U	5 UR
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	1 U	1 U	1 U	1 U	1 U	2	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	9
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	1
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U

ANALYTIC ATABASE
SHALLOw WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-63S 06/19/98 27-46	W-HN-640 06/11/98 W-HN-640-DUP 29-50	W-HN-640-DUP 06/11/98 W-HN-640 29-50	W-HN-85S 06/18/98 TBD	W-HN-86S 06/19/98 TBD	W-HN-87S 06/19/98 TBD	W-MW-HN15S 08/19/98 ?
VOLATILES							
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methylene Chloride	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	1 U	13
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	1 U	4 B	4 B	1 U	1 U	1 U	320
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U	1 U
PESTICIDES/PCBS							
4,4'-DDD	NA	0.096 UL	0.094 UL	NA	NA	NA	NA
4,4'-DDE	NA	0.096 UL	0.094 UL	NA	NA	NA	NA
4,4'-DDT	NA	0.096 UL	0.094 UL	NA	NA	NA	NA
Aldrin	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Alpha-BHC	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Alpha-Chlordane	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Aroclor-1016	NA	0.96 UL	0.94 UL	NA	NA	NA	NA
Aroclor-1221	NA	1.9 UL	1.9 UL	NA	NA	NA	NA
Aroclor-1232	NA	0.96 UL	0.94 UL	NA	NA	NA	NA
Aroclor-1242	NA	0.96 UL	0.94 UL	NA	NA	NA	NA
Aroclor-1248	NA	0.96 UL	0.94 UL	NA	NA	NA	NA
Aroclor-1254	NA	0.96 UL	0.94 UL	NA	NA	NA	NA
Aroclor-1260	NA	0.96 UL	0.94 UL	NA	NA	NA	NA
Beta-BHC	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Delta-BHC	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Dieldrin	NA	0.096 UL	0.094 UL	NA	NA	NA	NA
Endosulfan I	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Endosulfan II	NA	0.096 UL	0.094 UL	NA	NA	NA	NA

ANALYTICAL DATABASE
SHALLOW WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-63S 06/19/98 27-46	W-HN-640 06/11/98 W-HN-640-DUP 29-50	W-HN-640-DUP 06/11/98 W-HN-640 29-50	W-HN-85S 06/18/98 TBD	W-HN-86S 06/19/98 TBD	W-HN-87S 06/19/98 TBD	W-MW-HN15S 08/19/98 ?
PESTICIDES/PCBS							
Endosulfan Sulfate	NA	0.096 UL	0.094 UL	NA	NA	NA	NA
Endrin	NA	0.096 UL	0.094 UL	NA	NA	NA	NA
Endrin Aldehyde	NA	0.096 UL	0.094 UL	NA	NA	NA	NA
Endrin Ketone	NA	0.096 UL	0.094 UL	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Gamma-Chlordane	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Heptachlor	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Heptachlor Epoxide	NA	0.048 UL	0.047 UL	NA	NA	NA	NA
Methoxychlor	NA	0.48 UL	0.47 UL	NA	NA	NA	NA
Toxaphene	NA	4.8 UL	4.7 UL	NA	NA	NA	NA

ANALYTIC ATABASE
SHALLOw WELLS

Data Qualifiers:
B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
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).
K -- Positive result is considered biased high due to exceedance of technical quality control criteria.
L -- Positive result is considered biased low due to exceedance of technical quality control criteria.
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-detected result is considered unusable due to exceedance of technical quality control criteria.
NA -- No result is available/applicable for this parameter in this sample.

APPENDIX B.2

SUMMARY OF INTERMEDIATE ZONE ANALYTICAL RESULTS

ANAYLTIC. ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-EW-12	W-EW-12-DUP	W-EW-14	W-HN-01I	W-HN-02I	W-HN-03I
Sample Date:	06/17/98	06/17/98	06/16/98	06/10/98	06/10/98	06/17/98
Duplicate:	W-EW-12-DUP	W-EW-12				
Screen:	20-100	20-100	20-100	68-92	85-104	81-102
INORGANICS						
Aluminum	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-EW-12	W-EW-12-DUP	W-EW-14	W-HN-01I	W-HN-02I	W-HN-03I
Sample Date:	06/17/98	06/17/98	06/16/98	06/10/98	06/10/98	06/17/98
Duplicate:	W-EW-12-DUP	W-EW-12				
Screen:	20-100	20-100	20-100	68-92	85-104	81-102
SEMIVOLATILES						
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA
2-Chlorophenol	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	NA	NA	NA
2-Nitroaniline	NA	NA	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA
3-Nitroaniline	NA	NA	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA
4-Chloroaniline	NA	NA	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA	NA	NA
Benz(a)anthracene	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	NA	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA

ANAYLTIC ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-EW-12	W-EW-12-DUP	W-EW-14	W-HN-01I	W-HN-02I	W-HN-03I
Sample Date:	06/17/98	06/17/98	06/16/98	06/10/98	06/10/98	06/17/98
Duplicate:	W-EW-12-DUP	W-EW-12				
Screen:	20-100	20-100	20-100	68-92	85-104	81-102
SEMIVOLATILES						
Butylbenzylphthalate	NA	NA	NA	NA	NA	NA
Carbazole	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA	NA	NA
Dimethylphthalate	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA
Hexachlorobenzene	NA	NA	NA	NA	NA	NA
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA
Isophorone	NA	NA	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA	NA
Nitrobenzene	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA
Phenol	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-EW-12	W-EW-12-DUP	W-EW-14	W-HN-01I	W-HN-02I	W-HN-03I
Sample Date:	06/17/98	06/17/98	06/16/98	06/10/98	06/10/98	06/17/98
Duplicate:	W-EW-12-DUP	W-EW-12				
Screen:	20-100	20-100	20-100	68-92	85-104	81-102
VOLATILES						
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 UR	5 U	5 UR	5 U	5 U	5 UR
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U

ANAYLTIC ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-EW-12	W-EW-12-DUP	W-EW-14	W-HN-01I	W-HN-02I	W-HN-03I
Sample Date:	06/17/98	06/17/98	06/16/98	06/10/98	06/10/98	06/17/98
Duplicate:	W-EW-12-DUP	W-EW-12				
Screen:	20-100	20-100	20-100	68-92	85-104	81-102
VOLATILES						
Styrene	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	1 U	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U
PESTICIDES/PCBS						
4,4'-DDD	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA	NA	NA
Alpha-BHC	NA	NA	NA	NA	NA	NA
Alpha-Chlordane	NA	NA	NA	NA	NA	NA
Aroclor-1016	NA	NA	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	NA	NA	NA
Aroclor-1242	NA	NA	NA	NA	NA	NA
Aroclor-1248	NA	NA	NA	NA	NA	NA
Aroclor-1254	NA	NA	NA	NA	NA	NA
Aroclor-1260	NA	NA	NA	NA	NA	NA
Beta-BHC	NA	NA	NA	NA	NA	NA
Delta-BHC	NA	NA	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA	NA	NA
Endosulfan Sulfate	NA	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA	NA
Endrin Aldehyde	NA	NA	NA	NA	NA	NA
Endrin Ketone	NA	NA	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	NA	NA	NA	NA	NA
Gamma-Chlordane	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA
Heptachlor Epoxide	NA	NA	NA	NA	NA	NA
Methoxychlor	NA	NA	NA	NA	NA	NA
Toxaphene	NA	NA	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-05I	W-HN-06I	W-HN-07I	W-HN-08I	W-HN-09I	W-HN-10I	W-HN-29I	W-HN-35I
Sample Date:	06/11/98	06/08/98	06/09/98	06/05/98	06/08/98	06/23/98	06/24/98	06/15/98
Duplicate:								
Screen:	70-88	80-103	64-85	60-78	75-103	80-101	?	87-105
INORGANICS								
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA

ANAYLTIC. ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-05I	W-HN-06I	W-HN-07I	W-HN-08I	W-HN-09I	W-HN-10I	W-HN-29I	W-HN-35I
Sample Date:	06/11/98	06/08/98	06/09/98	06/05/98	06/08/98	06/23/98	06/24/98	06/15/98
Duplicate:								
Screen:	70-88	80-103	64-85	60-78	75-103	80-101	?	87-105
SEMIVOLATILES								
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA	NA	NA
2-Chlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA	NA	NA
3-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benz(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-05I	W-HN-06I	W-HN-07I	W-HN-08I	W-HN-09I	W-HN-10I	W-HN-29I	W-HN-35I
Sample Date:	06/11/98	06/08/98	06/09/98	06/05/98	06/08/98	06/23/98	06/24/98	06/15/98
Duplicate:								
Screen:	70-88	80-103	64-85	60-78	75-103	80-101	?	87-105
SEMIVOLATILES								
Butylbenzylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Dimethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorobenzene	NA	NA	:NA	NA	NA	NA	:NA	NA
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Isophorone	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA	NA	NA	NA
Nitrobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA

ANAYLTIC ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-05I	W-HN-06I	W-HN-07I	W-HN-08I	W-HN-09I	W-HN-10I	W-HN-29I	W-HN-35I
Sample Date:	06/11/98	06/08/98	06/09/98	06/05/98	06/08/98	06/23/98	06/24/98	06/15/98
Duplicate:								
Screen:	70-88	80-103	64-85	60-78	75-103	80-101	?	87-105
VOLATILES								
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U:	1 U	1	1 U	1 U :	1 U	1 U	1 U
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 UR	5 U	5 U	5 U	5 U	5 UR	5 UR	5 UR
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	2	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-05I	W-HN-06I	W-HN-07I	W-HN-08I	W-HN-09I	W-HN-10I	W-HN-29I	W-HN-35I
Sample Date:	06/11/98	06/08/98	06/09/98	06/05/98	06/08/98	06/23/98	06/24/98	06/15/98
Duplicate:								
Screen:	70-88	80-103	64-85	60-78	75-103	80-101	?	87-105
VOLATILES								
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	1 U	1 U	9 B	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
PESTICIDES/PCBS								
4,4'-DDD	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1016	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1242	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1248	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1260	NA	NA	NA	NA	NA	NA	NA	NA
Beta-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Delta-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Aldehyde	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Ketone	NA	NA	NA	NA	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	NA	NA	NA	NA	NA	NA	NA
Gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor Epoxide	NA	NA	NA	NA	NA	NA	NA	NA
Methoxychlor	NA	NA	NA	NA	NA	NA	NA	NA
Toxaphene	NA	NA	NA	NA	NA	NA	NA	NA

ANAYLTIC ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-36I1	W-HN-36I2	W-HN-37I	W-HN-38I	W-HN-40I	W-HN-41I	W-HN-430	W-HN-430-DUP
Sample Date:	06/10/98	06/15/98	06/19/98	06/15/98	06/23/98	06/22/98	06/22/98	06/22/98
Duplicate:							W-HN-430-DUP	W-HN-430
Screen:	82-100	101-115	75-103	97-119	88-114	72-93	90-104	90-104
INORGANICS								
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-36I1	W-HN-36I2	W-HN-37I	W-HN-38I	W-HN-40I	W-HN-41I	W-HN-430	W-HN-430-DUP
Sample Date:	06/10/98	06/15/98	06/19/98	06/15/98	06/23/98	06/22/98	06/22/98	06/22/98
Duplicate:							W-HN-430-DUP	W-HN-430
Screen:	82-100	101-115	75-103	97-119	88-114	72-93	90-104	90-104
SEMIVOLATILES								
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA	NA	NA
2-Chlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA	NA	NA
3-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Chloroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benz(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	NA	NA	NA	NA

ANAYLTIC. ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-36I1	W-HN-36I2	W-HN-37I	W-HN-38I	W-HN-40I	W-HN-41I	W-HN-430	W-HN-430-DUP
Sample Date:	06/10/98	06/15/98	06/19/98	06/15/98	06/23/98	06/22/98	06/22/98	06/22/98
Duplicate:							W-HN-430-DUP	W-HN-430
Screen:	82-100	101-115	75-103	97-119	88-114	72-93	90-104	90-104
SEMIVOLATILES								
Butylbenzylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Dimethylphthalate	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Isophorone	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA	NA	NA	NA
Nitrobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-36I1	W-HN-36I2	W-HN-37I	W-HN-38I	W-HN-40I	W-HN-41I	W-HN-430	W-HN-430-DUP
Sample Date:	06/10/98	06/15/98	06/19/98	06/15/98	06/23/98	06/22/98	06/22/98	06/22/98
Duplicate:							W-HN-430-DUP	W-HN-430
Screen:	82-100	101-115	75-103	97-119	88-114	72-93	90-104	90-104
VOLATILES								
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 U	5 UR	5 U	5 UR	5 UR	5 U	5 UR	5 U
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	0.9 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	2	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U

ANAYLTIC. ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-36I1	W-HN-36I2	W-HN-37I	W-HN-38I	W-HN-40I	W-HN-41I	W-HN-430	W-HN-430-DUP
Sample Date:	06/10/98	06/15/98	06/19/98	06/15/98	06/23/98	06/22/98	06/22/98	06/22/98
Duplicate:							W-HN-430-DUP	W-HN-430
Screen:	82-100	101-115	75-103	97-119	88-114	72-93	90-104	90-104
VOLATILES								
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	1 B	1 U	1	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
PESTICIDES/PCBS								
4,4'-DDD	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1016	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1242	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1248	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1260	NA	NA	NA	NA	NA	NA	NA	NA
Beta-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Delta-BHC	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA	NA	NA	NA	NA
Endosulfan Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
Endrin	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Aldehyde	NA	NA	NA	NA	NA	NA	NA	NA
Endrin Ketone	NA	NA	NA	NA	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	NA	NA	NA	NA	NA	NA	NA
Gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor Epoxide	NA	NA	NA	NA	NA	NA	NA	NA
Methoxychlor	NA	NA	NA	NA	NA	NA	NA	NA
Toxaphene	NA	NA	NA	NA	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-49I	W-HN-61I	W-HN-62I	W-HN-64I	W-HN-84I	W-HN-85I	W-HN-85I-DUP	W-HN-86I
Sample Date:	06/08/98	06/10/98	06/16/98	06/18/98	06/19/98	06/19/98	06/19/98	06/18/98
Duplicate:						W-HN-85I-DUP	W-HN-85I	W-HN-86I-DUP
Screen:	55-75	110-124.	70.5-85.	82-104	TBD	TBD	?	TBD
INORGANICS								
Aluminum	116	NA	NA	52.9 B	NA	NA	NA	NA
Antimony	1.8 U	NA	NA	1.8 U	NA	NA	NA	NA
Arsenic	2.1 U	NA	NA	2.1 U	NA	NA	NA	NA
Barium	434	NA	NA	591	NA	NA	NA	NA
Beryllium	0.2 U	NA	NA	0.2 U	NA	NA	NA	NA
Cadmium	0.3 U	NA	NA	0.3 U	NA	NA	NA	NA
Calcium	39700	NA	NA	78200	NA	NA	NA	NA
Chromium	1.8	NA	NA	1.1	NA	NA	NA	NA
Cobalt	0.48	NA	NA	0.4 U	NA	NA	NA	NA
Copper	1.6 B	NA	NA	3.1 B	NA	NA	NA	NA
Cyanide	10 U	NA	NA	10 U	NA	NA	NA	NA
Iron	12.5 UL	NA	NA	210	NA	NA	NA	NA
Lead	1.7 UJ	NA	NA	2.2 J	NA	NA	NA	NA
Magnesium	27100	NA	NA	17100	NA	NA	NA	NA
Manganese	23.7	NA	NA	946	NA	NA	NA	NA
Mercury	0.1 UL	NA	NA	0.1 U	NA	NA	NA	NA
Nickel	3.4	NA	NA	1.4	NA	NA	NA	NA
Potassium	1140 J	NA	NA	1430 J	NA	NA	NA	NA
Selenium	1.6 U	NA	NA	2.2 U	NA	NA	NA	NA
Silver	0.7 U	NA	NA	0.7 U	NA	NA	NA	NA
Sodium	12000	NA	NA	13400	NA	NA	NA	NA
Thallium	3.1 UL	NA	NA	3.1 UL	NA	NA	NA	NA
Vanadium	0.6 U	NA	NA	0.6 U	NA	NA	NA	NA
Zinc	2.7 B	NA	NA	18.4 B	NA	NA	NA	NA

ANAYLTIC. ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-49I	W-HN-61I	W-HN-62I	W-HN-64I	W-HN-84I	W-HN-85I	W-HN-85I-DUP	W-HN-86I
Sample Date:	06/08/98	06/10/98	06/16/98	06/18/98	06/19/98	06/19/98	06/19/98	06/18/98
Duplicate:						W-HN-85I-DUP	W-HN-85I	W-HN-86I-DUP
Screen:	55-75	110-124.	70.5-85.	82-104	TBD	TBD	?	TBD
SEMIVOLATILES								
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	9 U	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	47 U	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA	9 U	NA	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA	9 U	NA	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA	9 U	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	47 U	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	9 U	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	9 U	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	9 U	NA	NA	NA	NA
2-Chlorophenol	NA	NA	NA	9 U	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	9 U	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	9 U	NA	NA	NA	NA
2-Nitroaniline	NA	NA	NA	47 U	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	9 U	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	19 U	NA	NA	NA	NA
3-Nitroaniline	NA	NA	NA	47 UJ	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA	47 U	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	NA	NA	9 U	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	19 U	NA	NA	NA	NA
4-Chloroaniline	NA	NA	NA	19 U	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	NA	NA	9 U	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	9 U	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	47 U	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	47 U	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	9 U	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	9 U	NA	NA	NA	NA
Anthracene	NA	NA	NA	9 U	NA	NA	NA	NA
Benz(a)anthracene	NA	NA	NA	9 U	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	9 U	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	9 U	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	9 U	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	9 U	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	NA	NA	9 U	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	NA	9 U	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	2 B	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-49I	W-HN-61I	W-HN-62I	W-HN-64I	W-HN-84I	W-HN-85I	W-HN-85I-DUP	W-HN-86I
Sample Date:	06/08/98	06/10/98	06/16/98	06/18/98	06/19/98	06/19/98	06/19/98	06/18/98
Duplicate:						W-HN-85I-DUP	W-HN-85I	W-HN-86I-DUP
Screen:	55-75	110-124.	70.5-85.	82-104	TBD	TBD	?	TBD
SEMIVOLATILES								
Butylbenzylphthalate	NA	NA	NA	9 U	NA	NA	NA	NA
Carbazole	NA	NA	NA	9 U	NA	NA	NA	NA
Chrysene	NA	NA	NA	9 U	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	9 U	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	9 U	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	9 U	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	9 U	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	1 B	NA	NA	NA	NA
Dimethylphthalate	NA	NA	NA	9 U	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	9 U	NA	NA	NA	NA
Fluorene	NA	NA	NA	9 U	NA	NA	NA	NA
Hexachlorobenzene	NA	NA	NA	9 U	NA	NA	NA	NA
Hexachlorobutadiene	NA	NA	NA	9 U	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	NA	9 U	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	9 U	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	9 U	NA	NA	NA	NA
Isophorone	NA	NA	NA	9 U	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	9 U	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	NA	NA	9 U	NA	NA	NA	NA
Naphthalene	NA	NA	NA	9 U	NA	NA	NA	NA
Nitrobenzene	NA	NA	NA	9 U	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	47 U	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	9 U	NA	NA	NA	NA
Phenol	NA	NA	NA	9 U	NA	NA	NA	NA
Pyrene	NA	NA	NA	9 U	NA	NA	NA	NA

ANAYLTIC ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-49I	W-HN-61I	W-HN-62I	W-HN-64I	W-HN-84I	W-HN-85I	W-HN-85I-DUP	W-HN-86I
Sample Date:	06/08/98	06/10/98	06/16/98	06/18/98	06/19/98	06/19/98	06/19/98	06/18/98
Duplicate:						W-HN-85I-DUP	W-HN-85I	W-HN-86I-DUP
Screen:	55-75	110-124.	70.5-85.	82-104	TBD	TBD	?	TBD
VOLATILES								
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	: 30	1 U	1 U	3	1 U	1 U	1 U	1 U:
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 U	5 U	5 UR	5 U	5 U	5 U	5 U	5 U
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	1 U	4	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-49I	W-HN-61I	W-HN-62I	W-HN-64I	W-HN-84I	W-HN-85I	W-HN-85I-DUP	W-HN-86I
Sample Date:	06/08/98	06/10/98	06/16/98	06/18/98	06/19/98	06/19/98	06/19/98	06/18/98
Duplicate:						W-HN-85I-DUP	W-HN-85I	W-HN-86I-DUP
Screen:	55-75	110-124.	70.5-85.	82-104	TBD	TBD	?	TBD
VOLATILES								
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	120	1 U	1 U	1	1 U	1 U	1 U	1 U
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
PESTICIDES/PCBS								
4,4'-DDD	NA	NA	NA	0.094 U	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	0.094 U	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	0.094 U	NA	NA	NA	NA
Aldrin	NA	NA	NA	0.047 U	NA	NA	NA	NA
Alpha-BHC	NA	NA	NA	0.047 U	NA	NA	NA	NA
Alpha-Chlordane	NA	NA	NA	0.047 U	NA	NA	NA	NA
Aroclor-1016	NA	NA	NA	0.94 U	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	1.9 U	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	0.94 U	NA	NA	NA	NA
Aroclor-1242	NA	NA	NA	0.94 U	NA	NA	NA	NA
Aroclor-1248	NA	NA	NA	0.94 U	NA	NA	NA	NA
Aroclor-1254	NA	NA	NA	0.94 U	NA	NA	NA	NA
Aroclor-1260	NA	NA	NA	0.94 U	NA	NA	NA	NA
Beta-BHC	NA	NA	NA	0.047 U	NA	NA	NA	NA
Delta-BHC	NA	NA	NA	0.047 U	NA	NA	NA	NA
Dieldrin	NA	NA	NA	0.094 U	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	0.047 U	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	0.094 U	NA	NA	NA	NA
Endosulfan Sulfate	NA	NA	NA	0.094 U	NA	NA	NA	NA
Endrin	NA	NA	NA	0.094 U	NA	NA	NA	NA
Endrin Aldehyde	NA	NA	NA	0.094 U	NA	NA	NA	NA
Endrin Ketone	NA	NA	NA	0.094 U	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	NA	NA	0.047 U	NA	NA	NA	NA
Gamma-Chlordane	NA	NA	NA	0.047 U	NA	NA	NA	NA
Heptachlor	NA	NA	NA	0.047 U	NA	NA	NA	NA
Heptachlor Epoxide	NA	NA	NA	0.047 U	NA	NA	NA	NA
Methoxychlor	NA	NA	NA	0.47 U	NA	NA	NA	NA
Toxaphene	NA	NA	NA	4.7 U	NA	NA	NA	NA

ANAYLTIC ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-86I-DUP	W-OB-10	W-OB-8	W-OB-8-DUP
Sample Date:	06/18/98	06/12/98	06/15/98	06/15/98
Duplicate:	W-HN-86I		W-OB-8-DUP	W-OB-8
Screen:	?	20-100	20-100	20-100
INORGANICS				
Aluminum	NA	NA	NA	NA
Antimony	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA
Barium	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA
Calcium	NA	NA	NA	NA
Chromium	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA
Copper	NA	NA	NA	NA
Cyanide	NA	NA	NA	NA
Iron	NA	NA	NA	NA
Lead	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA
Manganese	NA	NA	NA	NA
Mercury	NA	NA	NA	NA
Nickel	NA	NA	NA	NA
Potassium	NA	NA	NA	NA
Selenium	NA	NA	NA	NA
Silver	NA	NA	NA	NA
Sodium	NA	NA	NA	NA
Thallium	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA
Zinc	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-86I-DUP	W-OB-10	W-OB-8	W-OB-8-DUP
Sample Date:	06/18/98	06/12/98	06/15/98	06/15/98
Duplicate:	W-HN-86I		W-OB-8-DUP	W-OB-8
Screen:	?	20-100	20-100	20-100
SEMIVOLATILES				
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA
2,4,6-Trichlorophenol	NA	NA	NA	NA
2,4-Dichlorophenol	NA	NA	NA	NA
2,4-Dimethylphenol	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA
2,4-Dinitrotoluene	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	NA
2-Chlorophenol	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA
2-Methylphenol	NA	NA	NA	NA
2-Nitroaniline	NA	NA	NA	NA
2-Nitrophenol	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA
3-Nitroaniline	NA	NA	NA	NA
4,6-Dinitro-2-methylphenol	NA	NA	NA	NA
4-Bromophenyl Phenyl Ether	NA	NA	NA	NA
4-Chloro-3-methylphenol	NA	NA	NA	NA
4-Chloroaniline	NA	NA	NA	NA
4-Chlorophenyl Phenyl Ether	NA	NA	NA	NA
4-Methylphenol	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA
Benz(a)anthracene	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA
Bis(2-chloroethoxy)methane	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA

ANAYLTIC ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-86I-DUP	W-OB-10	W-OB-8	W-OB-8-DUP
Sample Date:	06/18/98	06/12/98	06/15/98	06/15/98
Duplicate:	W-HN-86I		W-OB-8-DUP	W-OB-8
Screen:	?	20-100	20-100	20-100
SEMIVOLATILES				
Butylbenzylphthalate	NA	NA	NA	NA
Carbazole	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA
Di-n-butylphthalate	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA
Dibenz(a,h)anthracene	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA
Dimethylphthalate	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA
Hexachlorobenzene	NA	NA	NA	NA
Hexachlorobutadiene	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA
Isophorone	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	NA
N-Nitrosodiphenylamine (1)	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA
Nitrobenzene	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA
Phenol	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-86I-DUP	W-OB-10	W-OB-8	W-OB-8-DUP
Sample Date:	06/18/98	06/12/98	06/15/98	06/15/98
Duplicate:	W-HN-86I		W-OB-8-DUP	W-OB-8
Screen:	?	20-100	20-100	20-100
VOLATILES				
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U	1 U	1 U	1 U
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 U	5 UR	5 UR	5 UR
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U
Carbon Disulfide	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U

ANAYLTIC. ATABASE
INTERMEDIATE GROUNDWATER

Sample ID:	W-HN-86I-DUP	W-OB-10	W-OB-8	W-OB-8-DUP
Sample Date:	06/18/98	06/12/98	06/15/98	06/15/98
Duplicate:	W-HN-86I		W-OB-8-DUP	W-OB-8
Screen:	?	20-100	20-100	20-100
VOLATILES				
Styrene	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	2	2
Toluene	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U
Trichloroethene	1 U	1 U	4	4
Vinyl Chloride	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U
PESTICIDES/PCBS				
4,4'-DDD	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA
Alpha-BHC	NA	NA	NA	NA
Alpha-Chlordane	NA	NA	NA	NA
Aroclor-1016	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	NA
Aroclor-1242	NA	NA	NA	NA
Aroclor-1248	NA	NA	NA	NA
Aroclor-1254	NA	NA	NA	NA
Aroclor-1260	NA	NA	NA	NA
Beta-BHC	NA	NA	NA	NA
Delta-BHC	NA	NA	NA	NA
Dieldrin	NA	NA	NA	NA
Endosulfan I	NA	NA	NA	NA
Endosulfan II	NA	NA	NA	NA
Endosulfan Sulfate	NA	NA	NA	NA
Endrin	NA	NA	NA	NA
Endrin Aldehyde	NA	NA	NA	NA
Endrin Ketone	NA	NA	NA	NA
Gamma-BHC (Lindane)	NA	NA	NA	NA
Gamma-Chlordane	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA
Heptachlor Epoxide	NA	NA	NA	NA
Methoxychlor	NA	NA	NA	NA
Toxaphene	NA	NA	NA	NA

ANAYLTICAL DATABASE
INTERMEDIATE GROUNDWATER

Data Qualifiers:
B -- Positive result is considered to be an artifact of blank contamination, and should not be considered present.
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-detected result is considered unusable due to exceedance of technical quality control criteria.
NA -- No result is available/applicable for this parameter in this sample.

Database source file: C:\WAGW_DBF\GREGS_GW_TABLES\WABIGW2.DBF data retrieved on: 12/15/99

APPENDIX B.3

SUMMARY OF DEEP ZONE ANALYTICAL RESULTS

ANALYTIC TABASE
DEEP WELLS

Sample ID:	W-HN-01D	W-HN-02D	W-HN-03D	W-HN-05D	W-HN-06D	W-HN-07D	W-HN-08D	W-HN-09D	W-HN-10D
Sample Date:	06/11/98	06/11/98	06/12/98	06/10/98	06/05/98	06/05/98	06/05/98	06/08/98	06/24/98
Duplicate:									
Screen:	108-127	116-133	115-140	180-204	134-154	144-162	157-178	138-161	225-245
VOLATILES									
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 U	5 UR	5 UR	5 U	5 U	5 U	5 U	5 U	5 UR
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	1 U	1 U	1 U	2	1 U	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methylene Chloride	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U

ANALYTICAL DATABASE
DEEP WELLS

Sample ID: Sample Date: Duplicate: Screen:	W-HN-35D 06/11/98 115-130	W-HN-36D 06/11/98 133-147	W-HN-37D 06/12/98 116-141	W-HN-39D 06/12/98 125-150	W-HN-40D 06/22/98 120-148	W-HN-43D 06/22/98 117-135	W-HN-49D 06/08/98 118-135
VOLATILES							
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trimethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (cis)	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethene (trans)	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Butanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
2-Hexanone	5 UR	5 UR	5 UR	5 UR	5 UR	5 U	5 U
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Acetone	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR
Benzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Disulfide	3	1 U	1 U	1 U	1 U	1 U	1 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methylene Chloride	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (Total)	1 U	1 U	1 U	1 U	1 U	1 U	1 U

ANALYTIC TABASE
DEEP WELLS

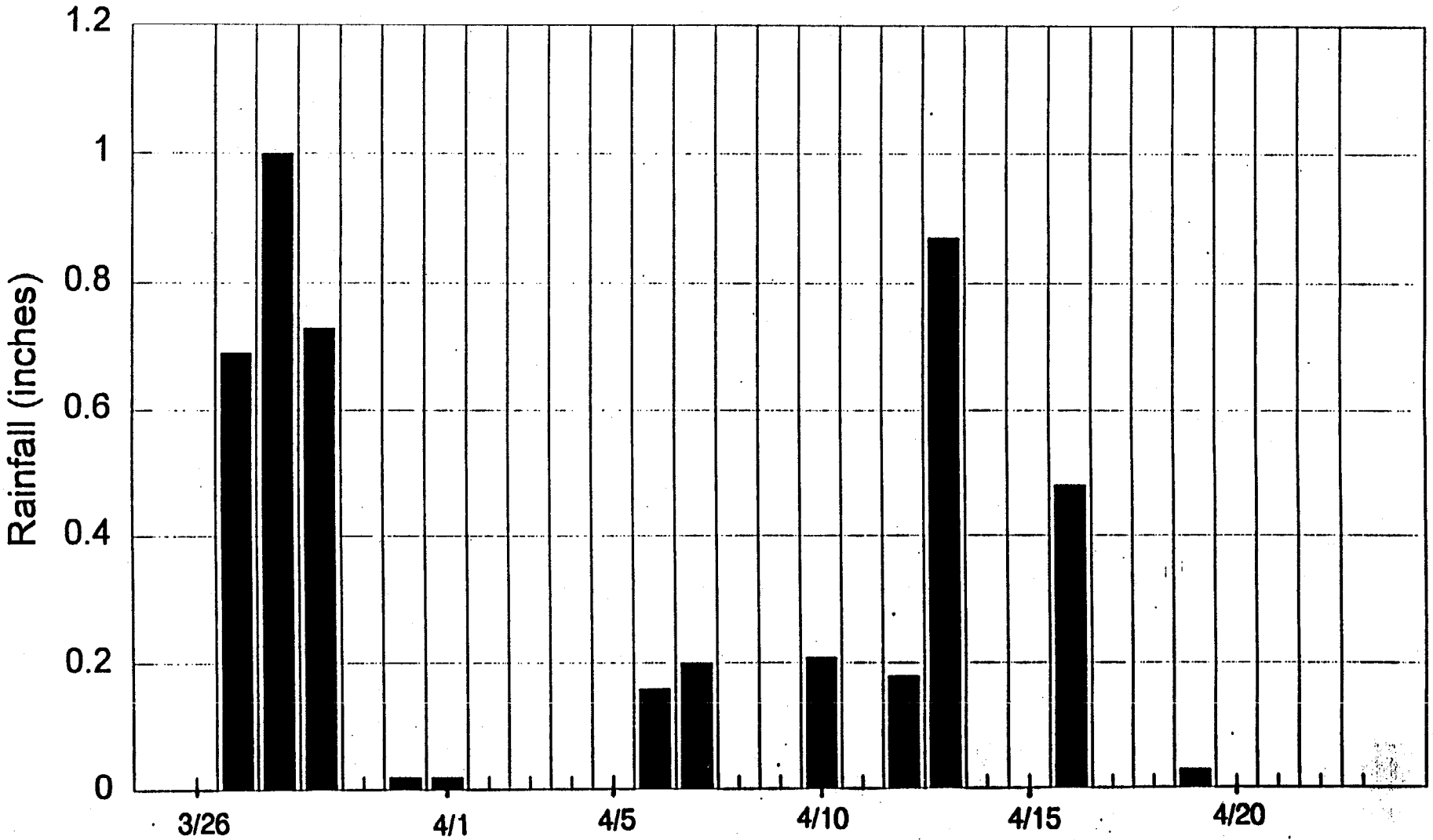
Data Qualifiers:
U -- Value is a non-detected result as reported by the laboratory.
UR -- Non-detected result is considered unusable due to exceedance of technical quality control criteria.

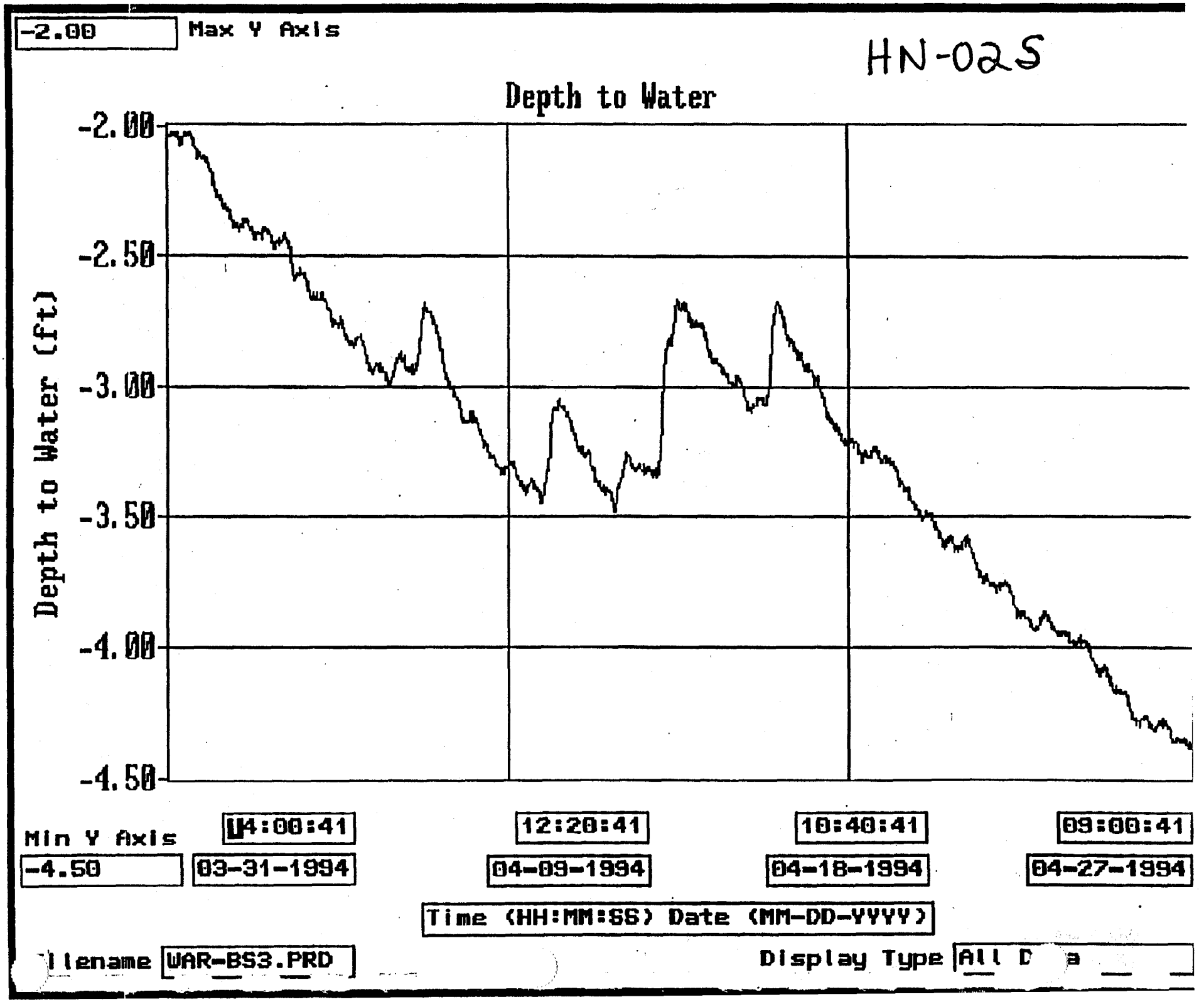
APPENDIX C

GROUNDWATER ELEVATION MEASUREMENTS

Area B Water-Level Study

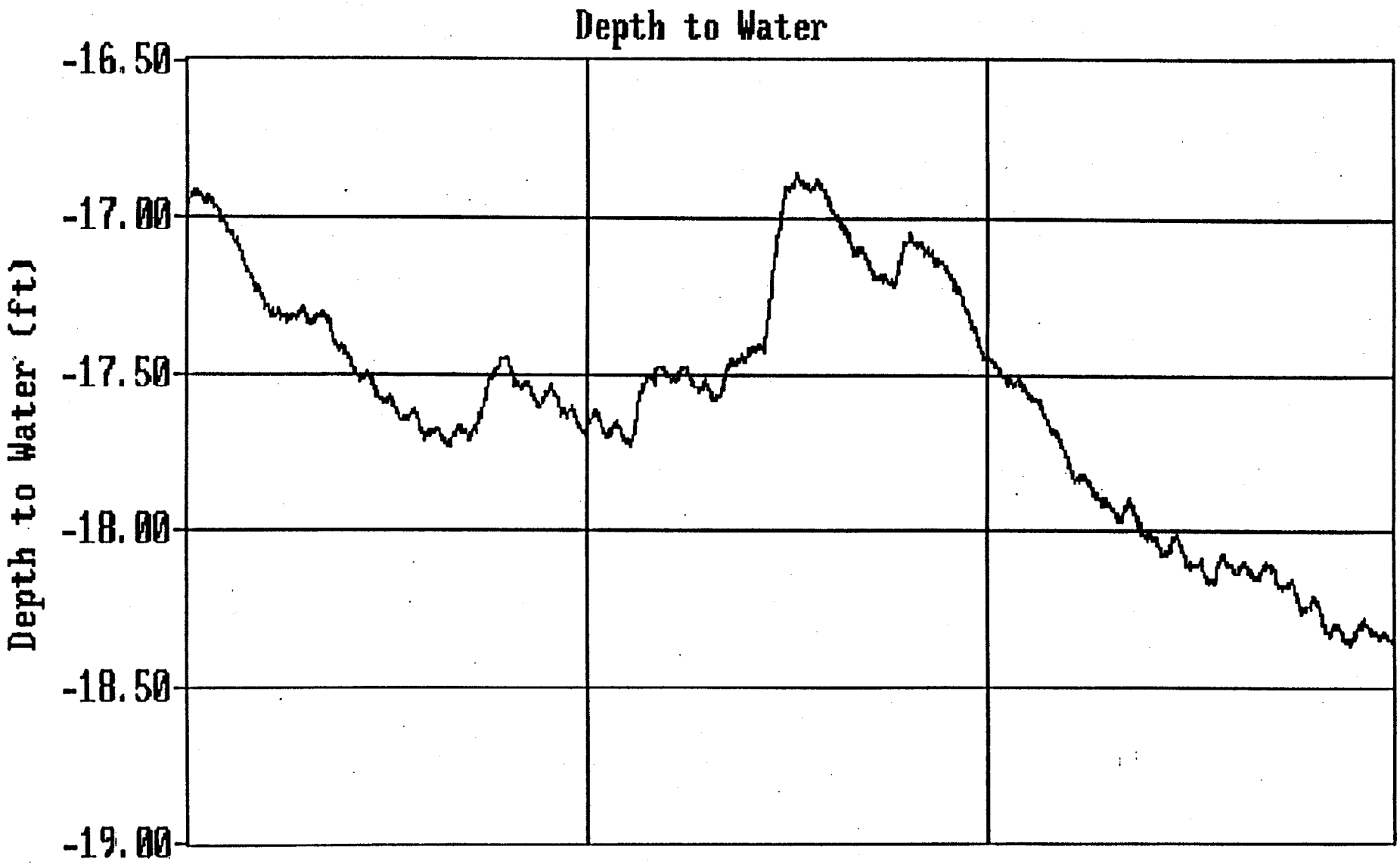
Daily Precipitation




-2.00
Max Y Axis
HN-02S
Depth to Water
-2.00
-2.50
-3.00
-3.50
-4.00
-4.50
Depth to Water (ft)
Min Y Axis
-4.50
04:00:41
03-31-1994
12:20:41
04-09-1994
10:40:41
04-18-1994
09:00:41
04-27-1994
Time (HH:MM:SS) Date (MM-DD-YYYY)
Filename WAR-BS3.PRD
Display Type All Data

-16.50 Max Y Axis

HN-02 I



Min Y Axis -19.00

04:00:50 03-31-1994

12:20:50 04-09-1994

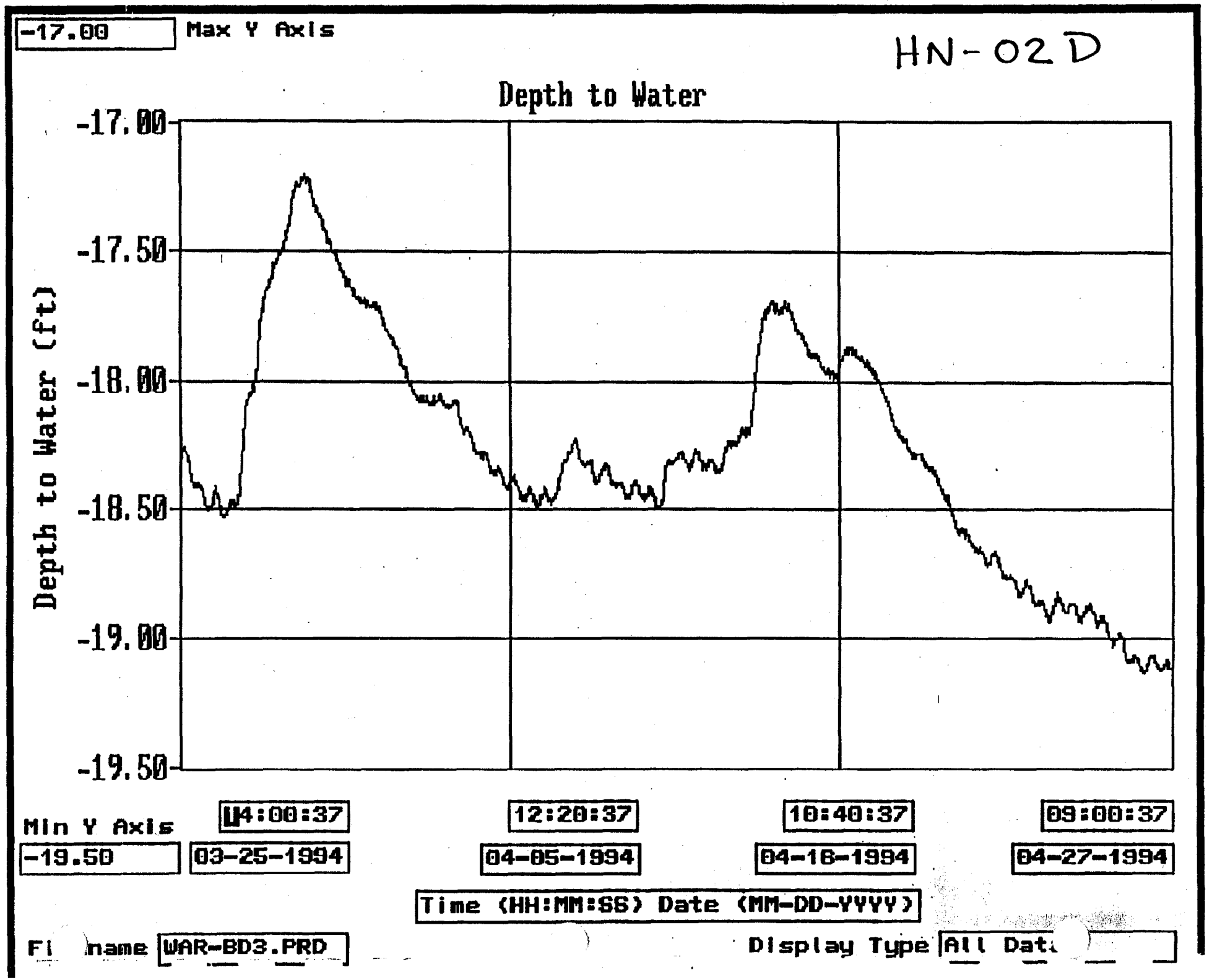
10:40:50 04-18-1994

09:00:50 04-27-1994

Time (HH:MM:SS) Date (MM-DD-YYYY)

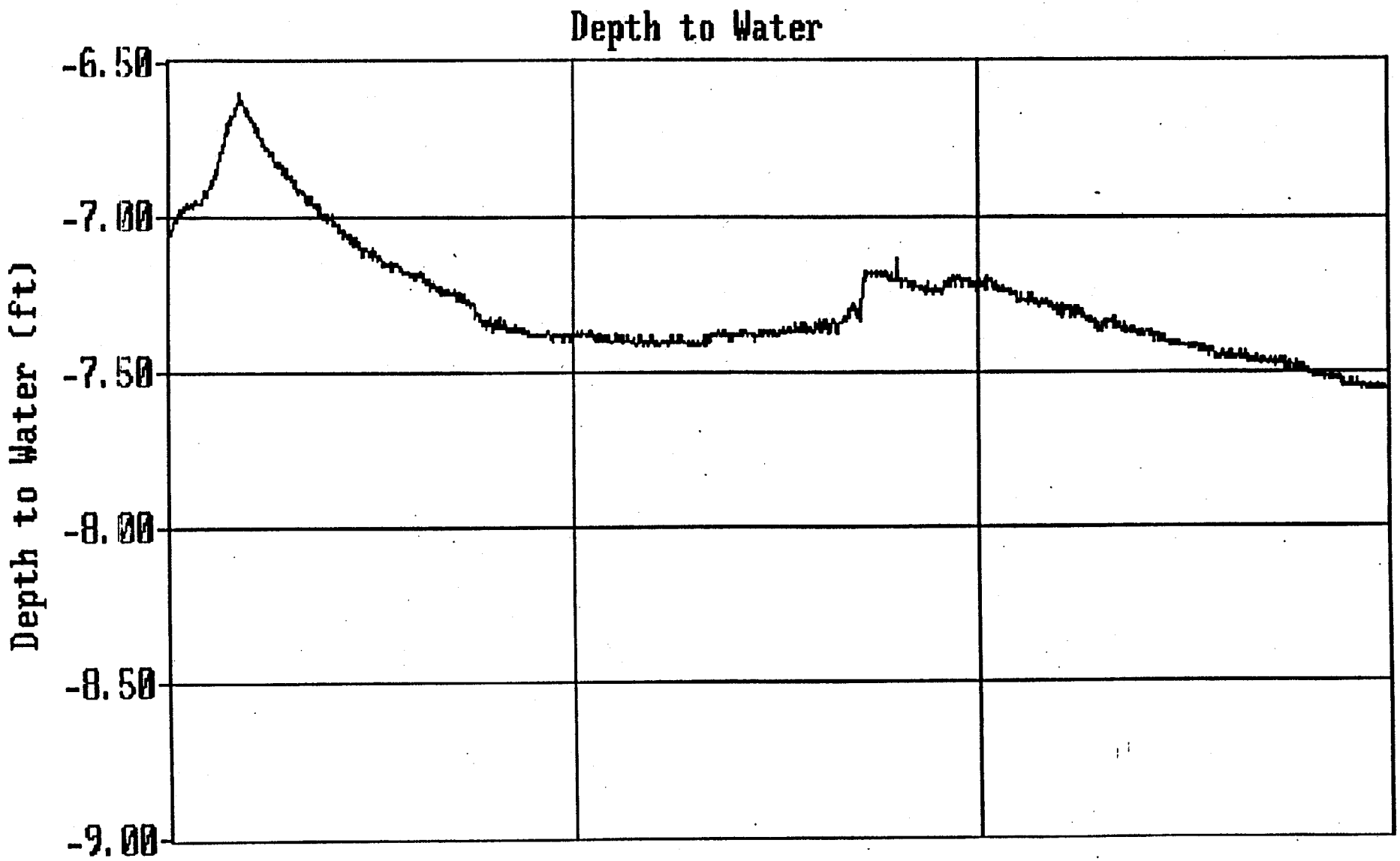
Filename WAR-BI3.PRD

Display Type All Data


-17.00
Max Y Axis
HN-02D
Depth to Water
-17.00
-17.50
-18.00
-18.50
-19.00
-19.50
Depth to Water (ft)
Min Y Axis
-19.50
14:00:37
03-25-1994
12:20:37
04-05-1994
10:40:37
04-16-1994
09:00:37
04-27-1994
Time (HH:MM:SS) Date (MM-DD-YYYY)
File name
WAR-BD3.PRD
Display Type
All Data

-6.50 Max Y Axis

HN-05 S



Min Y Axis -9.00

03:00:00 03-28-1994

11:10:14 04-07-1994

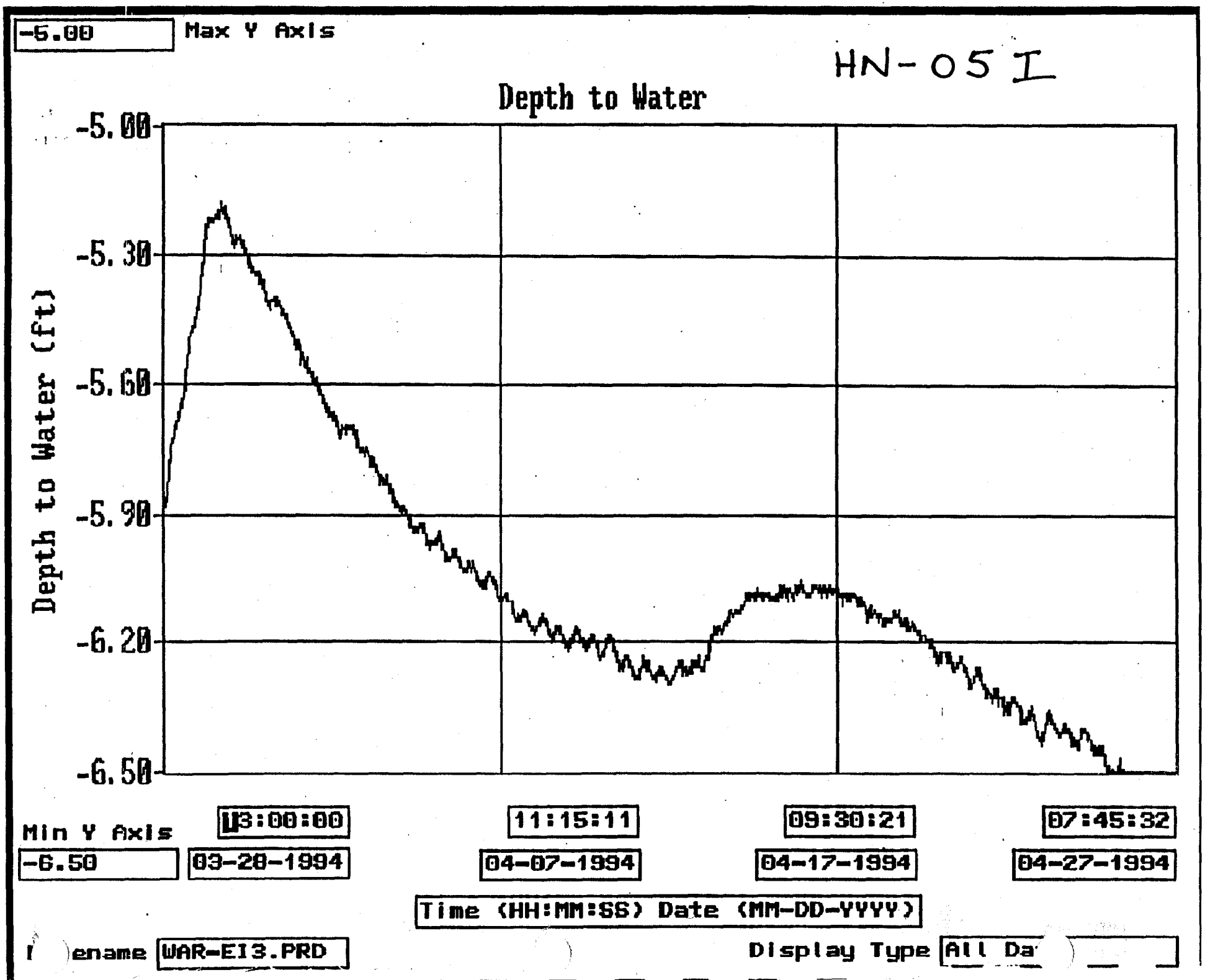
09:20:29 04-17-1994

07:30:43 04-27-1994

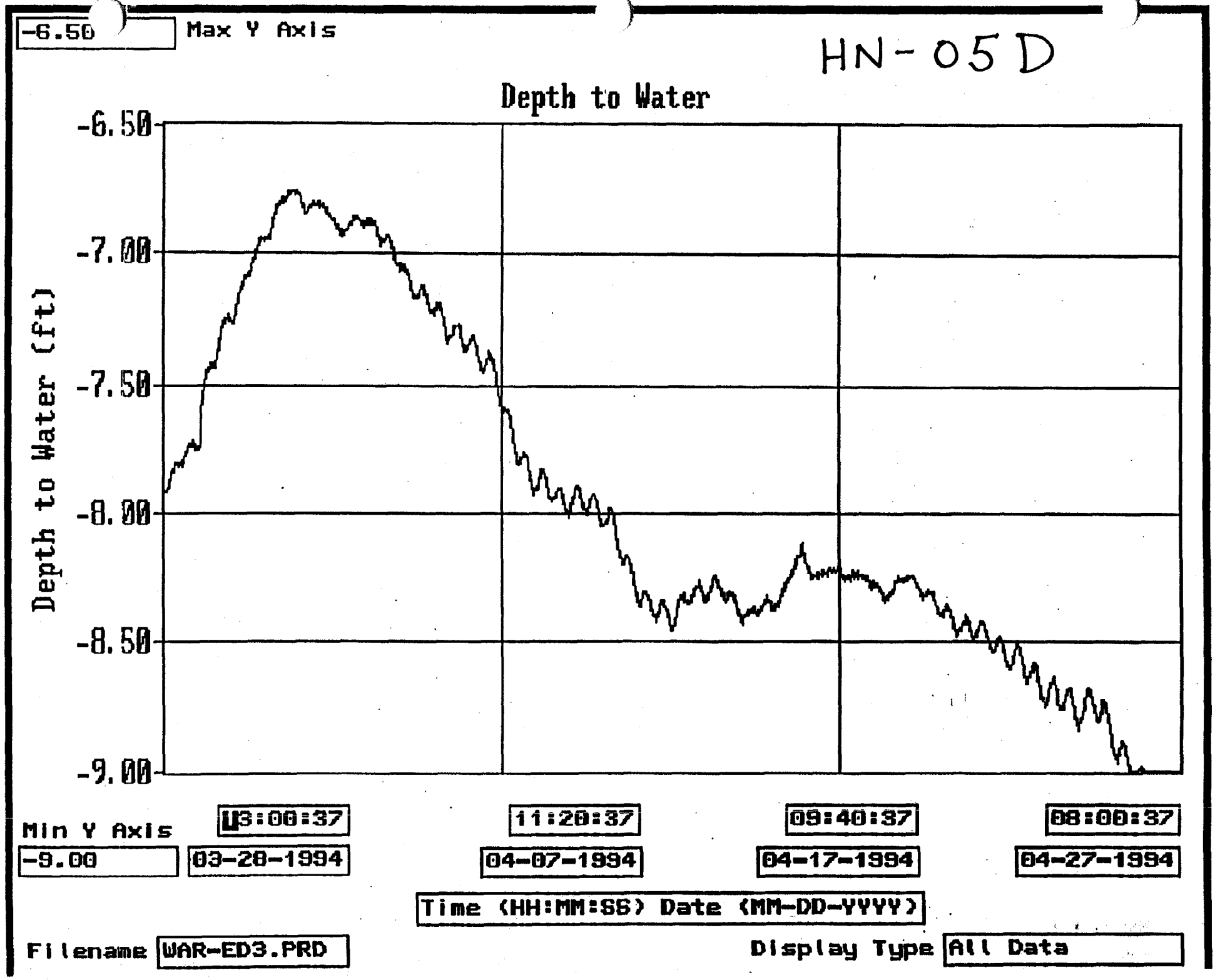
Time (HH:MM:SS) Date (MM-DD-YYYY)

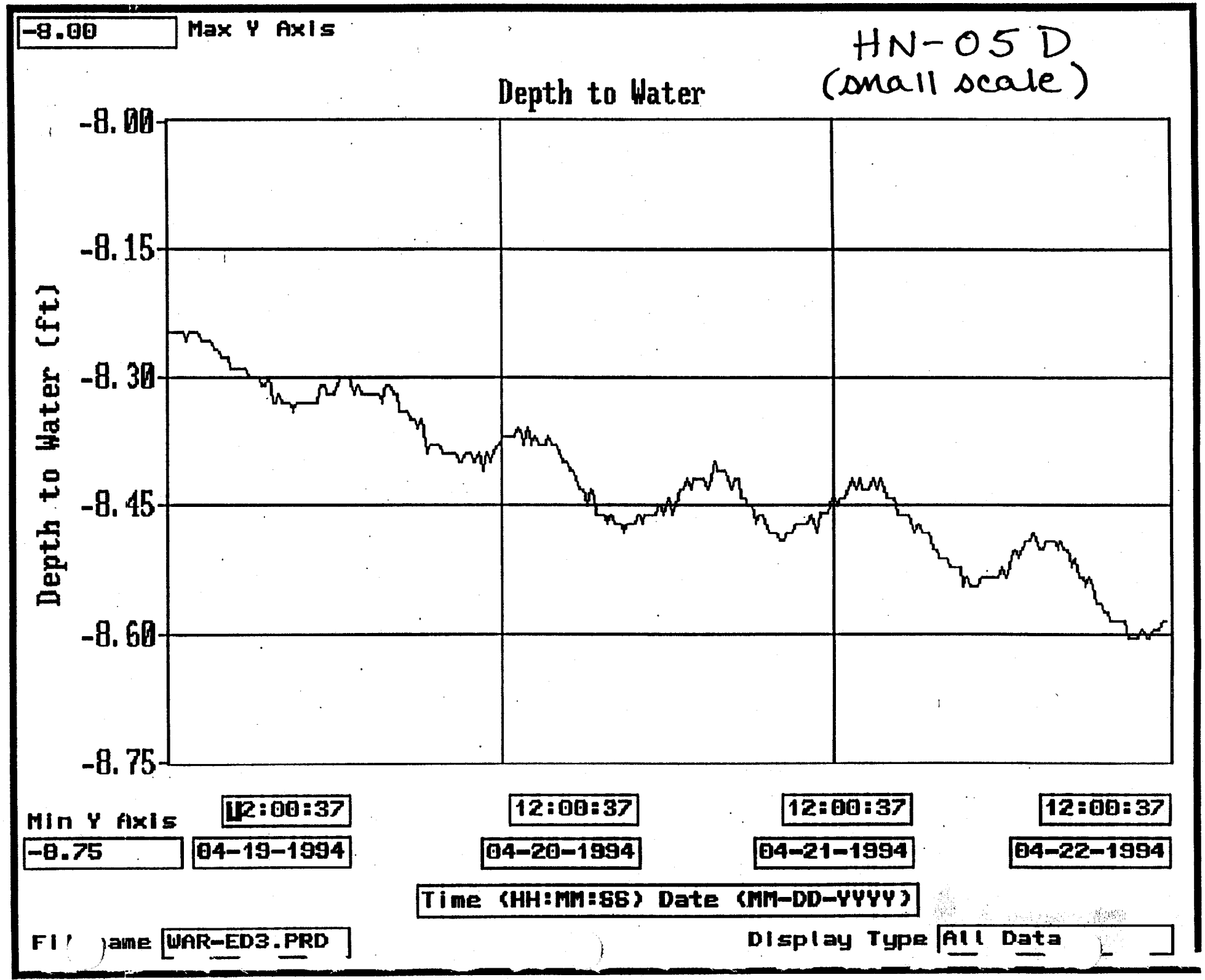
Filename WAR-ES3.PRD

Display Type All Data


-5.00
Max Y Axis
HN-05 I
Depth to Water
-5.00
-5.30
-5.60
-5.90
-6.20
-6.50
Depth to Water (ft)
Min Y Axis
-6.50
03:00:00
03-28-1994
11:15:11
04-07-1994
09:30:21
04-17-1994
07:45:32
04-27-1994
Time (HH:MM:SS) Date (MM-DD-YYYY)
ename
WAR-EI3.PRD
Display Type
All Da

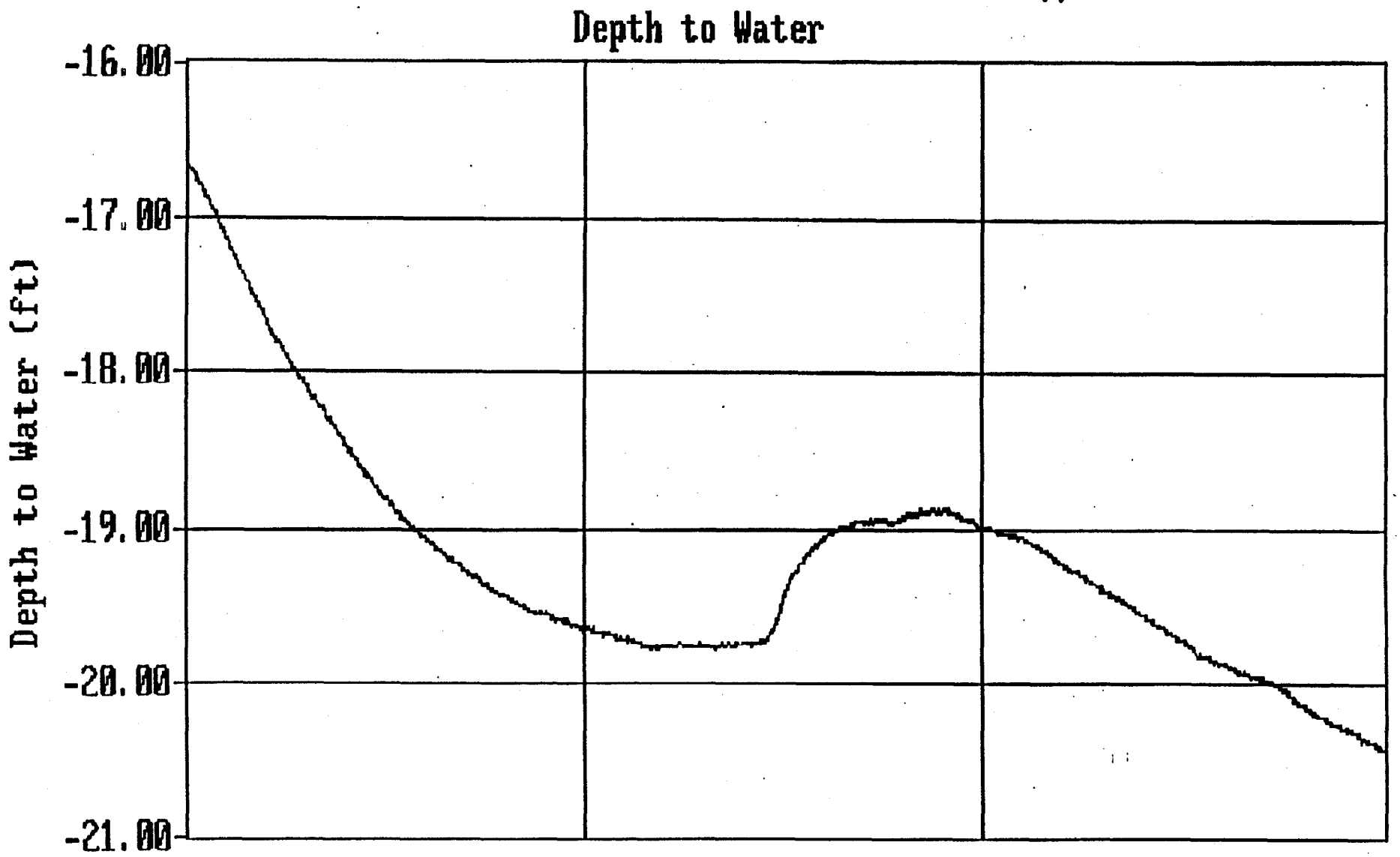
S11


-6.50
Max Y Axis
HN-05D
Depth to Water
-6.50
-7.00
-7.50
-8.00
-8.50
-9.00
Depth to Water (ft)
Min Y Axis
-9.00
03:00:37
03-28-1994
11:20:37
04-07-1994
09:40:37
04-17-1994
08:00:37
04-27-1994
Time (HH:MM:SS) Date (MM-DD-YYYY)
Filename
WAR-ED3.PRD
Display Type
All Data


-8.00
Max Y Axis
HN-05D
(small scale)
Depth to Water
-8.00
-8.15
-8.30
-8.45
-8.60
-8.75
Depth to Water (ft)
Min Y Axis
-8.75
12:00:37
04-19-1994
12:00:37
04-20-1994
12:00:37
04-21-1994
12:00:37
04-22-1994
Time (HH:MM:SS) Date (MM-DD-YYYY)
File Name
WAR-ED3.PRD
Display Type
All Data

-16.00 Max Y Axis

HN-07S



Min Y Axis -21.00

12:30:48 03-31-1994

11:55:48 04-09-1994

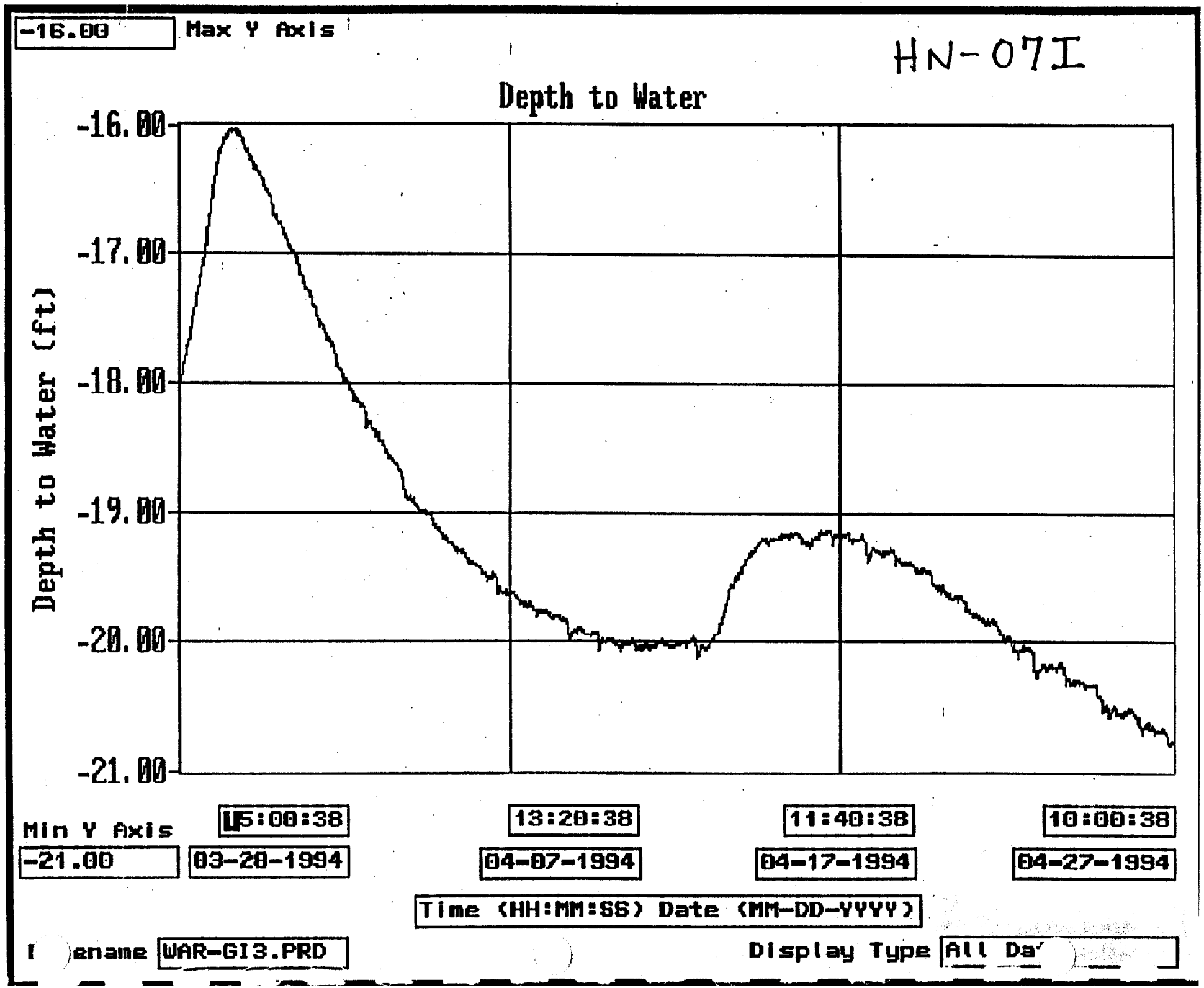
11:20:48 04-18-1994

10:45:48 04-27-1994

Time (HH:MM:SS) Date (MM-DD-YYYY)

Filename WAR-GS3.PRD

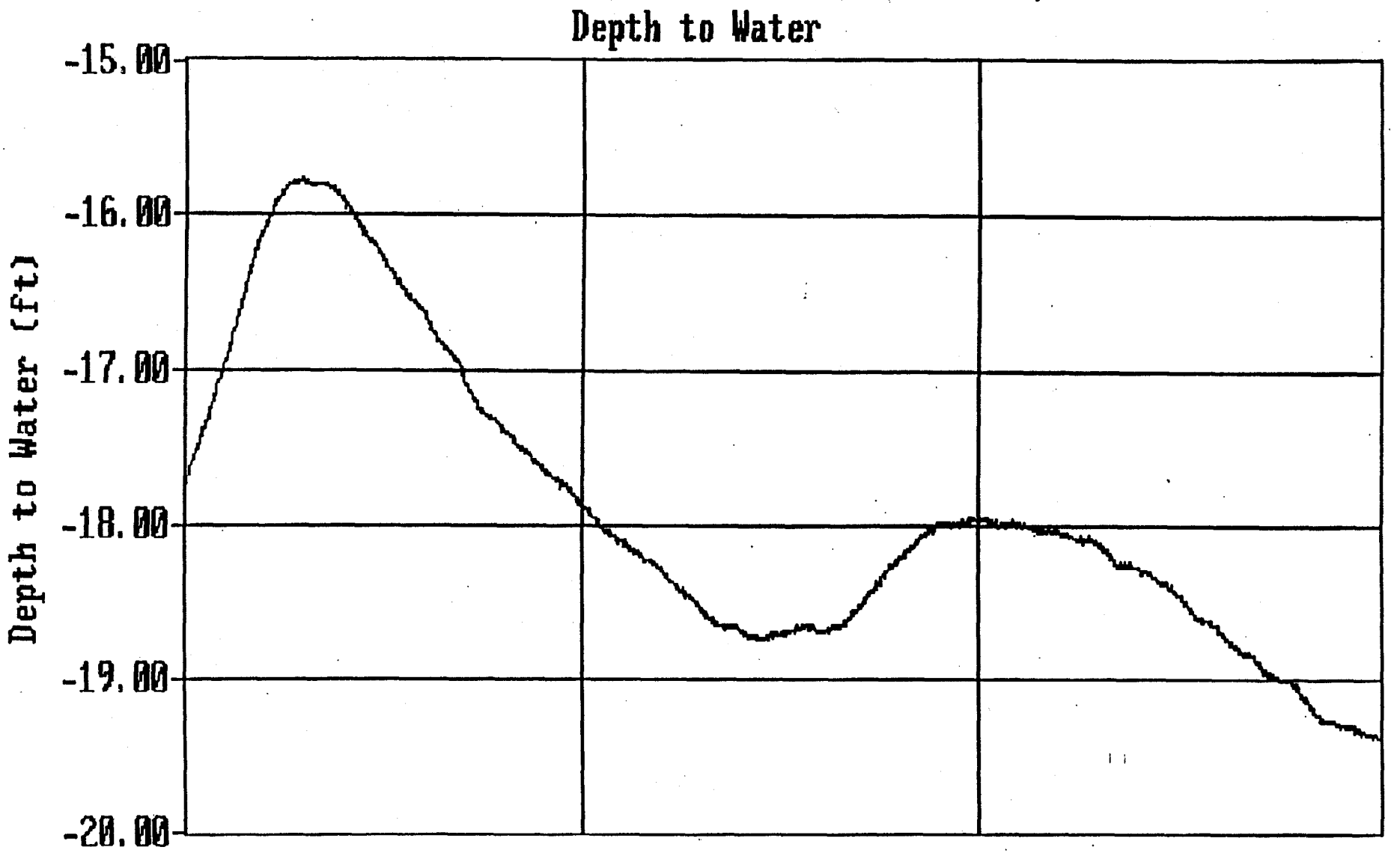
Display Type All Data


-16.00
Max Y Axis
HN-07I
Depth to Water
-16.00
-17.00
-18.00
-19.00
-20.00
-21.00
Depth to Water (ft)
Min Y Axis
-21.00
15:00:38
03-28-1994
13:20:38
04-07-1994
11:40:38
04-17-1994
10:00:38
04-27-1994
Time (HH:MM:SS) Date (MM-DD-YYYY)
ename
WAR-GI3.PRD
Display Type
All Da

S13

-15.0 Max Y Axis

HN-07D



Min Y Axis -20.00

15:00:38 03-28-1994

13:20:38 04-07-1994

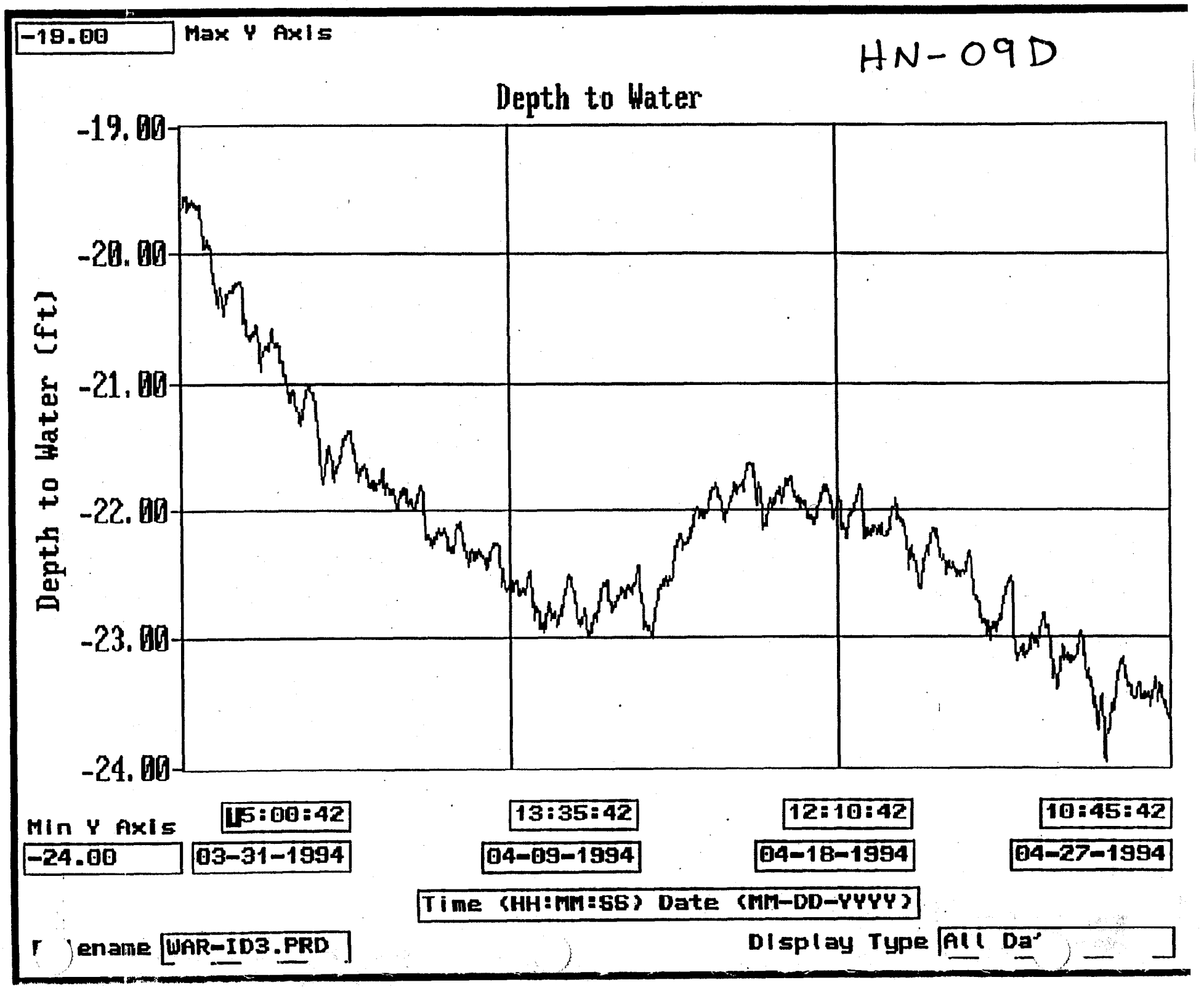
11:40:38 04-17-1994

10:00:38 04-27-1994

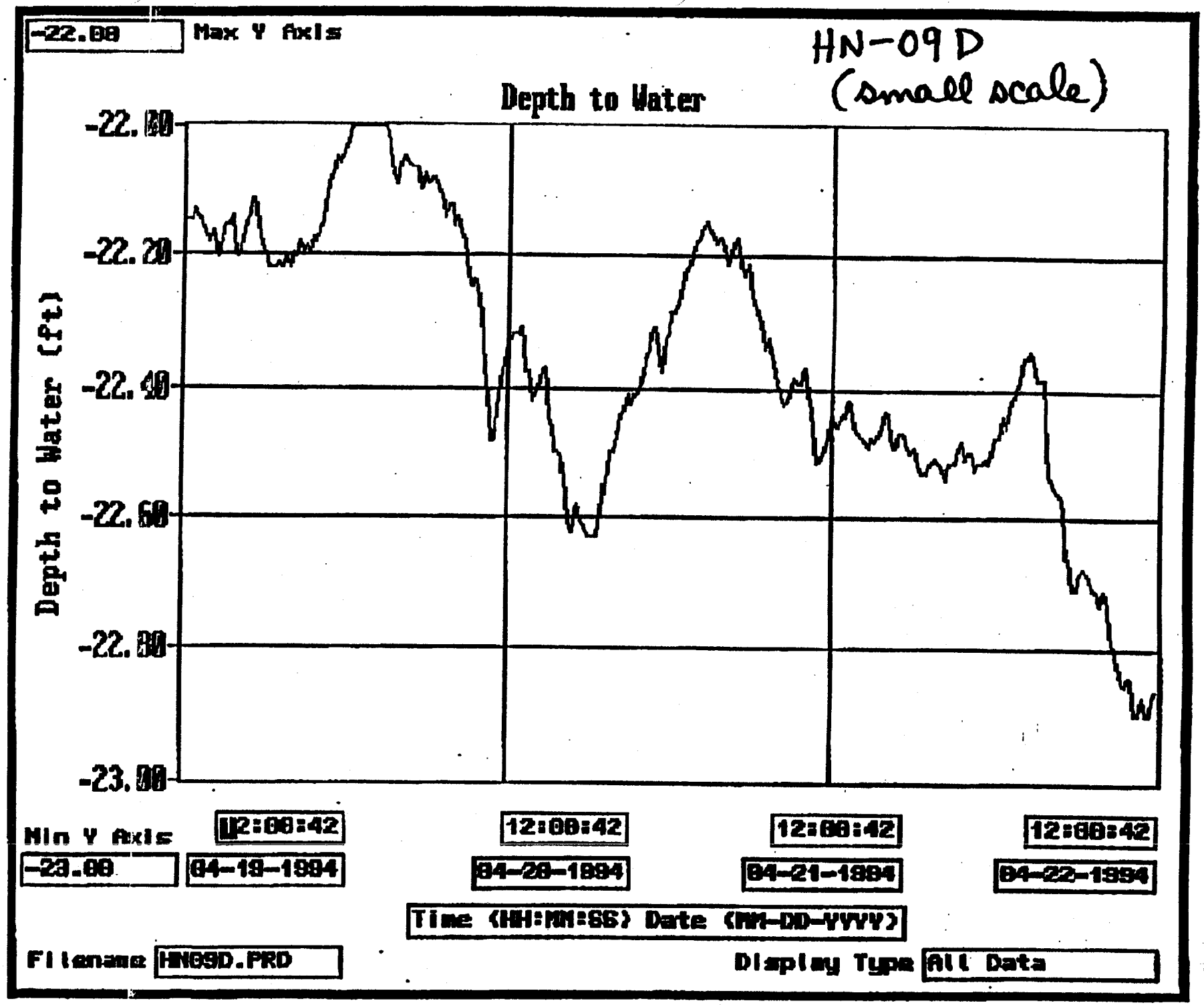
Time (HH:MM:SS) Date (MM-DD-YYYY)

Filename WAR-GD3.PRD

Display Type All Data


-19.00
Max Y Axis
HN-09D
Depth to Water
-19.00
-20.00
-21.00
-22.00
-23.00
-24.00
Depth to Water (ft)
Min Y Axis
-24.00
15:00:42
03-31-1994
13:35:42
04-09-1994
12:10:42
04-18-1994
10:45:42
04-27-1994
Time (HH:MM:SS) Date (MM-DD-YYYY)
ename
WAR-ID3.PRD
Display Type
All Da

5/4


-22.00
Max Y Axis
HN-09D
(small scale)
Depth to Water
-22.00
-22.20
-22.40
-22.60
-22.80
-23.00
Depth to Water (Ft)
Min Y Axis
-23.00
12:00:42
04-19-1994
12:00:42
04-20-1994
12:00:42
04-21-1994
12:00:42
04-22-1994
Time (HH:MM:SS) Date (MM-DD-YYYY)
Filename
HN09D.PRD
Display Type
All Data

APPENDIX D

GROUND SURFACE ELEVATIONS

AREA B MONITORING WELL CONSTRUCTION DETAILS
FORMER NAWC WARMINSTER
December 16, 1999

WELL	ELEVATION (FEET) GROUND	/TOC	BOREHOLE DEPTH (FEET)	MONITORED INTERVAL (FEET)	WELL YIELD	COMMENTS
AREA B MONITORING WELLS						
HN-01S	NA	368.11	37	18.5-37	<0.5	BG-7
HN-01I	367.31	369.28	104	68-92	16	
HN-01D	367.51	369.02	155	108-127	0.5	
HN-02X	NA	338.38	13.2	6.2-13.2	0.5	DG-27
HN-02S	NA	338.90	33	15-33	<0.5	DG-21
HN-02I	338.54	339.63	104	85-104	8	
HN-02D	338.84	340.18	153	116-133	20	
HN-03X	332.40	332.08	10	5.05-9.6		DG-8 (Filled In)
HN-03S	NA	333.20	32	17.6-32	1	DG-20
HN-03I	332.54	334.71	102	81-102	12	
HN-03D	332.54	335.26	162	115-140	1	
HN-04S	366.33	367.27	37	20-37	22	
HN-04I	366.15	367.93	104	55-73	1	
HN-04D	366.23	367.65	179	105-124	16	
HN-05S	339.42	339.11	55	36-55	6	
HN-05I	338.63	337.70	154	70-88	1	
HN-05D	338.17	338.30	204	180-204	12	
HN-06S	343.34	345.62	53	30-53	6	
HN-06I	343.24	345.52	103	80-103	4	
HN-06D	343.24	345.54	154	134-154	1.5	
HN-07S	350.83	352,86	45	29-45	9	
HN-07I	350.73	352.54	103	64-85	1	
HN-07D	350.23	350.59	201	144-162	<1	
HN-08S	355.03	356.07	54	29-48	<0.5	
HN-08I	354.83	356.23	78	60-78	6	
HN-08D	354.63	355.55	178	157-178	11	
HN-09S	351.73	355.01	52	29-52	9	
HN-09I	351.73	354.32	103	75-103	<0.5	
HN-09D	351.73	353.98	202	138-161	17	
HN-10S	331.05	331.05	54	26-40	22	
HN-10I	331.17	331.17	112	80-101	22	
HN-10D	330.89	330.89	254	225-245	<1	
HN-35S	338.63	338.69	105	35-48	1	
HN-35I		338.69		87-105		
HN-35D	339.12	338.85	150	115-130		
HN-36X	342.80	342.08	15.5	6.8-14.7		DG-9; Site 6
HN-36S	NA	343.99	27	22-27	1	DG-18
HN-36I1	342.16	342.76	177	82-100	2	
HN-36I2	341.22	342.68	151	101-115	<1	
HN-36D		341.94		133-147	1	
HN-37X	338.60	338.29	15.5	5.6-15.05		DG-7 (Filled In)

AREA B MONITORING WELL CONSTRUCTION DETAILS
FORMER NAWC WARMINSTER
December 16, 1999

WELL	ELEVATION (FEET) GROUND	/TOC	BOREHOLE DEPTH (FEET)	MONITORED INTERVAL (FEET)	WELL YIELD	COMMENTS
HN-37S	NA	338.17	41	21-41	1	DG-25
HN-37I	336.98	338.90	159	75-103	2	
HN-37D		338.42		116-141	3	
HN-38X	NA	328.30	7	2-7		MW-08
HN-38S	NA	328.53	35	25-35	>7	MW-05
HN-38I	327.53	329.16	119	97-119	5	HN-38D
HN-39X	NA	327.81	7	2-7	<0.5	MW-09
HN-39S	NA	331.84	50	18-50	>5	MW-06
HN-39D	326.28	326.71	150	125-150	<1	HN-39
HN-40S	353.53	354.74	69	55-69	3	
HN-40I	353.53	355.12	133	88-114	<1	
HN-40D	352.97	355.07	161	120-148	2	
HN-41S	352.78	354.42	54	41-54	2	
HN-41I	352.77	354.63	101	72-93	<1	
HN-41D	352.96	354.14	176	151-176	<1	
HN-43S	347.56	348.01	64	43-64	2	
HN-43I	347.46	348.28	104	90-104	2	
HN-43D	347.26	348.13	151	117-135	2	
HN-49S	351.51	352.72	51	36-51	<1	Enl Housing
HN-49I	351.56	352.45	102	55-75	1.5	Enl Housing
HN-49D	351.51	352.96	152	118-135	2	Enl Housing
HN-61S	350.76	352.03	142.5	81-95.5	1.5	Enl Housing
HN-61I	350.48	350.75	142	110-124.5	1	Enl Housing
HN-62S	345.61	345.94	57	35-50	2	Enl Housing
HN-62I	345.32	345.13	140	70.5-85.5	1	Enl Housing
HN-63X	362.80	362.63	18	7-15.9		BG-01
HN-63S	360.79	361.38	54	27-46		Site 6
HN-64S	342.84	343.38	104	29-50		Site 6
HN-64I	343.21	344.16		82-104		Site 6
HN-84S	347.84	347.88	52	TBD	2.5	Enl Housing
HN-84I	347.96	348.03	122	TBD	2	Enl Housing
HN-85S	347.49	347.57	43	TBD	>5	Enl Housing
HN-85I	348.76	348.87	94	TBD	20	Enl Housing
HN-86S	360.33	362.88	50	TBD	5	Enl Housing
HN-86I	359.97	362.59	102	TBD	>7	Enl Housing
HN-87S	338.11	338.13	62	TBD	2	Enl Housing
DG-17	NA	347.64	38	16.5-38	<0.5	Bldg. 108
DG-19	NA	346.25	47	21.75-47	0.5	Site 6
SW-08			200	?-200		Area B
SW-09			385	62-385		Bristol Road
SW-11			400	57-400		Inactive
EW-12		333.60	100	20-100		Area B
EW-14		331.43	100	20-100	10-12	Area B
OB-5		338.09	100	20-100		Area B
OB-7		332.06	100	20-100		Area B

AREA B MONITORING WELL CONSTRUCTION DETAILS
FORMER NAWC WARMINSTER
December 16, 1999

WELL	ELEVATION (FEET) GROUND /TOC		BOREHOLE DEPTH (FEET)	MONITORED INTERVAL (FEET)	WELL YIELD	COMMENTS
OB-8		330.97	100	20-100		Area B
OB-9		333.03	100	20-100	1-2	Area B
OB-10		330.20	100	20-100	>20	Area B

Well numbers in italics show wells that have been renumbered.

APPENDIX E

HUMAN HEALTH RISK ASSESSMENT APPENDICES

NAWC WARMINSTER AREA B

TOXICOLOGICAL PROFILES

Toxicological Profiles

E.1 Barium

E.1.1 Non-carcinogenic Toxicity

Barium is a naturally occurring alkaline earth metal that comprises approximately 0.04 percent of the earth's crust (Reeves 1986). Acute oral toxicity was manifested by GI upset, altered cardiac performance, and transient hypertension, convulsions, and muscular paralysis. Repeated oral exposures were associated with hypertension. Occupational exposure to insoluble barium sulfate induced benign pneumoconiosis (ACGIH 1991). EPA (1999b) published an oral RfD of 7.00E-02 mg/kg/day, based on an NOAEL of 0.21 mg/kg/day in a ten-week study in humans exposed to barium in drinking water. An uncertainty factor of 3 is assigned to the oral RfD to account for a lack of potential differences between adults and children. The critical effects seen were hypertension and the data suggested possible renal effects in animal and human studies. EPA (1997) published a inhalation RfD of 1.43E-04 mg/kg/day based on a fetotoxicity study in rats. An uncertainty/modifying factor of 1000 is assigned to the inhalation RfD. Fetotoxicity appears to be the principal target organ for inhalation exposure to barium.

E.1.2 Carcinogenicity

EPA (1999b) considers barium as not likely to be a human carcinogen, however, the lack of adequate inhalation studies preclude EPA from classifying barium as a cancer weight-of-evidence Group D substance (not classifiable as to carcinogenicity in humans).

E.2 Benzene

E.2.1 Non-carcinogenic Toxicity

In humans, short-term inhalation exposure to benzene induced CNS effects such as drowsiness, dizziness, and headaches; long-term exposure induced anemia (ACGIH 1991). Oral dosing in animals induced hematopoietic effects (ATSDR 1995a). EPA (1999a) presented an oral RfD of 3.00E-03 mg/kg/day (NCEA-07/02/96). An uncertainty/modifying factor of 3000 is assigned to the oral RfD. The target organs for oral benzene exposure include the immune and hematopoietic systems. EPA (1999a) presented an inhalation RfD of 1.70E-03 mg/kg/day (NCEA-07/02/96). An uncertainty/modifying factor of 1000 is assigned to the inhalation RfD. The target organs for oral benzene exposure include the hematopoietic system.

E.2.2 Carcinogenicity

EPA (1999b) classifies benzene in cancer weight-of-evidence Group A (human carcinogen) based on several studies of increased risk of non-lymphocytic leukemia associated with occupational exposure, supported by an increased incidence of neoplasia in rats and mice exposed by inhalation and gavage. An oral SF of 2.90E-02 per mg/kg/day (EPA 1999b) and an inhalation SF of 2.90E-02 per mg/kg/day are based on the increased incidence of leukemia in several occupational (inhalation exposure) studies.

E.3 Chloroform

E.3.1 Non-carcinogenic Toxicity

Oral or inhalation exposure of animals to chloroform was associated with liver and kidney damage (ACGIH 1991; EPA 1999b). In humans, acute inhalation exposure to high levels induced narcosis, ventricular fibrillation, and death (ACGIH 1991). Limited occupational data associated chronic exposure to chloroform with CNS depression, digestive disturbances, and enlarged livers. EPA (1999b) published an oral RfD of 1.00E-02 mg/kg/day based on an LOAEL of 15 mg/kg/day for fatty cyst formation in the livers of dogs treated orally for 7.5 years. An uncertainty factor of 1000 is assigned to the oral RfD; 10 was applied to account for interspecies conversion, 10 was applied to account for protection of sensitive human subpopulations, and 10 was applied to account for the basis of the RfD on a LOAEL rather than a NOEL. EPA (1999a) presented an inhalation RfD of 8.60E-05 mg/kg/day (NCEA-12/01/97). An uncertainty/modifying factor of 1000 is assigned to the inhalation RfD. Target organs for the toxicity of chloroform include the liver and kidney for oral and inhalation exposure, and the respiratory system for inhalation exposure.

E.3.2 Carcinogenicity

Chloroform is classified as a cancer weight-of-evidence Group B2 compound (probable human carcinogen), based on increased incidence of several tumor types in rats and liver tumors in mice (EPA 1999b). Human carcinogenicity data are inadequate. An oral SF of 6.10E-03 per mg/kg/day (EPA 1999b) was derived from the incidence of kidney tumors in rats treated with chloroform in drinking water for two years. An inhalation unit risk of 2.3E-05 per ug/m3, equivalent to an inhalation SF of 6.30E+00 per mg/kg/day, was based on the incidence of hepatocellular carcinomas in mice treated by gavage for 78 weeks (EPA 1999b).

E.4 cis-1,2-Dichloroethene

E.4.1 Non-carcinogenic Toxicity

Repeated oral exposure of rats to cis-1,2-dichloroethene (cis-1,2-DCE) was associated with signs of anemia (decreased hematocrit and hemoglobin) (EPA 1999b). Inhalation exposure to isomeric mixtures of 1,2-DCE induced narcosis, and mixed isomers of 1,2-DCE were used as an anesthetic gas (ACGIH 1991). EPA

(1999a) presented a provisional oral RfD of 1.0E-02 mg/kg/day for cis-1,2-DCE based on an NOAEL for signs of anemia in rats. An uncertainty factor of 3000 is assigned to the oral RfD. Target organs appear to be the erythrocyte for cis-1,2-DCE oral exposure. An inhalation RfD was not presented for cis-1,2-DCE (EPA, 1999a).

E.4.2 Carcinogenicity

EPA (1999b) classifies cis-1,2-DCE as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans), based on an absence of human or animal cancer data.

E.5 Manganese

E.5.1 Non-carcinogenic Toxicity

Manganese is nutritionally required in humans for normal growth and health (EPA 1999b). The elderly appeared to be more sensitive than children. Oral treatment of laboratory rodents induced biochemical changes in the brain, but rodents did not exhibit the neurological signs exhibited by humans. Occupational exposure to high concentrations in air induced a generally typical spectrum of neurological effects, and increased incidence of pneumonia (ACGIH 1986). EPA (1999b) published an RfD for manganese of 2.4E-02 mg/kg/day based on drinking water study. An modifying factor of 3 is assigned to the oral RfD when assessing exposure to manganese from drinking water. There are four reasons for this recommendation. First, while the data suggest that there is no significant difference between absorption of manganese as a function of the form in which it is ingested (i.e., food versus water), there is some degree of increased uptake of manganese from water in fasted individuals. Second, the study by Kondakis et al. (1989) raises some concern for possible adverse health effects associated with a lifetime consumption of drinking water containing about 2 mg/L of manganese. Third, although toxicity has not been demonstrated, there is concern for infants fed formula that typically has a much higher concentration of manganese than does human milk. If powdered formula is made with drinking water, the manganese in the water would represent an additional source of intake. Finally, there is some evidence that neonates absorb more manganese from the gastrointestinal tract, that neonates are less able to excrete absorbed manganese, and that in the neonate the absorbed manganese more easily passes the blood-brain barrier. EPA (1999b) published an inhalation RfC based on a LOAEL for impairment of neurobehavioral function in occupationally exposed humans. The inhalation RfC is equivalent to 1.43E-05 mg/kg/day, assuming humans inhale 20 m3 of air/day and weigh 70 kg. An uncertainty factor of 1000 is assigned to the inhalation RfD; 10 was applied to account for protection of sensitive human subpopulations, 10 was applied to account for use of a LOAEL, and 10 was applied to account for database limitations reflecting both the less-than-chronic periods of exposure and the lack of developmental data, as well as potential but unquantified differences in the toxicity of different forms of manganese. The central nervous system is the target organ for oral and inhalation exposure to manganese.

E.5.2 Carcinogenicity

EPA (1999b) classifies manganese in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans).

E.6 Tetrachloroethene (PCE)

E.6.1 Non-carcinogenic Toxicity

Occupational (inhalation and dermal) exposure to tetrachloroethene (PCE) was associated with neuralgic effects, beginning with incoordination and progressing to dizziness, headache, vertigo, and unconsciousness (ACGIH, 1986). EPA (1999b) published an oral RfD for PCE of 1.00E-02 mg/kg/day based on an NOAEL for liver toxicity in mice in a subchronic gavage study, and on a NOEL for depressed body weight gain in rats in a subchronic drinking water study. An uncertainty factor of 1000 is assigned to the oral RfD; 10 was applied to account for intraspecies variability, 10 was applied to account for interspecies variability, and 10 was applied to account for extrapolation of a subchronic effect level to its chronic equivalent. The liver is the principal target organ for oral exposure to PCE. EPA (1999a) presented an inhalation RfD of 1.40E-01 mg/kg/day (NCEA-06/20/97). An uncertainty/modifying factor of 300 is assigned to the inhalation RfD. The liver and kidney are the principal target organs for inhalation exposure to PCE.

E.6.2 Carcinogenicity

Inhalation exposure to tetrachloroethene induced mononuclear cell leukemia in rats, and inhalation or oral exposure induced hepatocellular carcinomas in mice (ATSDR 1995b). EPA (1999a) presented an oral SF of 5.20E-02 per mg/kg/day and an inhalation SF of 2.03E-03 per mg/kg/day for PCE (NCEA Other-04/01/87).

E.7 Trichloroethene (TCE)

E.7.1 Non-carcinogenic Toxicity

Little is known about the toxicity of prolonged oral exposure to TCE. Acute inhalation exposure to high levels of TCE induced anesthesia, tachypnea, and ventricular arrhythmias (ACGIH, 1986). Occupational exposure to TCE was associated with headache, dizziness, lassitude, and other CNS effects. Prolonged inhalation exposure of animals to TCE affected the liver and kidneys. EPA (1999a) presented an oral RfD of 6.00E-03 mg/kg/day (NCEA-03/05/92). An uncertainty/modifying factor of 3000 is assigned to the oral RfD. The liver and kidney are the principal target organs for oral exposure to TCE. An inhalation RfD was not presented for cis-1,2-DCE (EPA, 1999a).

E.7.2 Carcinogenicity

Carcinogenicity studies in laboratory animals showed increased incidence of hepatocellular carcinomas (gavage exposure) and malignant lymphomas (inhalation exposure) in mice and increased incidence of renal adenocarcinomas in male rats (gavage) (ATSDR, 1995c). Cancer studies in humans were inadequate. Interpretation of the data regarding the carcinogenicity of trichloroethene is controversial, and EPA (1999b) has not adopted a final position on a cancer weight-of-evidence classification. Currently, EPA believes the weight-of-evidence to be on the B2-C continuum (possible-probable human carcinogen). EPA (1999a) presents an oral SF of 1.10E-02 per mg/kg/day and an inhalation SF of 6.00E-03 per mg/kg/day for inhalation exposure (NCEA-07/01/89).

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NAWC WARMINSTER AREA B

DATA USABILITY WORKSHEET

Data Usability Summary
Warminster Area B
Groundwater Data

Compound	No. of Rejected Results	No. of Positive Results	Minimum Positive Result	Maximum Positive Result	No. of Results Qualified by Blank	Minimum Sample Value Qualified by Blank	Maximum Sample Value Qualified by Blank	No. of Nondetect Results	Minimum Detection Limit	Maximum Detection Limit
aluminum		5	116	502	8	13	209			
antimony								13	1.8	1.8
arsenic		1	2	2	1	3	3	11	2.1	2.1
barium		13	5	591						
beryllium		1						12	0.2	0.2
cadmium		1	1	1				12	0.3	0.3
calcium		13	3750	78200						
chromium		12	1	7				1	0.8	0.8
cobalt		7		11				6	0.4	0.4
copper					13	1	4			
cyanide								13	10	10
iron		8	24	696	2	27	93	3	12.5	12.5
lead		5	2	17				8	1.7	1.7
magnesium		13	1460	27100						
manganese		10	6	1320	3	1	3			
mercury								13	0.1	0.1
nickel		9	1	9	4	2	2			
potassium		12	799	2660	1	708	708			
selenium		1	2	2				12	1.6	2.2
silver								13	0.7	0.7
sodium		13	6300	32300						
thallium								13	3.1	3.1
vanadium					1	1	1	12	0.6	0.6
zinc					13	2	22			
2,2'-oxybis(1-chloropropane)								3	9	10
2,4,5-trichlorophenol								3	24	47
2,4,6-trichlorophenol								3	9	10
2,4-dichlorophenol								3	9	10
2,4-dimethylphenol								3	9	10
2,4-dinitrophenol								3	24	47
2,4-dinitrotoluene								3	9	10
2,6-dinitrotoluene								3	9	10
2-chloronaphthalene								3	9	10
2-chlorophenol								3	9	10
2-methylnaphthalene								3	9	10
2-methylphenol								3	9	10
2-nitroaniline								3	24	47
2-nitrophenol								3	9	10
3,3'-dichlorobenzidine								3	10	19
3-nitroaniline								3	24	47
4,6-dinitro-2-methylphenol								3	24	47
4-bromophenyl-phenylether								3	9	10
4-chloro-3-methylphenol								3	10	19
4-chloroaniline								3	10	19
4-chlorophenyl phenyl ether								3	9	10
4-methylphenol								3	9	10
4-nitroaniline								3	24	47
4-nitrophenol								3	24	47
acenaphthene								3	9	10
acenaphthylene								3	9	10
anthracene								3	9	10
benzo(a)anthracene								3	9	10
benzo(a)pyrene								3	9	10
benzo(b)fluoranthene								3	9	10
benzo(g,h,i)perylene								3	9	10
benzo(k)fluoranthene								3	9	10
bis(2-chloroethoxy)methane								3	9	10
bis(2-chloroethyl)ether								3	9	10
bis(2-ethylhexyl)phthalate					3	1	2			
butylbenzylphthalate								3	9	10
carbazole								3	9	10
chrysene								3	9	10
di-n-butylphthalate								3	9	10
di-n-octylphthalate								3	9	10
dibenz(a,h)anthracene								3	9	10
dibenzofuran								3	9	10
diethylphthalate					1	1	1	2	10	10
dimethylphthalate								3	9	10
fluoranthene								3	9	10
fluorene								3	9	10

Data Usability Summary
Warminster Area B
Groundwater Data

Compound	No. of Rejected Results	No. of Positive Results	Minimum Positive Result	Maximum Positive Result	No. of Results Qualified by Blank	Minimum Sample Value Qualified by Blank	Maximum Sample Value Qualified by Blank	No. of Nondetect Results	Minimum Detection Limit	Maximum Detection Limit
hexachlorobenzene								3	9	10
hexachlorobutadiene								3	9	10
hexachlorocyclopentadiene								3	9	10
hexachloroethane								3	9	10
indeno(1,2,3-cd)pyrene								3	9	10
isophorone								3	9	10
n-nitroso-di-N-propylamine								3	9	10
n-nitrosodiphenylamine (1)								3	9	10
naphthalene								3	9	10
nitrobenzene								3	9	10
pentachlorophenol								3	24	47
phenanthrene								3	9	10
phenol								3	9	10
pyrene								3	9	10
1,1,1-trichloroethane								79	1	1
1,1,2,2-tetrachloroethane								79	1	1
1,1,2-trichloroethane								79	1	1
1,1-dichloroethane								79	1	1
1,1-dichloroethene								79	1	1
1,2,4-trichlorobenzene								79	1	1
1,2,4-trimethylbenzene								79	1	1
1,2-dibromo-3-chloropropane								79	1	1
1,2-dibromoethane								79	1	1
1,2-dichlorobenzene								79	1	1
1,2-dichloroethane								79	1	1
1,2-dichloroethene (cis)		8	1	30	1	4	4	70	1	1
1,2-dichloroethene (trans)								79	1	1
1,2-dichloropropane								79	1	1
1,3-dichlorobenzene								79	1	1
1,4-dichlorobenzene								79	1	1
2-butanone	79							79	5	5
2-hexanone	42							79	5	5
4-methyl-2-pentanone								79	5	5
acetone	79							79	5	5
benzene		1	1	1				78	1	1
bromochloromethane								79	1	1
bromodichloromethane								79	1	1
bromoform								79	1	1
bromomethane								79	1	1
carbon disulfide		6	2	4				73	1	1
carbon tetrachloride		1	9	9				78	1	1
chlorobenzene								79	1	1
chloroethane								79	1	1
chloroform		2	1	1				77	1	1
chloromethane								79	1	1
cis-1,3-dichloropropene								79	1	1
dibromochloromethane								79	1	1
ethylbenzene								79	1	1
methylene chloride								79	2	2
styrene								79	1	1
tetrachloroethene		5	2	13				74	1	1
toluene								79	1	1
trans-1,3-dichloropropene								79	1	1
trichloroethene		10	1	320	5	1	9	64	1	1
vinyl chloride								79	1	1
xylene (total)								79	1	1
4,4'-DDD								3	0.094	0.096
4,4'-DDE								3	0.094	0.096
4,4'-DDT								3	0.094	0.096
aldrin								3	0.047	0.048
alpha-BHC								3	0.047	0.048
alpha-chlordane								3	0.047	0.048
Aroclor-1016								3	0.94	0.96
Aroclor-1221								3	1.9	1.9
Aroclor-1232								3	0.94	0.96
Aroclor-1242								3	0.94	0.96
Aroclor-1248								3	0.94	0.96
Aroclor-1254								3	0.94	0.96
Aroclor-1260								3	0.94	0.96
beta-BHC								3	0.047	0.048

Data Usability Summary
Warminster Area B
Groundwater Data

Compound	No. of Rejected Results	No. of Positive Results	Minimum Positive Result	Maximum Positive Result	No. of Results Qualified by Blank	Minimum Sample Value Qualified by Blank	Maximum Sample Value Qualified by Blank	No. of Nondetect Results	Minimum Detection Limit	Maximum Detection Limit
delta-BHC								3	0.047	0.048
dieldrin								3	0.094	0.096
endosulfan I								3	0.047	0.048
endosulfan II								3	0.094	0.096
endosulfan sulfate								3	0.094	0.096
endrin								3	0.094	0.096
endrin aldehyde								3	0.094	0.096
endrin ketone								3	0.094	0.096
gamma-BHC (lindane)								3	0.047	0.048
gamma-chlordane								3	0.047	0.048
heptachlor								3	0.047	0.048
heptachlor epoxide								3	0.047	0.048
methoxychlor								3	0.47	0.48
toxaphene								3	4.7	4.8

NAWC WARMINSTER AREA B

DISTRIBUTIONAL ANALYSIS RESULTS

Representative Concentration and Statistical Distribution of COPCs - Warminster Area B Groundwater

Substance	Number of Sample Results	Degrees of Freedom	Statistical Distribution of Site Data	Results of Shapiro-Wilk or Shapiro-Francia Distribution Tests			Table Value for H_0 is (Lognorm.) or $T_{0.95}$ (Normal)	Standard Deviation or Log Standard Deviation	Arithmetic Mean of All Site Results	Upper 95 % Confidence Limit (UCL) on Mean	Maximum Positive Site Concentration	Representative Concentration (Lower of UCL vs Max)
				W-norm.	W-lognorm	W-Table						
Aluminum	11	10	nonparametric (assumed lognorm.)	0.724	0.8257	0.85	3.9212	1.45	159	1100	502	502
Arsenic	11	10	nonparametric (assumed lognorm.)	0.4205	0.4466	0.85	1.9035	0.251	1.2	1.39	2.4	1.39
Barium	11	10	lognormal	0.7616	0.9393	0.85	3.6845	1.34	148	919	591	591
Beryllium	11	10	nonparametric (assumed lognorm.)	0.3393	0.3393	0.85	1.8796	0.224	0.11	0.125	0.21	0.125
Cadmium	11	10	nonparametric (assumed lognorm.)	0.3393	0.3393	0.85	2.0447	0.392	0.186	0.235	0.55	0.235
Calcium	11	10	normal	0.9044	0.8705	0.85	1.8125	26900	33500	48200	78200	48200
Chromium	11	10	lognormal	0.8595	0.9582	0.85	2.4628	0.698	2.11	3.78	6.7	3.78
Cobalt	11	10	nonparametric (assumed lognorm.)	0.4781	0.7457	0.85	3.5346	1.27	1.3	4.29	10.7	4.29
Iron	11	10	lognormal	0.8254	0.8848	0.85	4.5451	1.73	223	4480	696	696
Lead	11	10	nonparametric (assumed lognorm.)	0.5952	0.7461	0.85	3.1361	1.07	3.51	9.32	16.6	3
Magnesium	11	10	normal	0.8845	0.8238	0.85	1.8125	7940	11500	15800	24600	15800
Manganese	11	10	lognormal	0.5642	0.9343	0.85	6.3114	2.5	218	67600	1320	1320
Nickel	11	10	lognormal	0.7693	0.9076	0.85	2.7321	0.857	2.88	6.11	9.2	6.11
Potassium	11	10	lognormal	0.9254	0.9496	0.85	2.246	0.552	1310	1990	2660	1990
Selenium	11	10	nonparametric (assumed normal)	0.6226	0.6024	0.85	1.8125	0.129	1.05	1.13	1.6	1.13
Sodium	11	10	lognormal	0.8475	0.9495	0.85	2.1797	0.503	13700	19600	32300	19600
1,2-Dichloroethene (cis)	53	52	nonparametric (assumed lognorm.)	0.2965	0.3198	0.979	1.8379	0.446	0.67	0.709	5	0.709
Benzene	53	52	nonparametric (assumed lognorm.)	0.0955	0.0956	0.979	1.6775	0.0807	0.508	0.517	0.9	0.517
Carbon Disulfide	53	52	nonparametric (assumed lognorm.)	0.3235	0.3279	0.979	1.8317	0.436	0.66	0.705	3	0.705
Chloroform	53	52	nonparametric (assumed lognorm.)	0.0955	0.0956	0.979	1.6815	0.0952	0.509	0.52	1	0.52
Tetrachloroethene	53	52	nonparametric (assumed lognorm.)	0.2238	0.2294	0.979	1.7875	0.358	0.604	0.635	3	0.635
Trichloroethene	53	52	nonparametric (assumed lognorm.)	0.3507	0.4536	0.979	1.9478	0.608	0.858	0.905	7	0.905

Notes:

Units are ug/L.

Number of sample results excludes rejected data. Duplicates are consolidated into one result. Non-detected results are treated as present at one-half the detection limit in all calculations.

Statistical distribution of data is determined using Shapiro-Wilk test for n <= 50, Shapiro-Francia test for n > 50. Statistical significance level is 0.05.

A normal distribution is assumed if the test statistic W-norm. is >= than the reference value (W-table), and W-norm. > W-lognorm.

A lognormal distribution is assumed if the test statistic W-lognorm. is >= the reference value (W-table), and W-lognorm. >= W-norm. The best fitting distribution is assumed if neither distribution passes Shapiro test.

H-values and standard deviations of log-transformed data are used to calculate the UCL if data are assumed to be lognormally distributed. Student's T-values and standard deviations are used for normally distributed data.

Arithmetic mean includes positive detections and non-detected results (detection limits are divided by two).

The representative concentration is selected as the lower of the 95 % UCL on the mean and the maximum positive site concentration.

NAWC WARMINSTER AREA B

CHEMICAL SPECIFIC PARAMETERS FOR DERMAL CONTACT

Dermal Permeability Coefficients for Aqueous Solutions
Warminster Area B RI

Substance	Kp	t*	TAU	B
Barium	0.001	NA	NA	NA
Manganese	0.001	NA	NA	NA
1,2-Dichloroethene (cis)	0.0079	NA	NA	NA
Benzene	0.021	NA	NA	NA
Chloroform	0.0089	NA	NA	NA
Tetrachloroethene	0.03	NA	NA	NA
Trichloroethene	0.011	NA	NA	NA

Source:
EPA, 1998. RAGS, Volume I. Supplemental Guidance, Dermal Risk Assessment. Interim Guidance. November.

NAWC WARMINSTER AREA B

EXAMPLE CALCULATIONS

RISK ASSESSMENT EXAMPLE CALCULATIONS

The example calculations listed in this appendix are presented in order to verify the approaches taken and calculations used to estimate groundwater risk at Warminster Area B.

The example calculations are all based on RME exposure. Example calculations based on CTE exposure would be estimated following the same pattern as RME exposure examples listed here; however several input parameter values are different for each exposure equation. For receptor-specific differences, see the Risk Input Tables.

Three potential exposure routes are associated with direct exposure to groundwater at Warminster Area B. These exposure routes are ingestion, dermal absorption, and inhalation of vapors during showering (Future Adult Resident Only).

E.1 Ingestion of Groundwater:

E.1.1 Future Adult Resident

Ingestion of tetrachloroethene (PCE) in groundwater at Warminster Area B for a future adult resident under an RME scenario was evaluated using the following equation (EPA 1989a):

$$IngestionDose(mg/kg/day) = \frac{CW * IR_{GW} * FI * CF * EF * ED}{BW * AT}$$

Where:

Carc-Ingestion Dose	= 5.96E-6	= Carcinogenic Ingestion exposure dose (mg/kg/day)
Noncarc-Ingestion Dose	= 1.74E-5	= Noncarcinogenic Ingestion exposure dose (mg/kg/day)
CW	= 0.635 ug/L	= PCE concentration in groundwater
CF	= 1 mg/10^3 ug	= conversion factor
IR_{GW}	= 2 L/day	= Ingestion rate
FI	= 100%	= Fraction Ingested
EF	= 350 days/yr	= Exposure frequency
ED	= 24 yr	= Exposure duration
BW	= 70 kg	= Body weight
ATC	= 25550 days	= Averaging time for carcinogens (365 d/yr x 70 yrs)
ATN	= 8760 days	= Averaging time for noncarcinogens (365 d/yr x 24 yrs)

The RME cancer risk for a future adult resident from ingestion of PCE in groundwater at Warminster Area B is estimated as follows:

CA = Ingestion Dose x SF

CA	= 3.10E-7	= Incremental cancer risk
SF	= 5.2E-2 $(mg/kg/day)^{-1}$	= Oral slope factor
Carc-Ingestion Dose	= 5.96E-6	= Carcinogenic Ingestion exposure dose (mg/kg/day)

The RME noncarcinogenic risk a future asult resident from ingestion of PCE in groundwater at Warminster Area B is estimated as follows:

NC = Ingestion Dose/RfD

NC	= 1.74E-3	= Noncarcinogenic risk
RfD	= 1.0E-2 (mg/kg/day)	= Oral reference dose
Noncarc-Ingestion Dose	= 1.74E-5	= Noncarcinogenic Ingestion exposure dose (mg/kg/day)

E.1.2 Future Child Resident

Ingestion of tetrachloroethene (PCE) in groundwater at Warminster Area B for a future child resident under an RME scenario was evaluated using the following equation (EPA 1989a):

$$IngestionDose(mg/kg/day) = \frac{CW * IR_{GW} * FI * CF * EF * ED}{BW * AT}$$

Where:

Carc-Ingestion Dose	= 3.48E-6	= Carcinogenic Ingestion exposure dose (mg/kg/day)
Noncarc-Ingestion Dose	= 4.06E-5	= Noncarcinogenic Ingestion exposure dose (mg/kg/day)

CW	= 0.635 ug/L	= PCE concentration in groundwater
CF	= 1 mg/10^3 ug	= conversion factor
IR_{GW}	= 1 L/day	= Ingestion rate
FI	= 100%	= Fraction Ingested
EF	= 350 days/yr	= Exposure frequency
ED	= 6 yr	= Exposure duration
BW	= 15 kg	= Body weight
ATC	= 25550 days	= Averaging time for carcinogens (365 d/yr x 70 yrs)
ATN	= 2190 days	= Averaging time for noncarcinogens (365 d/yr x 6 yrs)

The RME cancer risk for a future child resident from ingestion of PCE in groundwater at Warminster Area B is estimated as follows:

CA = Ingestion Dose x SF

CA	= 1.81E-7	= Incremental cancer risk
SF	= 5.2E-2 $(mg/kg/day)^{-1}$	= Oral slope factor
Carc-Ingestion Dose	= 3.48E-6	= Carcinogenic Ingestion exposure dose (mg/kg/day)

The RME noncarcinogenic risk a future asult resident from ingestion of PCE in groundwater at Warminster Area B is estimated as follows:

NC = Ingestion Dose/RfD

NC	= 4.06E-3	= Noncarcinogenic risk
RfD	= 1.0E-2 (mg/kg/day)	= Oral reference dose
Noncarc-Ingestion Dose	= 4.06E-5	= Noncarcinogenic Ingestion exposure dose (mg/kg/day)

E.2 Dermal Absorption of Groundwater:

If inhalation of groundwater is also estimated for exposure to groundwater, the concentration of PCE leaving water as a vapor must be estimated and subtracted from the water concentration in order to determine the proper concentration left for dermal contact.

$$Cv = Co - CWD$$

Where:

Cv	= 0.402 ug/L	= PCE concentration in water after vaporization
Co	= 0.635 ug/L	= original concentration of PCE in groundwater
Cwd	= 0.233 ug/L	= concentration of PCE leaving the water droplet in vapors

The concentration leaving the water droplet (Cwd; see derivation below) is 0.233 ug/L, therefore, the available concentration for dermal contact is equal to 0.635 ug/L - 0.233 ug/L = 0.402 ug/L, this value is input into Cv in the dermal equation above.

$$Cwd = CW * \left(1 - e^{-KaL * ts * \left(6/d\right)} * CF_4 * CF_5\right)$$

Cwd	= 0.233 ug/L	= Concentration leaving water droplet after time ts
CW	= 0.635 ug/L	= Concentration in water
KaL	= 13.69 cm/hr	= Adjusted overall mass transfer coefficient
ts	= 2 sec	= Shower droplet time
d	= 1 mm	= Shower droplet diameter
CF_4	= 1/3600 hr/sec	= Conversion factor
CF_5	= 10 mm/cm	= Conversion Factor

$$KaL = \frac{KL}{\sqrt{\frac{T_1 * u_s}{T_s * u_1}}}$$

KaL	= 13.69 cm/hr	= Adjusted overall mass transfer coefficient
KL	= 10.14 cm/hr	= Mass transfer coefficient
T_1	= 293 °K	= Calibration water temperature of KL
T_s	= 318 °K	= Shower water temperature
μ_1	= 1.002 centipoise	= Water viscosity at T_1
μ_s	= 0.596 centipoise	= Water viscosity at T_s

$$KL = \frac{1}{\left(\frac{1}{kl}\right) + \left(\frac{R * T}{H * kg}\right)}$$

KL	= 10.14 cm/hr	= Mass transfer coefficient
R	= 8.21E-5 atm m^3/mol/°K	= Ideal gas law constant
T	= 293 °K	= Absolute temperature
H	= 0.0153 atm m^3/mole	= Henry's Law constant
kg	= 988.38 cm/hr	= Gas-film mass transfer coefficient
kl	= 10.30 cm/hr	= Liquid-film mass transfer coefficient

$$kg = KH * \sqrt{\frac{MWH}{MW}}$$

$$kl = kC * \sqrt{\frac{MWC}{MW}}$$

kg	= 988.38 cm/hr	= Gas-film mass transfer coefficient
kl	= 10.30 cm/hr	= Liquid-film mass transfer coefficient
kH	= 3000 cm/hr	= kg for water
kC	= 20 cm/hr	= kl for carbon dioxide
MWH	= 18 g/mole	= Molecular weight of water
MWC	= 44 g/mole	= Molecular weight of carbon dioxide
MW	= 165.83 g/mole	= Molecular weight of PCE

E.2.1 Future Adult Resident

Dermal absorption of of tetrachloroethene (PCE) in groundwater at Warminster Area B for a future adult resident under an RME scenario was evaluated using the following equations (EPA 1989a; EPA 1995):

$$DermalDose(mg/kg/day) = \frac{(Cv) * KP * CF1 * CF2 * SA * Func(ET) * EF * ED}{BW * AT}$$

Where:

Carc-Dermal Dose	= 1.34E-6	= Carcinogenic Dermal exposure dose (mg/kg/day)
Noncarc- Dermal Dose	= 3.91E-6	= Noncarcinogenic Dermal exposure dose (mg/kg/day)
Cv	= 0.402 ug/L	= PCE concentration in water after vaporization
KP	= 0.03 cm/hr	= permeability coefficient from water
SA	= 18,150 cm^2	= Skin surface area available for contact
CF_1	= 1 mg/10^3 ug	= Conversion Factor
CF_2	= 1 L/10^3 cm^3	= Conversion Factor
FuncET	= 1.304 hr/day	= For Organics: where t^*_{PCE} (2.14hr)>ET (0.25hr) Func(ET)=SQRT([(24)*(tau (0.89hr)*(ET (0.25hr)]/pi)
EF	=350 days/yr	= Exposure frequency
ED	= 24 yr	= Exposure duration
BW	= 70 kg	= Body weight
ATC	= 25550 days	= Averaging time for carcinogens (365 d/yr x 70 yrs)
ATN	= 8760 days	= Averaging time for noncarcinogens (365 d/yr x 24 yrs)

The RME cancer risk for a future adult resident from dermal absorption of PCE in groundwater at Warminster Area B is estimated as follows:

CA = Dermal Dose x SF

CA	= 6.98E-8	= Incremental cancer risk
SF	= 5.2E-2 $(mg/kg/day)^{-1}$	= Oral slope factor
Carc-Dermal Dose	= 1.34E-6	= Carcinogenic Dermal exposure dose (mg/kg/day)

The RME noncarcinogenic risk a future adult resident from dermal absorption of of PCE in groundwater at Warminster Area B is estimated as follows:

NC = Dermal Dose/RfD

NC	= 3.91E-4	= Noncarcinogenic risk
RfD	= 1.0E-2 (mg/kg/day)	= Dermal reference dose = (RfD_{oral}*GI Factor; [1.0E-2*1.0])
Noncarc- Dermal Dose	= 3.91E-6	= Noncarcinogenic Dermal exposure dose (mg/kg/day)

E.2.2 Future Child Resident

Dermal absorption of of tetrachloroethene (PCE) in groundwater at Warminster Area B for a future child resident under an RME scenario was evaluated using the following equations (EPA 1989a; EPA 1995):

$$DermalDose(mg/kg/day) = \frac{CW*KP*CF1*CF2*Func(ET)*EF*AgeAdj}{AT}$$

$$AgeAdj = \sum_{i=m}^{n} \frac{SA_i * ED_i}{BW_i}$$

Where:

Carc-Dermal Dose	= 9.12E-7	= Carcinogenic Dermal exposure dose (mg/kg/day)
Noncarc- Dermal Dose	= 1.06E-5	= Noncarcinogenic Dermal exposure dose (mg/kg/day)

CW	= 0.635 ug/L	= PCE concentration in groundwater
KP	= 0.03 cm/hr	= permeability coefficient from water
AgeAdj	= 2682 cm^2-yr/kg	= Age adjusted surface area
SA_I	= Varying (cm^2)	= Surface area varies with age
ED_I	= 1 yr Increments	= One year increments
BW_I	= Varying (kg)	= Body weight varies with age
CF_1	= 1 mg/10^3 ug	= Conversion Factor
CF_2	= 1 L/10^3 cm^3	= Conversion Factor
FuncET	= 1.304 hr/day	= For Organics: where t^*_{PCE} (2.14hr)>ET (0.25hr) Func(ET)=SQRT([(24)*(tau (0.89hr)*(ET (0.25hr)]/pi)
EF	=350 days/yr	= Exposure frequency
ATC	= 25550 days	= Averaging time for carcinogens (365 d/yr x 70 yrs)
ATN	= 2190 days	= Averaging time for noncarcinogens (365 d/yr x 6 yrs)

The RME cancer risk for a future child resident from dermal absorption of PCE in groundwater at Warminster Area B is estimated as follows:

CA = Dermal Dose x SF

CA	= 4.74E-8	= Incremental cancer risk

SF	= 5.2E-2 $(mg/kg/day)^{-1}$	= Oral slope factor
Carc-Dermal Dose	= 9.12E-7	= Carcinogenic Dermal exposure dose (mg/kg/day)

The RME noncarcinogenic risk a future child resident from dermal absorption of of PCE in groundwater at Warminster Area B is estimated as follows:

NC = Dermal Dose/RfD

NC	= 1.06E-3	= Noncarcinogenic risk
RfD	= 1.0E-2 (mg/kg/day)	= Dermal reference dose = (RfD_{oral}*GI Factor; [1.0E-2*1.0])
Noncarc- Dermal Dose	= 1.06E-5	= Noncarcinogenic Dermal exposure dose (mg/kg/day)

E.3 Inhalation of Vapors (During Showering):

Inhalation of PCE (vapor phase during showering) in groundwater at Warminster Area B for a future adult resident under an RME scenario was evaluated using the following equation (EPA 1989a; Foster and Chrostowski 1987):

$$InhalationDose(mg/kg/day) = \frac{D*ED*EF*CF2}{AT}$$

$$D = \left(\frac{IR*S}{BW*Ra*CF1} \right) * Q$$

$$Q = Ds + \left[\frac{e^{-Ra*Dt}}{Ra} \right] - \left[\frac{e^{Ra*(Ds-Dt)}}{Ra} \right]$$

$$S = \frac{Cwd*Fr}{Sv}$$

The concentration leaving the water droplet (Cwd; 0.233 ug/L) was derived in the dermal equation in Section 6.1.2.

Where:

Carc-Inhalation Dose	= 6.10E-6	= Carcinogenic Inhalation exposure dose (mg/kg/day)
Noncarc-Inhalation Dose	= 1.78E-5	= Noncarcinogenic Inhalation exposure dose (mg/kg/day)

D	= 1.86E-2 ug/kg/day	= Dose absorbed per unit area per day
EF	= 350 days/yr	= Exposure frequency
ED	= 24 yr	= Exposure duration
ATC	= 25550 days	= Averaging time for carcinogens (365 d/yr x 70 yrs)
ATN	= 8760 days	= Averaging time for noncarcinogens (365 d/yr x 24 yrs)
IR_{air}	= 10 L/min	= Inhalation rate
S	= 2.79 $ug/m^3/min$	= Indoor VOC generation rate
BW	= 70 kg	= Body weight
Ra	= 1.667E-2 min^{-1}	= Rate of air exchange
CF_1	= 1000 L/m^3	= Conversion factor
CF_1	= 1 $mg/10^3$ ug	= Conversion Factor
Q	= 2.79 min	= Function of air exchange rate & time in shower/room
Ds	= 15 min	= Duration of shower
Dt	= 20 min	= Total time in shower room
Cwd	= 0.233 ug/L	= Concentration leaving water droplet after time ts

Fr	= 20 L/min	= Shower flow rate
Sv	= 6 m^3	= Shower room air volume

The RME carcinogenic risk a future adult resident from inhalation of PCE vapors in groundwater during showering at Warminster Area B is estimated as follows:

CA = Inhalation Dose x SF

CA	= 1.24E-8	= Incremental cancer risk
SF	= 2.03E-3 $(mg/kg/day)^{-1}$	= Inhalation slope factor
Carc-Inhalation Dose	= 6.10E-6	= Carcinogenic Inhalation exposure dose (mg/kg/day)

The RME noncarcinogenic risk a future adult resident from inhalation of PCE vapors in groundwater during showering at Warminster Area B is estimated as follows:

NC = Dermal Dose/RfD

NC	= 1.27E-4	= Noncarcinogenic risk
RfC	= 1.4E-1 (mg/kg/day)	= Inhalation Reference Concentration
Noncarc-Inhalation Dose	= 1.78E-5	= Noncarcinogenic Inhalation exposure dose (mg/kg/day)

The volatile chemical generation rate was estimated using the Foster and Chrostowski mass transfer model, which is based on two-phase film theory. The model employs contaminant-specific mass transfer coefficients, Henry's Law constants, droplet drop time, viscosity, temperature, etc. Specific details regarding the application of the mass transfer model can be found in the source documents (Foster and Chrostowski 1987).